[Assessment sheet] Climate change vulnerability assessments of rusty blackbird (*Euphagus carolinus*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	.
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Artificial land uses, like deforestation of southern boreal forests, could lose habitats of this species (MTRI, 2008; Greenberg et al., 2011). · I think effect of deforestation outside the national park are buffered enough, and therefore the subscore should be neutral. [Expert in Kejimkujik]
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This migratory bird can move for very long distances, like an average moving distance of 4430 km between breeding site and wintering area (Johnson et al., 2012).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species breeds from northern Alaska south to southern Canada or the northern United States (Godfrey, 1986), and Kejimkujik is in the southern side of the species' range. Increasing water and air temperatures could change aquatic invertebrate communities (particularly odonates), which are valuable food resources for this species (McClure et al., 2012; Loomis, 2013). However, this effect is reflected in the subfactor of C4b, while little is known about the physiological thermal niche of blackbird itself. Therefore, the C2aii was not assessed. · I would choose a neutral score. [Expert in Kejimkujik]
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-**Inc**-SI-N-SD GI-**Inc**-SI-N-SD	This species often breeds in streams with coniferous trees, swamps and bogs (MTRI, 2008). Warming could bring about wetland drying, and growth and survival rates of particularly young individuals of this species may be lowered (Greenberg et al., 2011). Also, wetland drying could change aquatic invertebrate communities, which are valuable food resources for this species (Loomis, 2013).

		· I would choose Inc score. [Additional Expert]
C2c (Disturbance)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	Greenberg et al. (2011) mentioned a possibility that outbreak of spruce budworms as well as related salvage logging led to widespread changes of blackbird's habitat. However, little is known about in what way and how they affected the habitat. On the other hand, Environment Canada (2014) suggested that storms and snow storms intensified by climate change would be devastating for breeding sites as well as foraging sites of the species. · Low balsam fir population for budworm and wouldn't affect logging. [Expert in Kejimkujik] · It is not a disturbance-dependent species. [Expert in Kejimkujik]
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-**SI**-**N**-**SD**-Dec Inc-**SI**-**N**-**SD**-Dec	No preference for certain geological features. Furthermore, this species can migrate for more than 4,000 km on average (Johnson et al., 2012), suggesting its great ability to be compatible with various geological conditions. · Mercury listed as a threat, make a note (like brook trout) mercury could be a factor. [Expert in Kejimkujik] · Does it lower its vulnerability because it has no geological feature requirements? [Expert in Kejimkujik] [Follow-up] High mercury contamination was found in rusty blackbird in Kejimkujik National Park, and the high availability of MeHg is due to low pH and low dissolved oxygen (Edmonds et al. 2010; 2012). However, the effects of the elevated mercury concentration on the species (at the population level) are not understood (Edmonds et al. 2010; Environment Canada, 2014). Without consideration of the mercury, the subscore of SD was recommeneded by expert consultation in Kejimkujik National Park. Nonetheless, given that such mercury effects will be generally articulated by climate change (Krabbenhoft and Sunderland 2013), the scores of SI, N, and SD were chosen here to reflect the uncertainty.
C4a (Other spp for habitat)	GI-Inc-**SI**-N GI-Inc-**SI**-N	This species often breeds in streams with coniferous trees (*Picea* spp.), swamps and bogs in Canada including Nova Scotia (MTRI, 2008). However, its nests are sometimes found in deciduous forests in Canada (Matsuoka et al., 2010), and this species prefers oak forests and hickories in the United States (Greenberg et al., 2011). · The birds will find a nesting place and they don't necessarily need particular tree species. [Expert in Kejimkujik] · I would choose SI score, because this species inhabits specifically conifer forests (but not pines). [Additional expert]
C4b	Inc-**SI**-N-SD	Both aquatic and terrestrial inverteberates (particularly odonates) are foraged by this species during breeding

(Diet)	Inc-**SI**-N-SD	period, whereas vegetable matters (e.g., acorns) are also eaten during fall and winter seasons (Edmonds et al., 2010; Greenberg et al., 2011; McClure et al., 2012). Increasing water and air temperatures could change aquatic invertebrate communities (particularly odonates), which are valuable food resources for this species (McClure et al., 2012; Loomis, 2013). Here, to reflect the seriousness of temperature increase on the food resource of blackbird, SI but not SD was chosen in the CCVI. As well, Inc and SI were chosen in the MVA. · Mercury listed as a threat, make a note (like brook trout) mercury could be a factor. [Expert in Kejimkujik] [Follow-up] High mercury contamination was found in rusty blackbird in Kejimkujik National Park, and the high availability of MeHg is due to low pH and low dissolved oxygen (Edmonds et al. 2010; 2012). This mercury effect was reflected in the subfator of C3.
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-**SI**-N-SD Inc-**SI**-N-SD	Because of limited flexibility of phenotypes of rusty blackbird, it may lag in its response to phenological changes (earlier emergence due to temperature increase) of preys, which are at lower trophic levels like odonates (McClure et al., 2012). · Flowering season becoming more important for birds. [Expert in Kejimkujik] · Short breeding season, if something isn't properly timed with that, it would have an impact. [Expert in Kejimkujik]
D1 (Documented response)	GI-**Inc**-SI-N-SD-Dec GI-**Inc**-SI-N-SD-Dec	The population of this species in southern Nova Scotia showed a moderate extinction probability (41-60%) likely due to climate change, based on a modelling, and the result of this modelling was consistent with actual observations at continental scale (McClure et al., 2012).
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	100	0	0
Severe scenario	0	0	100	0	0

The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario		-------------------------------			
Severe scenario		-------------------------------			
	This species breeds from northern Alaska south to southern Canada or the northern United States (Godfrey, 1986), and Kejimkujik is in the southern side of the species' range. Increasing water and air temperatures could change aquatic invertebrate communities (particularly odonates), which are valuable food resources for this species (McClure et al., 2012; Loomis, 2013). As well, drier environment under changing climates will be harmful on blackbird. High mercury contamination was found in rusty blackbird in Kejimkujik National Park (Edmonds et al. 2010; 2012), and such mercury effects will be generally articulated by climate change (Krabbenhoft and Sunderland 2013). Thus, even though we assume that climate change has no effects on the species in terms of physiological thermal niche, as suggested in expert consultation, rusty blackbird is likely to decline in the southern side of the species' range (including Kejimkujik National Park) due to several indirect effects of climate change. Yet, it means that temperature increase will not directly affect the species' survival, and hence HV is too strong to reflect the possible vulnerability. Consequnetly, only MV was chosen here. · If vernal pools dry up there will be less habitat available. [Expert in Kejimkujik] · This bird number continues to decline and climate change will make it worse. [Expert in Kejimkujik] · Drying has already been beginning in Kejimkujik National Park, which seems to be negative for rusty blackbird. [Additional expert]				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of common loon (*Gavia immer*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	Large individuals of this species inhabit inshore seacoasts during winter, and immature ones do so throughout a year (Godfrey, 1986). This species is also known to be sensitive to water-level fluctuation (Erskine, 1992). Therefore, this species might be partly influenced by sea level rise, but this effect is not taken into account in the assessed area, the inland part of Kejimkujik National Park.
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species has been empirically considered as a species being intolerant to human disturbances (e.g, Vermeer, 1973; Parks Canada, 2011c). Also, this species is more likely to present in areas with less road densities (Kuhn et al., 2011). However, the artificial barriers outside the park should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species migrates from breeding lakes to coastal wintering areas ranged across distances of around 2,000 km in the United States (Kenow et al., 2002). Also, the longest individual movements were 921 km over a 3-day period and 674 km over a 2-day period (Kenow et al., 2002).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-**N**-SD GI-**Inc**-**SI**-N-SD	This species breeds from northern Alaska south to the northern United States like New Hampshire and Maine (Godfrey, 1986), and Kejimkujik is in the southern side of the species' range. According to research in Newfoundland, breeding loons were less likely to be found in more northern regions because of shorter growing period and poorer fish production (Kerekes et al., 2000). According to a study in New Hampshire, the sites occupied by loons showed a higher water surface temperature (12.4°C) than that of unoccupied sites (11.8°C) (Blair, 1992). This is likely because loons feed on yellow perch rather than trout (Blair, 1992). In contrast, Byrd (2013) reported that loons that are more close to the southern (warmer) limit of the species' range were more likely to expend energy, suggesting that temperature increase will be adverse on energentic condition of loon. Considering the position of Kejimkujik National Park within the species's range, such negative impacts of climate change were regarded as more relevant than the abovementioned positive effect of temperature increase here (c.f., the subfactor of diet was assessed with the subscores of N and SD) .
C2bi (Historical hydrological	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	

niche)		
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	On average, lakes larger than 40 ha are preferred as habitats by this species in Kejimkujik National Park, because only large lakes could sustain fish resources (Kerekes, 2008). Similarly, loons were observed in large and deep lakes rather than small and shallow ones in New Hampshire (Blair, 1992). Decreases in seasonal runoff are likely to lower lake water levels, possibly affecting this species negatively (Byrd, 2013). Parks Canada (2011c) suggested that water level fluctuation could be harmful to this species.
C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	This species is also known to be sensitive to water-level fluctuation (Erskine, 1992; Parks Canada, 2011c). · Strong rains and floods could lead to water-level fluctuation, which will be harmful on loon. [CS]
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	This species is seen in most of the 40 oligotrophic lakes in Kejimkujik National Park (Kerekes, 2008). Lakes with lower productivity are preferred by loons (Blair, 1992). According to a study in Ontario, this species is unlikely to breed successfully at pH < 4.3 (Alvo, 2009). However, in Kejimkujik National Park, where dissolved organic carbon content (DOC) is very high, this species may be able to inhabit at pH <4.3 (Alvo, 2009). Yet, Parks Canada (2011c) documented that this species is sensitive to acidification in this park. High mercury contamination in loons in acid lakes in this park was observed, and such contamination limited productivity of the species (Burgess and Meyer 2008). Given that such mercury effects will be generally articulated by climate change (Krabbenhoft and Sunderland 2013), the scores of SI and N were chosen here to reflect the uncertainty.
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Paper birch and balsam fir, both of which are supposed to be vulnerable to climate change, were taken into account for predicting future distribution of loon in the US (Matthews et al., 2004). However, little is known about the dependence of loon on the two tree species (Matthews et al., 2004). · I cannot see any association between paper birch/balsam fir vs. loon. [Additional expert]
C4b (Diet)	Inc-SI-**N**-**SD** Inc-SI-**N**-**SD**	This species feeds on a wide variety of foods, including fish, ducklings, and plant materials (Blair, 1992; Kerekes et al., 2008; Alvo, 2009). However, according to a record in Alberta, small-bodied fish may not be enough for this species to nest (Gingras and Paszkowski, 1999). Blair (1992) documented that loons are likely to feed on yellow perch rather than trout, because trout can escape from predation by quick movements.
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a	Inc-SI-N-SD	

(Genetic variation)	Inc-SI-N-SD				
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N				
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD				
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	0	12	88	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario		-------------------------------	-------------------------------		
Severe scenario		-------------------------------			
	This species breeds from northern Alaska south to the northern United States like New Hampshire and Maine (Godfrey, 1986), and Kejimkujik is in the southern side of the species’ range. According to research in Newfoundland, breeding loons were less likely to be found in more northern regions because of shorter growing period and poorer fish production (Kerekes et al., 2000). According to a study in New Hampshire, the sites occupied by loons showed a higher water surface temperature (12.4°C) than that of unoccupied sites (11.8°C) (Blair, 1992). This is likely because loons feed on yellow perch rather than trout (Blair, 1992). In contrast, Byrd (2013) reported that loons that are more close to the southern (warmer) limit of the species’ range were more likely to expend energy, suggesting that temperature increase will be adverse on energentic condition of loon. Considering the position of Kejimkujik National Park within the species’s range, such negative impacts of climate change were regarded as more relevant than the abovementioned positive effect of temperature increase here. Erskine (1992) and Parks Canada (2011c) suggested that water level fluctuation could be harmful to this species. High mercury contamination in loons in acid lakes in this park was observed, and such contamination limited productivity of the species (Burgess and Meyer 2008). Such mercury effects will be generally articulated by climate change (Krabbenhoft and Sunderland 2013). Paper birch and balsam fir, both of which are supposed to be vulnerable to climate change, were taken into account for predicting future distribution of loon in the US (Matthews et al., 2004). However, little is known about the dependence of loon on the two tree species (Matthews et al., 2004). In short, although dietary condition could be improved, temperature increase will be adverse on loon by accelerating energy expenditure and possibly merucy contamination. Yet, we did not find critically serious factors, and hence the class of HV was not given for loon.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of Eastern Barred Owl (*Strix varia*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species prefers mature forests and large trees (Godfray, 1986; Erskine, 1992), and therefore logging has reduced the number of this owl in the Maritimes (Erskine, 1992). In contrast, some researchers pointed out this species' resilience to forest harvesting, considering an ongoing expansion of this species' distribution (Vanderwel et al., 2009). However, the artificial barriers outside the park should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	A median dispersal distance of this species is at least larger than 20 km, and some individuals move for longer distances like 50 km or over than 250 km (Livezey, 2009).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-SD	This subspecies is distributed in not only southern wooded Canada but also the United States (south to North Carolina and Kansas), while other subspecies of the same species is distributed in more southern parts of the United States, mountains of Mexico, western Guatemala and Honduras (Godfray, 1986). Increased summer temperature was regarded as a positive factor for a recent expansion of this species' distribution westwards (Monahan and Hijmans, 2007). Also, sub-arctic climate in northern Quebec is likely to have constrained this owl's distribution (Schmelzer and Phillips, 2004). However, in newly colonized areas, this owl partly inhabits colder conditions than the coldest places in its original distribution, indicating that cold temperature did not restrict this species' former distribution (Livezey, 2009). In contrast, this species could be susceptible to heat stress than cold one (Mazur, 1997), though there has been no supporting evidence. The mean summer temperatures of this species' putative source ranges between 15°C and 20°C (Monahan and Hijmans, 2007).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species prefers dark forests near lakes, streams, swamps and marshes (Godfray, 1986).

hydrological niche)		
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	This species prefers mature forests and large trees (Godfray, 1986; Erskine, 1992). Although this species has been believed as a habitat generalist, it was observed at high densities in late-successional reserves (Noon and Blakesley, 2006). As well, fire suppression is likely to have contributed to expanded woody vegetation and also the distribution of barred owl (Livezey 2009). · The owl seems to inhabit a wide range of habitats in Kejimkujik National Park, and disturbances led by climate change are unlikely to change its population status. [Additional expert]
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**-SD	Snowfall may restrict food availability for this species, like spruce grouse in Cape Breton Highlands.
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	No clear preference for certain geological features is known with this species, though some local populations have been observed in specific geological features (e.g., sandy soil (Schmelzer and Phillips, 2004)). Furthermore, this species can migrate for more than 20 km on average (Livezey, 2009), suggesting its moderate ability to be compatible with various geological conditions.
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	Generally, this species prefers coniferous forests or mixed forests (Godfray, 1986). However, local populations of this species tend to prefer specific tree species (e.g., oaks (Allen, 1987), aspens and white birches (Schmelzer and Phillips, 2004)).
C4b (Diet)	Inc-SI-**N**-SD Inc-SI-**N**-SD	This species can forage fish, frogs, crayfish, earthworms and slugs, which allows it to adapt to a wider range of habitats than the habitat of its competitor, spotted owl (Livezey et al., 2008).
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-**SI**-N-SD Inc-**SI**-N-SD	This species has formed a refugium in southern Atlantic coast in the United States, and it has expanded northwards along with post-glacial vegetation expansion (Barrowclough et al., 2011). In line with this scenario, a population of this species in Nova Scotia harbored poor diversity in both mtDNA and nuclear DNA (Barrowclough et al., 2011).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	(N/A)
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Increased summer temperature was regarded as a positive factor for a recent expansion of this species' distribution westwards (Monahan and Hijmans, 2007). However, in newly colonized areas, this owl partly inhabits in colder conditions than the coldest places in its original distribution, indicating that cold

		temperature did not restrict this species' former distribution (Livezey, 2009). Yet, sub-arctic climate in northern Quebec is likely to have constrained this owl's distribution, and this species is gradually expanding its distribution in Labrador northwards now (Schmelzer and Phillips, 2004).			
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	0	0	71	29
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			------------------------------		
Severe scenario			------------------------------		
	This subspecies is distributed in not only southern wooded Canada but also the United States (south to North Carolina and Kansas), while other subspecies of the same species is distributed in more southern parts of the United States, mountains of Mexico, western Guatemala and Honduras (Godfray, 1986). Increased summer temperature was regarded as a positive factor for a recent expansion of this species' distribution westwards (Monahan and Hijmans, 2007). Also, sub-arctic climate in northern Quebec is likely to have constrained this owl's distribution (Schmelzer and Phillips, 2004). However, in newly colonized areas, this owl partly inhabits colder conditions than the coldest places in its original distribution, indicating that cold temperature did not restrict this species' former distribution (Livezey, 2009). In contrast, this species could be susceptible to heat stress than cold one (Mazur, 1997), though there has been no supporting evidence. This species prefers mature forests and large trees (Godfray, 1986; Erskine, 1992), but it seems to be a habitat generalist at least in Kejimkujik National Park. As a conclusion, the owl population in the park may be stable under future climates.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of brown bullhead (*Ameiurus nebulosus*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	This species inhabits warm water, and natural barriers, like those among cold refugia for brook trout, are not likely to affect it. In contrast, it is also not clear if this species inhabits just large lakes and/or main rivers, which are given an example of “neutral” subscore by Young et al. (2011). Therefore, SI as well as N are chosen here.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-Dec GI-Inc-SI-N-**SD**-Dec	There are both sedentary and mobile types of this species, but possibly it could move for distances of up to 4 km or 6 km (Millard et al., 2009; Sakaris et al., 2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** Dec GI-Inc-SI-N-**SD** Dec	Although this species is distributed widely in Canada, it could be seen mainly in warm ponds and lakes in southern Ontario (Scott, 1967). Specifically, this species can be alive in temperature zone from 2°C to 35°C with a high ability of acclimation to rising temperature (Brett, 1956). According to an experiment of acclimation to temperatures between 3.5 and 28°C, this species preferred a temperature of 27.3°C (Richards and Ibara, 1978).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-**SD** GI-Inc-**SI**-N-**SD**	This species grows faster in lotic environments than lentic ones, and also it moves to lotic habitats from lentic ones (Rypel, 2011). Yet, lotic waterflows need much water. According to a meta-analysis, in contrast, the growth of this species was also positively correlated with potential evapotranspiration (Rypel, 2011).
C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	According to a meta-analysis, the growth of this species was negatively correlated with wind speed (Rypel, 2011).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-**SI**-**N**-**SD**-Dec Inc-**SI**-**N**-**SD**-Dec	This species can inhabit even acid environments (Dick and Trudel, 2006). In Kejimkujik, this species was found even at pH of 4.6 (Kerekes and Freedman, 1989). Mercury contamination in brown bullhead was not

<table>
<tr><td></td><td></td><td colspan="4">examined in Kejimkujik National Park. However, many components of the ecosystem in the park harbored highly concentrated mercury (Rencz et al. 2003), and similar mercury accumulation is likely with bullhead. Although brown bullheard was collected from less acidic lake than another lake of yellow perch in Ontario, Scheuhammer and Graham (1999) found mercury accumulation in brown bullhead as much as yellow perch. Given that such mercury effects will be generally articulated by climate change as well (Krabbenhoft and Sunderland 2013), the scores of SI, N, and SD were chosen here to reflect the uncertainty.</td></tr>
<tr><td>C4a
(Other spp for habitat)</td><td>GI-Inc-SI-N
GI-Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C4b
(Diet)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4">This species is an omnivorous predator, feeding on not only insects, fish, snails but also plant materials (Scott, 1967; Rypel, 2011).</td></tr>
<tr><td>C4c
(Pollination)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4">(N/A)</td></tr>
<tr><td>C4d
(Other spp for disp)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4"></td></tr>
<tr><td>The CCVI [%]</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>Moderate scenario</td><td>0</td><td>0</td><td>0</td><td>91</td><td>9</td></tr>
<tr><td>Severe scenario</td><td>0</td><td>0</td><td>0</td><td>35</td><td>65</td></tr>
<tr><td>The MVA**</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td>Moderate scenario</td><td></td><td></td><td></td><td>-------------------------------</td><td></td></tr>
<tr><td>Severe scenario</td><td></td><td></td><td></td><td></td><td>-------------------------------</td></tr>
<tr><td></td><td colspan="5">Although this species is distributed widely in Canada, it could be seen mainly in warm ponds and lakes in southern Ontario (Scott, 1967). Specifically, this species can be alive in temperature zone from 2°C to 35°C with a high ability of acclimation to rising temperature (Brett, 1956). According to an experiment of acclimation to temperatures between 3.5 and 28°C, this species preferred a</td></tr>
</table>

	temperature of 27.3°C (Richards and Ibara, 1978). According to a meta-analysis, in contrast, the growth of this species was negatively correlated with wind speed (Rypel, 2011). Mercury might also be accumulated in brown bullhead in Kejimkujik, according to a case study in Ontario (Scheuhammer and Graham 1999). Yet, clear evidence of such possibly negative effects on the species was reported. Overall, this species is a warm-water fish species, and therefore it will flourish under climate change well. The degree of expected growth of this species' populations may depend on mainly temperature increase alone, and hence MA and HA were assigned in moderate and severe climate change scenarios respectively here.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

References cited in just this sheet (references that were already cited in the main text as common documents for many species are not shown here.)

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[Assessment sheet] Climate change vulnerability assessments of white perch (*Morone americana*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	This species inhabits warm water, and natural barriers, like those among cold refugia for brook trout, are not likely to affect it. In contrast, it is also not clear if this species inhabits just large lakes and/or main rivers, which are given an example of “neutral” subscore by Young et al. (2011). Therefore, SI as well as N are chosen here.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	In eastern Nebraska, this species expanded its distribution for 322 km upstream during 13 years (Hergenrader, 1980). Downstream and seaward migrations of this species were also indicated in Nova Scotia as well as eastern Nebraska (Livingstone, 1951; Hergenrader, 1980). This species was judged as more mobile than yellow perch as well (Kanno and Beazley, 2004).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** Dec GI-Inc-SI-N-**SD** Dec	White perch is alive under temperatures ranging between 2.0 and 32.5°C (Stanley and Danie, 1983). This species collected from north Carolina, Maryland and New Jersey during May and August (when water temperature was around 25°C) preferred high temperature of 29.6-32.5°C (Hall et al., 1978; Hall et al., 1979). In contrast, according to overwinter experiments at temperatures of 2.5° and 4.0°C, this species showed high (71.2%) and moderate (11.1%) mortality rates (Johnson and Evans, 1991). In comparison with yellow perch, white perch are much less tolerant to low winter temperatures (Johnson and Evans, 1990).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-**SD**	Increased spring rainfall could alter salinity and negatively influence on this species’ growth, though it can be tolerate to a wide range of salinity (e.g., 5-18 ppt for adults) (Stanley and Danie, 1983). Less snow accumulation that severe climate change scenario assmued may reduce stream flows in spring, canceling out the negative influence of spring rainfall. Thus, SD was also chosen for just severe scenario.
C2c (Disturbance)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	

<table>
<tr><td>C2d
(Ice/Snow)</td><td>GI-Inc-SI-**N**
GI-Inc-SI-**N**</td><td colspan="4">*(see C2bii)*</td></tr>
<tr><td>C3
(Physical habitat)</td><td>Inc-**SI**-**N**-SD-Dec
Inc-**SI**-**N**-SD-Dec</td><td colspan="4">White perch inhabits estuaries with slightly salty water (Mansueti, 1961; Stanley and Danie, 1983). This species occurs in many lakes in Nova Scotia, but not in the granite areas (Livingstone, 1951). Increase of mercury concentration in yellow perch in this park was observed between 1996-1997 and 2006-2007, and such contamination may have led to decline of the species' condition (Wyn et al. 2010). Similar data with white perch are limited, but white perch retains mercury to the similar level according to a study conducted in Cumberland and Guysborough Counties in Nova Scotia (Stevens 2014). Given that such mercury effects will be generally articulated by climate change (Krabbenhoft and Sunderland 2013), the scores of SI and N were chosen here to reflect the uncertainty.</td></tr>
<tr><td>C4a
(Other spp for habitat)</td><td>GI-Inc-SI-**N**
GI-Inc-SI-**N**</td><td colspan="4"></td></tr>
<tr><td>C4b
(Diet)</td><td>Inc-SI-**N**-SD
Inc-SI-**N**-SD</td><td colspan="4">White perch feeds on both insects and fish (Scott, 1967). According to a report in New Brunswick, this species also eats sand shrimps (*Crangon septemspinosa*) and Copepods (cyclopoids and large calanoid *Eurytemora* sp.) (St-Hilaire et al., 2002). In contrast, the same species forages amphipods more frequently than shrimps and fish in New Jersey (Weis, 2005). In Missisquoi Bay of Lake Champlain, white perch feed on mainly Daphnia, and such variations among regions indicated the diet plasticity and opportunistic feeding of this species (Couture and Watzin, 2008).</td></tr>
<tr><td>C4c
(Pollination)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4">(N/A)</td></tr>
<tr><td>C4d
(Other spp for disp)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="4"></td></tr>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="4"></td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4">Global warming is likely to improve recruitment and expansion of this species' distribution in the Great Lakes (Johnson and Evans, 1991).</td></tr>
<tr><td rowspan="2">The CCVI [%]
Moderate scenario</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>75</td><td>25</td></tr>
</table>

Severe scenario	0	0	0	0	100
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario				-------------------------------	
Severe scenario					-------------------------------
	White perch is alive under temperatures ranging between 2.0 and 32.5°C (Stanley and Danie, 1983). This species collected from north Carolina, Maryland and New Jersey during May and August (when water temperature was around 25°C) preferred high temperature of 29.6-32.5°C (Hall et al., 1978; Hall et al., 1979). In contrast, according to overwinter experiments at temperatures of 2.5° and 4.0°C, this species showed high (71.2%) and moderate (11.1%) mortality rates respectively (Johnson and Evans, 1991). In comparison with yellow perch, white perch are much less tolerant to low winter temperatures (Johnson and Evans, 1990). Therefore, it is plausible that this species will adapt to climate change, like brown bullhead. Here, following the judgement of brown bullhead, white perch was also judged MA and HA under moderate and severe climate change scenarios.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

References cited in just this sheet (references that were already cited in the main text as common documents for many species are not shown here.)

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Hall, L. W., Hocutt, C. H., & Stauffer, J. R. (1978). Implication of geographic location on temperature preference of white perch, *Morone americana*. Journal of the Fisheries Board of Canada, 35(11), 1464-1468.

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[Assessment sheet] Climate change vulnerability assessments of yellow perch (*Perca flavescens*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	This species inhabits warm water, and natural barriers, like those among cold refugia for brook trout, are not likely to affect it. In contrast, it is also not clear if this species inhabits just large lakes and/or main rivers, which are given an example of “neutral” subscore by Young et al. (2011). Therefore, SI as well as N are chosen here.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-**Dec** GI-Inc-SI-N-**SD**-**Dec**	This species can move for long distances (up to 160-175 km) (Järv, 2000; Leclerc et al., 2008), though its movement ability was regarded as limited by some other researchers (Kanno and Beazley, 2004).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** Dec GI-Inc-SI-N-**SD** Dec	Higher survival rates were observed in warmer years in Oneida Lake in New York State (mean temperature varied between 11 and 12.5°C) (Clady, 1976). Also, the optimal temperature range for this species’ survival was reported between 13 and 16°C (Hokanson and Kleiner, 1974). In contrast, according to an experiment with this species from Minnesota in summer season, the species’ growth was best at the temperature of 28°C (McCormick, 1976). Mortality of yellow perch increases with winter duration (the number of days’ exposure to 4.0°C) (Johnson and Evans, 1990). In comparison with white perch, yellow perch are much more tolerant to low winter temperatures (Johnson and Evans, 1990). Mean annual water temperature is not documented in Kejimkujik National Park, but mean annual air temperature in the same park is 6.4°C. Also, mean air temperature in winter is -4.0°C. Therefore, even though we cannot specify the degree of warming effects, increase in temperature will be beneficial for yellow perch.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-**SI**-N-SD	Water level rise and flood in spring could be beneficial to increase spawning habitats for this species (Leclerc et al., 2008; Longhenry et al., 2010). Less snow accumulation that severe climate change scenario assmued may lead to decline of such benefits. Thus, SI was chosen for just severe scenario.
C2c	Inc-**SI**-N-SD-Dec	Strong winds could kill eggs of this species in Oneida Lake in New York State by dispersal and physical

(Disturbance)	Inc-**SI**-N-SD-Dec	destruction (Clady, 1976). Water level rise and flood in spring could be beneficial to increase spawning habitats for this species (Leclerc et al., 2008; Longhenry et al., 2010), but this type of disturbance is less likely to occur in the future due to less amount of snow. Thus, the positive effect of spring flood is not taken into account here.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	*(see C2bii)*
C3 (Physical habitat)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	This species is very common in soft rock areas, but rare in granite areas, in the mainland of Nova Scotia (Livingstone, 1951). As well, in Kejimkujik, this species was found even at pH of 4.1 (Kerekes and Freedman, 1989). Yellow perch in Kejimkujik contain mercury at higher concentrations than acceptable limits for wildlife (Parks Canada, 2011c). Increase of mercury concentration in perch in this park was observed between 1996-1997 and 2006-2007, and such contamination may have led to decline of the species' condition (Wyn et al. 2010). Given that such mercury effects will be generally articulated by climate change (Krabbenhoft and Sunderland 2013), the scores of SI and N were chosen here to reflect the uncertainty.
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C4b (Diet)	Inc-SI-**N**-SD Inc-SI-**N**-SD	This species is an opportunistic feeder, consuming zooplanktons, fish, and benthic invertebrates, though adults of the same species prefer benthic invertebrates (Tyson and Knight, 2001).
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-**SI**-N-SD Inc-**SI**-N-SD	A population of this species in Nova Scotia harbored exceptionally no allelic diversity (Todd and Hatcher, 1993), though this species is likely to retain relatively limited genetic variations as a species (Todd and Hatcher, 1993; Sepulveda-Villet et al., 2009). This result is consistent with less diversity detected in this species' northeastern migrating populations (e.g., the St. Johns River population) (Sepulveda‐Villet and Stepien, 2012).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	(N/A)
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2	GI-Inc-SI-N-SD-Dec	

(Modeled change)	GI-Inc-SI-N-SD-Dec				
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	0	50	50	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	
Severe scenario				------------------------------	------------------------------
	Higher survival rates were observed in warmer years in Oneida Lake in New York State (mean temperature varied between 11 and 12.5°C) (Clady, 1976). Also, the optimal temperature range for this species' survival was reported between 13 and 16°C (Hokanson and Kleiner, 1974). In contrast, according to an experiment with this species from Minnesota in summer season, the species' growth was best at the temperature of 28°C (McCormick, 1976). Mortality of yellow perch increases with winter duration (the number of days' exposure to 4.0°C) (Johnson and Evans, 1990). Mean annual water temperature is not documented in Kejimkujik National Park, but mean annual air temperature in the same park is 6.4°C. Also, mean air temperature in winter is -4.0°C. Therefore, even though we cannot specify the degree of warming effects, increase in temperature will be beneficial for yellow perch. However, in comparison with white perch, yellow perch are much more tolerant to low winter temperatures (Johnson and Evans, 1990). As well, water level rise and flood in spring could be beneficial to increase spawning habitats for this species (Leclerc et al., 2008; Longhenry et al., 2010). Less snow accumulation that severe climate change scenario assmued may lead to decline of such benefits. Thus, SI was chosen for just severe scenario. Increase of mercury concentration in perch in this park was observed between 1996-1997 and 2006-2007, and such contamination may have led to decline of the species' condition (Wyn et al. 2010). Such mercury effects will be generally articulated by climate change (Krabbenhoft and Sunderland 2013). However, because benefits of temperature increase are clearer than possibly negative impacts of climate change in combination with mercury, we gave this species PS/MA and MA/HA under moderate and severe climate change scenarios, while white perch was judged MA and HA.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of brook trout (*Salvelinus fontinalis*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-**N** GI-**Inc**-**SI**-**N**	Although this species has both marine-type and freshwater-type, the latter type is considered in Kejimkujik National Park (Parks Canada, 2010a). Stream gradients and natural barriers like watersheds may have restricted the native distribution of this species (Meisner, 1990; Parks Canada, 2010a). · Natural barriers would be bad. [Expert in Kejimkujik] · Uncertainty might prevent us from making a call towards natural barriers. [Expert in Kejimkujik] [Follow-up] In spite of the uncertainty mentioned by PD, there are no highlands (like Cape Breton Highlands) in the park. In this regard, this species has little adaptation opportunity. To show lack of such potential opportunities, Inc and SI were chosen in the MVA.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Forest logging is one of strong negative factors limiting the distribution of this species (Bivens, 1984). Also, in Kejimkujik National Park, valuable habitats for spawning and rearing of this species were destroyed by artificial dams (Corbett, 2003). Parks Canada (2011c) also suggested that this species is sensitive to artificial modifications of its habitats. · Dams impact populations in Kejimkujik National Park even if dams aren’t in the park. As well, if water dries up the barriers may be more pronounced. [Expert in Kejimkujik] · Logging is still an issue due to where they spawn. Logging is deregulating flow into Kejimkujik National Park. [Expert in Kejimkujik] · What DC is talking about may be an indicator but is not addressing the issue inside the park. [Expert in Kejimkujik]
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	In Kennebecasis River and Bay, New Brunswick, this species moved upstream for 65-100 km during spring and also moved to spawning areas for less than 10 km in autumn (Curry et al., 2002). In Wyoming, this species moved for 320 m on average (0-1,638 m) during autumn, whereas it did not move during winter (latter half of January to former half of March) (Lindstrom and Hubert, 2004).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii	GI-Inc-**SI**-N-SD	This species is distributed in cool, clear waterflows in the Maritime Provinces, Newfoundland, and Labrador

(Physiological thermal niche)	GI-**Inc**-SI-N-SD	westward to Manitoba in Canada (Scott, 1967). Although adults of this species can be alive at temperature of less than 25.3°C, eggs of the same species will be dead at tmperature higher than 11.7°C (Chiasson, 2008). Also, groundwater whose temperature is higher than 15°C may be too warm for this trout (Meisner, 1990). According to one Habitat Quality Index model, the most optimal summer temperature for this species is between 12.6 and 18.6°C (Scarnecchia and Bergersen, 1987). According to another observation in Nova Scotia, the mean summer water temperature less than 16.5°C was preferred by brook trouts (MacMillan et al., 2008). Warmwater zones (mean summer water temperature > 18.9°C) in Nova Scotia are mostly confined to its southwestern part, and such zones will be unsuitable for this trout in warming climate (MacMillian et al., 2005). Exceptionally, Mountain Lake is a solely possible refugium for this species in future climates in Kejimkujik National Park (Corbett, 2003).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Deep pools could be important refugia under warming climate for this trout (MacMillan et al., 2005), but an observation in Nova Scotia did not find any significant relationship between water depth and density of this species (MacMillan et al., 2008).
C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	If snow shifts to snow-rain mix, high waterflows (floods) in winter would be frequent, negatively affecting brook trout (Wenger et al., 2011). This is because this species spawns in autumn (Wenger et al., 2011). As well, wildfires are likely to affect negatively salmonid thermal habitats (Isaak et al., 2010).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-N	Snow accumulation could contribute to stability of winter habitats of this species (Lindstrom and Hubert, 2004). If snow shifts to snow-rain mix, high waterflows (floods) in winter would be frequent, negatively affecting brook trout (Wenger et al., 2011). This is because this species spawns in autumn (Wenger et al., 2011).
C3 (Physical habitat)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	This species can be more tolerant of acid environments than rainbow trout (pH > around 4.3) (Bivens, 1984; Hurley et al., 1989). In contrast, according to on-site observation in Nova Scotia, this species was more frequent in less acid rivers (pH = around 7.1) (MacMillan et al., 2008), and Mountain Lake is one of a few lakes at optimal pH for this species in Kejimkujik National Park (Corbett, 2003). Type of substrates in habitats was not significantly correlated with the frequency of this species (MacMillan et al., 2008). · Generally speaking, water quality and toxins (i.e., mercury) should be included into consideration. [Expert in Kejimkujik] · The methylation of mercury could happen because of warmer temperatures, but I am not sure if it's been proven that mercury accumulation affects trout. [Expert in Kejimkujik] [Follow-up] Mercury contamination in brook trout was not examined in Kejimkujik National Park. However, many components of the ecosystem in the park harbored highly concentrated mercury (Rencz et al. 2003),

		and similar mercury accumulation is likely with trout. Because there were correlations between mercury concentration in trouts vs. macrophage accumulations in the spleen and the kidney, such mercury could damage brook trout (Schwindt et al. 2008). As well, a related species, rainbow trout showed higher mercury-related mortality at warmer water temperature, probably due to accelerated chemical reactions and/or metabolic rates (MacLeod and Pessah 1973). Given that such mercury effects will be generally articulated by climate change as well (Krabbenhoft and Sunderland 2013), the scores of SI and N were chosen here to reflect the uncertainty.
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** SD GI-Inc-**SI**-**N**	Beaver ponds are preferred as habitats to overwinter by this species (Lindstrom and Hubert, 2004). In the MVA, because beaver will be presumably stable or moderately adaptable under moderate climate change scenario, the subscores of N and SD were chosen instaed of SI and N. · There is a minimal connection between brook trout and beaver. It could help if flashiness increases. [Expert in Kejimkujik] · Beavers will increase due to food availability. [Expert in Kejimkujik]
C4b (Diet)	Inc-SI-**N**-SD Inc-SI-**N**-SD	This species forages insects and fish, and especially slimy sculpin (*Cottus cognatus*) are commonly predated by large brook trout (Scott, 1967). However, slimy sculpin has never been seen in Nova Scotia (Gormley et al., 2005), and possibly some other fish species might be used as food resource in Kejimkujik National Park. · If they are a generalist they should decrease, not increase. [Expert in Kejimkujik]
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	This species has lost in an interspecific competition with an exotic salmonid, rainbow trout in many areas (Bivens, 1984). Negative impact of temperature increase on rainbow trout can be mitigated by high waterflow during winter under climate change (Wenger et al., 2011). In other words, less snow and more winter rain may help rainbow trout to outcompete brook trout. ·Brook trout is threatened by bass and chain pickerel rather than rainbow trout in Kejimkujik National Park [Expert in Kejimkujik]. [Follow-up] Because effects of invasive alien species are not supposed to be considered in the CCVI assessment, the score of Inc was adopted for just the MVA.
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b	Inc-**SI**-N	The populations of this species in Kejimkujik National Park were genetically diverged from other populations

(Genetic bottleneck)	Inc-SI-N	according to both allozyme and mtDNA analyses (Jones et al., 1996), suggesting kind of past bottlenecks. · Add line about sea-run brook trout population being annihilated by artificial dams. [Expert in Kejimkujik] · Also, we have a highly-specialized strain in the western watershed that is extremely acid tolerant [Expert in Kejimkujik]. · There is certainly phenotypic variation (in brook trout populations in Kejimkujik National Park), though it has never been determined if it's genetically fixed or not. [Expert in Kejimkujik]
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Warmwater zones (a mean summer water temperature > 18.9°C) in Nova Scotia are mostly confined to its southwestern part, and such zones will be unsuitable for this trout in warming climate (MacMillian et al., 2005). Yet, according to a prediction by Chu et al. (2005), brook trout populations still persist in and around Kejimkujik under minimum and moderate climate changes (with annual temperature changes of +1.96°C and +3.23°C respectively).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	91	9	0	0

The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario		-------------------------------			
Severe scenario	-------------------------------				
	This species is distributed in cool, clear waterflows in the Maritime Provinces, Newfoundland, and Labrador westward to Manitoba in Canada (Scott, 1967). Although adults of this species can be alive at temperature of less than 25.3°C, eggs of the same species will be dead at tmperature higher than 11.7°C (Chiasson, 2008). Also, groundwater whose temperature is higher than 15°C may be too warm for this trout (Meisner, 1990). According to one Habitat Quality Index model, the most optimal summer temperature for this species is between 12.6 and 18.6°C (Scarnecchia and Bergersen, 1987). According to another observation in Nova Scotia, the mean summer water temperature less than 16.5°C was preferred by brook trouts (MacMillan et al., 2008). Warmwater zones (mean summer water temperature > 18.9°C) in Nova Scotia are mostly confined to its southwestern part, and such zones will be unsuitable for this trout in warming climate (MacMillian et al., 2005). Exceptionally, Mountain Lake is a solely possible refugium for this species in future climates in Kejimkujik National Park (Corbett, 2003). If snow shifts to snow-rain mix, high waterflows (floods) in winter would be frequent, negatively affecting brook trout (Wenger et al., 2011). This is because this species spawns in autumn (Wenger et al., 2011). Snow accumulation could contribute to stability of winter habitats of this species (Lindstrom and Hubert, 2004). Mercury accumulation also damages brook trout (Schwindt et al. 2008), and the negative impact of mercury might be increased due to temperature increase (MacLeod and Pessah 1973; Krabbenhoft and Sunderland 2013). In short, not only warmer water temperatures but also decline of snow accumulation will be harmful to this species. As well, competition with alien fish species will contribute to				

	vulnerability of trout. Thus, the vulnerability may be the subscore of the physiological thermal niche (C2aii; SI) under moderate climate change scenario, while the vulnerability will be more serious than the subscore of the same attribute (Inc) under severe scenario. · It is a very temperature-dependent species so I think HV is sound. [Expert in Kejimkujik] · If temperature of spring water doesn't change, I would choose MV. [Expert in Kejimkujik] · Factor in invasive species which would be the tipping point, making them HV. [Expert in Kejimkujik]

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of Mainland moose (*Alces alces americana*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	There is the geographical barrier of the Nova Scotian peninsula isolated from the mainland. Parker (2003) proposed that immigration of moose from New Brunswick or Cape Breton may be irrelevant to population size of this species in mainland Nova Scotia, even if there are a few immigrants. Because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral. Yet, there are no highlands (like Cape Breton Highlands) in the park. In this regard, this species has little adaptation opportunity. To show lack of such potential opportunities, Inc and SI were chosen in the MVA.
B2b (Artificial barriers)	GI-Inc-**SI**-N GI-Inc-**SI**-N	Populations have been fragmented and isolated, possibly due to in part establishing and decommissioning roads (including forestry harvesting roads) (Snaith and Beazley, 2004). Parker (2003) also proposed that timber harvesting has disturbed suitable habitats for moose in mainland Nova Scotia. As well, deer, which often carry a fatal parasite (*Paralephostrongylus tenuis*), could utilize roads to approach habitats of moose (Robinson et al., 2010).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	According to dispersal records of this species in several regions, moose can migrate for more than 10 km (possibly up to 50 km) (Parker, 2003). Although this species in Nova Scotia may not seasonally migrate for long distances (Parker, 2003; Snaith and Beazley, 2004), these records show high dispersal ability of this species.
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-N-SD GI-**Inc**-SI-N-SD	Although heat-stress threshold of this species during summer was supposed to be between 14-20°C, some recent studies have shown that moose could be more tolerant to heat stress (McCann et al., 2013). McCann et al. (2013) reported heat-stress thresholds of 17°C under calm conditions and 24°C under windy ones, by observing moose at the Minnesota Zoological Garden. Nova Scotia is near to the southern limit of this species' distribution, and it is likely to be affected by heat stress (Snaith and Beazley, 2004). Broders et al. (2012) observed the fact that moose seeked for cooler sites when temperature reached at 14°C in summer nights and 24°C in summer days in mainland Nova Scotia. For instance, proportions of moose staying in softwoods or watersides were higher at warmer conditions (Broders et al., 2012).
C2bi	GI-Inc-SI-N-SD	

(Historical hydrological niche)	GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	Riverine and marsh habitat are beneficial for this species by alleviating heat stress (Parker, 2003; Dou et al., 2013). Parker (2003) suggested that post-fire forest regeneration often produces many aspen trees and that such aspen trees could be beneficial for beavers. Beavers then create wetlands, and such wetlands are useful for moose during summer season (Parker, 2003).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	Early successional vegetation and/or burned areas are beneficial for this species, though severe and repeated burning is harmful (Feldhamer, 2003; Snaith and Beazley, 2004; Fisher and Wikinson, 2005). Parker (2003) suggested that post-fire forest regeneration often produces many aspen trees and that such aspen trees could be beneficial for beavers. Beavers then create wetlands, and such wetlands are useful for moose during summer season (Parker, 2003).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-N	Moose are morphologically capable to move through snow, and only much deep snow (> 70cm) could restrict their movements in Atlantic Canada (Kelsall, 1969). Smaller amount of snowfall will increase the exposure of this species to *P. tenuis*, leading to higher mortality of moose (Beazley et al., 2006).
C3 (Physical habitat)	Inc-SI-N-**SD**-**Dec** Inc-SI-N-**SD**-**Dec**	No preference for certain geological features. Yet, Parker (2003) proposed that a combination between barren habitats and acidification in southwestern Nova Scotia may have led to poor quality of diet of moose in this area. Therefore, although acidity does not necessarily confine the distribution of this species, the acid condition should be negative for this species in Kejimkujik. Further, highly concentrated heavy metals in moose in southwestern Nova Scotia could be responsible for this species' mortality, though there have been no supporting evidence yet (Parker, 2003).
C4a (Other spp for habitat)	GI-Inc-**SI**-N SD GI-Inc-**SI**-N	Preferring early successional deciduous vegetation (Snaith and Beazley, 2004). Parker (2003) proposed that a combination between barren habitats and acidification in southwestern Nova Scotia may have suppressed development of such deciduous and mixed stands in this area. Parker (2003) also suggested that post-fire forest regeneration often produces many aspen trees and that such aspen trees could be beneficial for beavers. Beavers then create wetlands, and such wetlands are useful for moose during summer season (Parker, 2003). Further, mature coniferous stands could be also useful for this species to adjust its body temperature during summer season (Parker, 2003). In support of this idea, Broders et al. (2012) observed moose in mostly softwood or mixed forests during summer season in mainland Nova Scotia. In the MVA, because beaver will be presumably stable or moderately adaptable under moderate climate change scenario, the subscores of N and SD were additionally chosen.
C4b (Diet)	Inc-**SI**-N-SD Inc-**SI**-N-SD	In Nova Scotia, important foods for this species include red, sugar, and mountain maples, white and yellow birches, hazelnuts, and balsam firs (Parker, 2003; Snaith and Beazley, 2004).
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	

C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	Parker (2003) suggested that post-fire forest regeneration often produces many aspen trees and that such aspen trees could be beneficial for beavers. Beavers then create wetlands, and such wetlands are useful for the moose during summer season (Parker, 2003). Northward expansion of deer's distribution could partly lead to decline of moose populations via interspecific competition of food/habitats and bringing a parasitic nematode, *P. tenuis* (Robinson et al., 2010). There are already many deer in Kejimkujik, but negative influences of deer on moose may be enhanced with a larger number of deer in warmer climates.
C5a (Genetic variation)	Inc-**SI**-N-SD Inc-**SI**-N-SD	An intra-population genetic variation of moose populations was smaller for the mainland in Nova Scotia than those in northern Ontario as well as Cape Breton (Beazley et al., 2006). This result is consistent with moose population size decline over the last 30 years in mainland Nova Scotia (Parker, 2003).
C5b (Genetic bottleneck)	Inc-**SI**-N Inc-**SI**-N	(N/A)
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Northward expansion of deer's distribution has partly led to decline of moose populations in eastern Canada and the United States via interspecific competition of food/habitats and bringing a parasitic nematode, *P. tenuis* (Robinson et al., 2010). However, this trend is a macro-geographic pattern, but not a more local pattern focusing on Kejimkujik or Nova Scotia.
D2 (Modeled change)	GI-Inc-**SI**-N-SD-Dec GI-**Inc**-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	50	50	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario		-------------------------------			
Severe scenario	-------------------------------				
	Although heat-stress threshold of this species during summer was supposed to be between 14-20°C, some recent studies have shown that moose could be more tolerant to heat stress (McCann et al., 2013). McCann et al. (2013) reported heat-stress thresholds of 17°C under calm conditions and 24°C under windy ones, by observing moose at the Minnesota Zoological Garden. Nova Scotia is near to the southern limit of this species' distribution, and it is likely to be affected by heat stress (Snaith and Beazley, 2004). Broders et al. (2012) observed the fact that moose seeked for cooler sites when temperature reached at 14°C in summer nights and 24°C in summer days in mainland Nova Scotia. For instance, proportions of moose staying in softwoods or watersides were higher at warmer conditions (Broders et al., 2012). Riverine and marsh habitat are beneficial for this species by alleviating heat stress (Parker, 2003; Dou et al., 2013). Parker (2003) suggested that post-fire forest regeneration often produces many aspen trees and that such aspen trees could be beneficial for beavers. Beavers then create wetlands, and such wetlands are useful for moose during summer season (Parker, 2003). Early successional vegetation and/or burned areas are beneficial for this species, though severe and repeated burning is harmful (Feldhamer, 2003; Snaith and Beazley, 2004; Fisher and Wikinson, 2005). Moose are morphologically capable to move through snow,				

	and only much deep snow (> 70cm) could restrict their movements in Atlantic Canada (Kelsall, 1969). Smaller amount of snowfall will increase the exposure of this species to *P. tenuis*, leading to higher mortality of moose (Beazley et al., 2006). Northward expansion of deer's distribution could partly lead to decline of moose populations via interspecific competition of food/habitats and bringing a parasitic nematode, *P. tenuis* (Robinson et al., 2010). There are already deer in Kejimkujik, but negative influences of deer on moose may be enhanced with a larger number of deer in warmer climates. In short, although fire disturbances could be beneficial for moose, this species in Kejimkujik National Park will be significantly affected by temperature increase as well as further infections of *P. tenuis* negatively. This vulnerability will be articulated with less snow accumulation, like severe climate change scenario. Given that there are no immigrants from other populations, moose population in Kejimkujik National Park cannot be resilient to climate change. So, MV and HV were given for moose here under moderate and severe climate change scenarios respectively.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of coyote (*Canis latrans*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scotian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Although some coyotes have used roads to travel, demarcate boundaries and possibly collect foods (garbage), this species generally seems to refrain from including roads in their home ranges (Gompper, 2002; Porter, 2013). However, the artificial barriers outside the park should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	In northeastern America, this species can migrate for more than 100 km on average, and some individuals travel for more than 300 km (Gompper, 2002).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	Basically, this species is highly adaptable, ranging from 10°N latitude (Costa Rika) to 70°N latitude (northern Alaska). In cold winter, this species can predate deer, particularly dead deer, because of their high mortality (Gese et al., 1996). However, winter temperature lower than -10°C is critical for coyotes from Fairbanks in Alaska (Shield, 1972).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Generally, it seems to be common in hilly country with poplar bluffs and stream banks with willows (Banfield, 1976). In some parts in northeastern America, coyotes tend to gather in frozen lakes, ericaceous bogs and/or beaver meadows to get foods during winter (Gompper, 2002).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species tends to inhabit disturbed and open habitats, such as burned and logged stands (Fisher and Wilkinson, 2005).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-N	In deep snow, this species can predate deer, particularly dead deer (Gese et al., 1996; Feldhamer et al., 2003; Patterson and Messier, 2003). In southwestern Yukon, coyotes prefer harder snow, which could fall under colder temperatures. However, snow also limits the movements of coyotes, lowering the probability to harvest snowshoe hares (Murray and Boutin, 1991). Frozen lakes are preferred by coyotes as places where they can

<table>
<tr><td></td><td></td><td colspan="4">acquire foods, like deer, easily during winter (Gompper, 2002). Therefore, disappearance of ice and/or snow are likely to be negative for coyotes.</td></tr>
<tr><td>C3
(Physical habitat)</td><td>Inc-SI-N-SD-Dec
Inc-SI-N-SD-Dec</td><td colspan="4">No preference for certain geological features. Furthermore, this species can migrate for more than 100km on average (Gompper, 2002), suggesting its great ability to be compatible with various geological conditions.</td></tr>
<tr><td>C4a
(Other spp for habitat)</td><td>GI-Inc-SI-N
GI-Inc-SI-N</td><td colspan="4">It seems to be common in hilly country with poplar bluffs and stream banks with willows, though it could also be distributed in alpine tundra, boreal forests, aspen parklands and steppes with short-grass (Banfield, 1976).</td></tr>
<tr><td>C4b
(Diet)</td><td>Inc-SI-N-SD
Inc-SI-N-SD Dec</td><td colspan="4">In northeastern America, this species generally feeds on white-tailed deer, snowshoe hares and also sometimes fruits (Gompper, 2002). Both live prey and carrion are available for this species, and it is regarded as an opportunistic and generalist feeder (Feldhamer et al., 2003). In contrast, this species is generally known as important disperser of some plant species (Cypher and Cypher, 1999). However, coyotes in Kejimkujik National park are more likely to predate deer and less likely to do so snowshoe hares than coyotes in elsewhere (Parks Canada, n.d.). In this park, because deer is moderately adaptable under moderate climate change scenario and moderately/highly adaptable under severe scenario, SD and SD/Dec were chosen here in the MVA.</td></tr>
<tr><td>C4c
(Pollination)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4">(N/A)</td></tr>
<tr><td>C4d
(Other spp for disp)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4">Although there has been no genetic studies on coyotes in Nova Scotia, coyote populations in this province are recently established since 1970s (Telefer, 2004). In line with this, according to a study analyzing mtDNA, there is a geographical decline in genetic diversity northeastwards in coyote populations around the Great Lakes including Ontario (Kays et al., 2009).</td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4"></td></tr>
<tr><td rowspan="3">The CCVI [%]
Moderate scenario
Severe scenario</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>100</td></tr>
</table>

The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	
Severe scenario			-------------------------------		
	This species tends to inhabit disturbed and open habitats, such as burned and logged stands (Fisher and Wilkinson, 2005). In northeastern America, this species generally feeds on white-tailed deer, snowshoe hares and also sometimes fruits (Gompper, 2002). Both live prey and carrion are available for this species, and it is regarded as an opportunistic and generalist feeder (Feldhamer et al., 2003). In contrast, this species is generally known as important disperser of some plant species (Cypher and Cypher, 1999). However, coyotes in Kejimkujik National park are more likely to predate deer and less likely to do so snowshoe hares than coyotes in elsewhere (Parks Canada, n.d.). In this park, because deer is moderately/highly adaptable under moderate climate change scenario and highly adaptable under severe scenario. Nevertheless, difficulty to predate deer may also increase due to less snow, canceling out the positive effect of deer increase. As well, there is no clear thermal effect of climate change on coyote in Kejimkujik National Park. Therefore, in the current assessment, this species was judged to be probably stable under severe climate change scenario.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of beaver (*Castor canadensis*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	This species inhabits relatively warm water, and natural barriers, like those among cold refugia for brook trout, are not likely to affect it. In contrast, it is also not clear if this species inhabits just large lakes and/or main rivers, which are given an example of "neutral" subscore by Young et al. (2011). Therefore, SI as well as N are chosen here.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	The artificial barriers outside the park should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-**Dec** GI-Inc-SI-N-**SD**-**Dec**	Although dispersal distance of this species could be greatly varied (Feldhamer et al., 2003), overland movements tend to be limited in comparison with overwater dispersals (McNew and Woolf, 2005). It is plausible that some beavers move for distances longer than 1 or 10 km according to recent studies (Sun et al., 2000; McNew and Woolf, 2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	This subspecies is distributed in New Brunswick, Nova Scotia, southern Quebec, and Adirondacks in New York and previously Maine and Vermont as well (Bailey and Doutt, 1942). Beavers in southern Quebec are distributed under mean annual temperature higher than -5.1°C (Jarema et al., 2009), whereas the mean temperature in Kejimkujik National Park is 6.4°C. At a species level, the optimal temperature zone of *C. canadensis* ranges between 0 and 28°C (MacArthur, 1989).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	Generally, beavers prefer slow-flowing streams, lakes, rivers, marshes, though they can sometimes inhabit bogs without open water (Banfield, 1976; Feldhamer et al., 2003). According to an empirical study, water drawdown has a slightly negative impact on behaviour of this species (Smith and Peterson, 1991). It is also noteworthy, however, that this species has an ability to create open water in either of wet or dry climates, possibly mitigating even impacts of climate change that leads losses of wetlands (Hood and Bayley, 2008).

C2c (Disturbance)	Inc-SI-**N**-**SD**-Dec Inc-**SI**-N-**SD**-Dec	Particularly willows and trembling aspens, which are early successional vegetation species, are the most common foods for beavers across the species’ range (Banfield, 1976; Feldhamer et al., 2003). Although fire could be beneficial for regeneration of woody plants that are utilized by beavers, it can reduce beaver lodge occupancy, being harmful to populations of beaver itself (Hood et al., 2007). The latter effect (i.e., the negative effect) may outweigh the former effect (i.e., the positive effect), when the climate is drier (Hood et al., 2007). Such fires might occur in inland regions like Kejimkujik National Park. However, because Kejimkujik National Park is still unlikely to be so much dried, the negative effect was regarded as smaller than or equal to the positive effect under the two climate change scenarios.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	In ice-free areas, beavers can move, mark and defend their territories as well as forage more freely throughout winter (Feldhamer et al., 2003).
C3 (Physical habitat)	Inc-SI-N-**SD-Dec** Inc-SI-N-**SD-Dec**	No preference for certain geological features. Beavers can affect geological processes such as meadow development, erosion and also water quality (Feldhamer et al., 2003).
C4a (Other spp for habitat)	GI-Inc-**SI**-N SD GI-Inc-**SI**-N	Payne (1984) reported that natural mortality of beaver in Newfoundland could be mainly attaributed to insufficient deciduous forests as well as too shallow ponds. As well, aspen (*Populus spp.*) could contribute to generating habitats of beaver (Parker, 2003). Suitable habitats of aspens (*Populus grandidentata* and *P. tremuloides*) will be moved to more north than Kejimkujik National Park under severe climate change scenario (c.f., Natural Resources Canada, 2014).
C4b (Diet)	Inc-**SI**-**N**-SD Inc-**SI**-**N**-SD	This species is a generalist herbivore that can feed on tree barks, leaves, twigs, buds and so on, but particularly willows and trembling aspens are the most common foods across the species’ range (Banfield, 1976; Feldhamer et al., 2003).
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	Some mammals (e.g., coyotes, bobcats, and fishers) could occassionally attack beavers, but the most important predator is wolve, which does not inhabit Kejimkujik National Park (Payne, 1984).
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	2	34	62	2
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	
Severe scenario		-------------------------------	-------------------------------		
	This subspecies is distributed in New Brunswick, Nova Scotia, southern Quebec, and Adirondacks in New York and previously Maine and Vermont as well (Bailey and Doutt, 1942). Beavers in southern Quebec are distributed under mean annual temperature higher than -5.1°C (Jarema et al., 2009), whereas the mean temperature in Kejimkujik National Park is 6.4°C. At a species level, the optimal temperature zone of *C. canadensis* ranges between 0 and 28°C (MacArthur, 1989). Particularly willows and trembling aspens, which are early successional vegetation species, are the most common foods for beavers across the species' range (Banfield, 1976; Feldhamer et al., 2003). Payne (1984) reported that natural mortality of beaver in Newfoundland could be mainly attaributed to insufficient deciduous forests as well as too shallow ponds. Thus, beaver population will be probably stable or somewhat flourish under climate change with deciduous forests including aspens. On the other hand, suitable habitats of aspens (*Populus grandidentata* and *P. tremuloides*) will be moved to more north than Kejimkujik National Park under severe climate change scenario (c.f., Natural Resources Canada, 2014). So, PS as well as MV were chosen for beaver under severe climate change scenario.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of porcupine (*Erethizon dorsatum*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scotian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	101 killed porcupines were found in the highway No. 101 in Nova Scotia over a 20-month study period (Fudge et al., 2007). This result implies negative influence of artificial barriers on this species. However, the artificial barriers outside the park should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-Dec GI-Inc-SI-N-**SD**-Dec	This species moves within the scales of 1.2-1.5 km (Woods, 1973), and particularly females are likely to move for relatively long distances (e.g., 3.7 km) (Sweitzer and Berger, 1998).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This subspecies' distribution covers the northeastern and north-central United States together with eastern Canada, including Yukon Territory and British Columbia, but not Labrador and Newfoundland (Banfield, 1976; Feldhamer et al., 2003). This species' great ability to regulate body temperatures allows it to live even at extremely low temperatures (-50°C in winter, -30°C in summer), though summer temperature lower than 7°C and winter one lower than -12 to -18°C could be negatively influential on its activities (Woods, 1973).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species is distributed in a wide range of ecosystems across North America (e.g., forest, grassland, desert and tundra) (Banfield, 1976; Feldhamer et al., 2003; Mudge, 2005), though it seems to prefer riparian zones in arid lands in Mexico (List et al., 1999).
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	This species is distributed in a wide range of ecosystems across North America (e.g., forest, grassland, desert and tundra) (Banfield, 1976; Feldhamer et al., 2003; Mudge, 2005). Although this species feeds on selectively mature trees but not immature ones in Nova Scotia (Mudge, 2005), there is no known preference about

		early/late successional forests.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	Snow hinders this species' travel, reducing the scale of home ranges in winter (Roze, 1984).
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	No preference for certain geological features. This species is distributed in a wide range of ecosystems across North America (e.g., forest, grassland, desert and tundra) (Banfield, 1976; Feldhamer et al., 2003; Mudge, 2005), suggesting its great ability to be compatible with various geological conditions.
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is distributed in a wide range of ecosystems across North America (e.g., forest, grassland, desert and tundra) (Banfield, 1976; Feldhamer et al., 2003; Mudge, 2005). However, during winter, this species inhabits softwood forests in Kejimkujik (Parks Canada, n.d.).
C4b (Diet)	Inc-SI-**N**-SD Inc-SI-**N**-SD	This species has been traditionally regarded as a generalist herbivore (Banfield, 1976; Feldhamer et al., 2003), but a recent study suggests that each subspecies and regional population could be a specialist herbivore (facultative specialist) (Coltrane, 2012). This species eats ground vegetation during summer and bark as well as foliage of softwoods and the bark of hardwoods during winter in Nova Scotia (Mudge, 2005).
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	0	0	50	50
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------		
Severe scenario			-------------------------------		

	There is no specific attribute showing significantly positive or negative impact of climate change on porcupine. Therefore, in the current assessment, this species was judged to be probably stable under warmer climates.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of southern flying squirrel (*Glaucomys volans*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scotian peninsula isolated from the mainland. Although there are multiple populations of this species other than Kejimkujik in Nova Scotia (Lavers, 2004), these populations in this province is isolated from the nearest population in Maine by around 400 km across the Bay of Fundy (Lavers et al., 2006). However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Deforestation of mature coniferous forests around the Kejimkujik National Park could be serious for this species. However, the artificial barriers outside the park should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-**Dec** GI-Inc-SI-N-**SD**-**Dec**	The distance between nests used by this species ranged between 18 and 921 m, and there was an interval of 355 m on average between primary nests and secondary nests (Lavers, 2004). Also, according to the records in nine relatively warm winters between 1994 and 2004, this species expanded its distribution at a rate of spread of 22 km/yr (Bowman et al., 2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** Dec GI-Inc-SI-N-**SD** Dec	The population in Kejimkujik is supposed be a relic from the Hypsi-thermal period (Lavers, 2004; Petersen and Stewart, 2006). Currently, this species is distributed in temperate forests, from the mountains of Central America, through the eastern United States to southern Ontario, Quebec, and Nova Scotia (Lavers, 2004). Especially in Nova Scotia, this species' distribution is surprisingly overlapping with that of red oak (Lavers, 2004; Lavers et al., 2006). So, even southern flying squirrels will respond to temperature changes following red oak's responses.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii	GI-Inc-**SI**-N-SD	There seems to be no influences of moisture on this species' distribution. However, especially in Nova Scotia,

(Physiological hydrological niche)	GI-Inc-**SI**-N-SD	this species' distribution is amazingly overlapping with that of red oak (Lavers, 2004; Lavers et al., 2006). So, even southern flying squirrel will respond to temperature following the red oak's response.
C2c (Disturbance)	**Inc**-**SI**-N-SD-Dec **Inc**-**SI**-N-SD-Dec	Old growth forests and mature forests (e.g., American beeches, eastern hemlocks, white pines, red oaks) are much preferred by this species for food, locomotion, protection from predators, and cavities (Lavers, 2004; Fisher and Wilkinson, 2005; Lavers et al., 2006; Parks Canada, 2011c). On the other hand, this species is rarely found in initial stages just after burns (Fisher and Wilkinson, 2005). However, in Nova Scotia, this species appears to be a little flexible in its habitat requirements, because it could inhabit even forests with selective harvesting and uneven-aged management (Lavers, 2004).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	No preference for certain geological features. Furthermore, abrupt changes of this species' distribution have been found at wide scale (> 200 km/winter) (Bowman et al., 2005), suggesting its great ability to be compatible with various geological conditions.
C4a (Other spp for habitat)	GI-Inc-**SI**-N SD Dec GI-Inc-**SI**-N SD Dec	Old growth forests and mature forests (e.g., American beeches, eastern hemlocks, white pines) are much preferred by this species for food, locomotion, protection from predators, and cavities (Lavers, 2004; Fisher and Wilkinson, 2005; Lavers et al., 2006). On the other hand, this species is rarely found in initial stages just after burns (Fisher and Wilkinson, 2005). Although, in Nova Scotia, this species appears to be a little flexible in its habitat requirements, this species' distribution is amazingly overlapping with that of red oak (Lavers, 2004; Lavers et al., 2006). According to the CCVI protocol, the subscore of SI was chosen here. However, red oak is judged as moderately or highly adaptable according to the MVA, and therefore SD as well as Dec were selected here in the MVA.
C4b (Diet)	Inc-**SI**-N-**SD** Inc-**SI**-N-**SD**	The mix of northern and southern elements that are characteristics of Acadian forests, including red oak and American beech, provides valuable foods for this species in Nova Scotia (Lavers, 2004). Expansion and contraction of this species' distribution are determined by not only winter temperature but also success/failure of mast crops in autumn (Bowman et al., 2005). As well, this species has eaten other foods, such as fungi and insects, somewhere (Lavers, 2004). Thus, this species is omnivore in a broad sense, but still it has dietary preference and high dependence on a few species.
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	If hardwood forests increase due to climate change and/or land-use, this species would greatly benefit such forests (Smith, 2007). Therefore, although hardwood forests are still available for a related species, *Glaucomys sabrinus*, probably populations of *G. sabrinus* would decline (Smith, 2007). Other studies have also proposed that the northern limit of *G. volans* is determined by interspecific competition with *G. sabrinus*, and sympatry with this species will cause competition as well as hybridization between the two species (Lavers, 2004;

		Garroway et al., 2010). Such sympatry will be more likely to occur in warming climates, and actually hybridization has been already confirmed in Ontario (Bowman et al., 2005; Garroway et al., 2010). Yet, it is also true that the both species have been coexisted well in Nova Scotia (Lavers, 2004).
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-**SI**-N Inc-**SI**-N	The populations in Nova Scotia are genetically diverging from those in Ontario likely due to loss of populations situated between the two places (Petersen and Stewart, 2006). The peripheral populations in Nova Scotia may have unique genetic variations (Petersen and Stewart, 2006).
C6 (Phenol response)	Inc-SI-N-**SD** Inc-SI-N-**SD**	Abrupt changes of this species' distribution limit have been found at wide scale (> 200 km/winter), suggesting its great ability to respond to warm/cold winter (Bowman et al., 2005).
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	If hardwood forests increase due to climate change and/or land-use, a competitive species, *G. volans*, would greatly benefit such forests (Smith, 2007). Therefore, although hardwood forests are still available for *G. sabrinus*, probably populations of *G. sabrinus* would decline (Smith, 2007). Such northward expansion of the distribution of *G. volans* have been already reported (e.g., the northern Great Lakes Region) (Smith, 2007; Myers et al., 2009). However, this projection is a general prediction, and little is known about modeled damage by climate change on this species in Kejimkujik/Nova Scotia.

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	0	0	87	13
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			------------------------------	--------------------------------	
Severe scenario				--------------------------------	--------------------------------
	The population in Kejimkujik is supposed be a relic from the Hypsi-thermal period (Lavers, 2004; Petersen and Stewart, 2006). Currently, this species is distributed in temperate forests, from the mountains of Central America, through the eastern United States to southern Ontario, Quebec, and Nova Scotia (Lavers, 2004). Old growth forests and mature forests (e.g., American beeches, eastern hemlocks, white pines, red oaks) are much preferred by this species for food, locomotion, protection from predators, and cavities (Lavers, 2004; Fisher and Wilkinson, 2005; Lavers et al., 2006; Parks Canada, 2011c). On the other hand, this species is rarely found in initial stages just after burns (Fisher and Wilkinson, 2005). However, in Nova Scotia, this species appears to be a little flexible in its habitat requirements, because it could inhabit even forests with selective harvesting and uneven-aged management (Lavers, 2004). More specifically, this species' distribution is surprisingly overlapping with that of red oak (Lavers, 2004; Lavers et al., 2006). So, even southern flying squirrels will respond to temperature changes following red oak's responses. Yet, immature oak forests may not be suitable for squirrel. Hence, although this species is definitely adaptable to climate change, the degree of the adptability may be less than that of red oak. Given that red oak was judged MA and HA in moderate and severe climate change scenarios respectively, squirrel was judged PS/MA and MA/HA here.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of southern American marten (*Martes americana*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scotian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral. Yet, there are no highlands (like Cape Breton Highlands) in the park. In this regard, boreal forests (the marten's habitat) has little adaptation opportunity. To show lack of such potential opportunities, Inc and SI were chosen in the MVA.
B2b (Artificial barriers)	GI-Inc-**SI**-N GI-Inc-**SI**-N	Deforestation of mature coniferous forests around the Kejimkujik National Park could be serious for this species. Parks Canada (2011c) called for keeping habitats both inside and outside of this park to sustain this species' population there.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-Dec GI-Inc-SI-N-**SD**-Dec	A parent–offspring distance σ of this species is 3.8-7.25 km (Broquet et al., 2006). Its maximum dispersal distance is 40 km (Carroll, 2007).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	This species' distribution traverses north-central North America (circumboreal forests), being in a more northern side than the distribution of fishers (Banfield, 1976; Feldhamer et al., 2003; Krohn, 2012). Therefore, high temperature might be a partial reason for this distribution, but there have no relevant studies to this issue.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	This species occurs in mesic, conifer-dominated forests (Banfield, 1976).
C2c (Disturbance)	**Inc**-SI-N-SD-Dec **Inc**-SI-N-SD-Dec	Preferring old-growth forests but not burned-over or logged areas, though martens occasionally use the latter as well (Banfield, 1976; Bowman and Robitaille, 1997; Fisher and Wilkinson, 2005; Parks Canada, 2011c). Forest fires could seriously damage marten populations (Banfield, 1976).
C2d	GI-Inc-SI-**N**	Requiring deep snowpacks (Carroll, 2007; Wasserman et al., 2012). Being able to move more freely in deep

(Ice/Snow)	GI-**Inc**-SI-N	snow than predators and/or competitors (Godbout and Ouellet, 2010; Krohn, 2012).
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	No preference for certain geological features.
C4a (Other spp for habitat)	GI-Inc-**SI**-N GI-**Inc**-**SI**-N	Preferring mature coniferous forests (Banfield, 1976; Godbout and Ouellet, 2010), particularly balsam firs and black spruces, in eastern Canada (Banfield, 1976). Because balsam fir as well as black spruce will be vulnerable to severe climate change scenario, not only “SI” but also “Inc” were chosen in this scenario.
C4b (Diet)	Inc-**SI**-N-**SD** Inc-**SI**-N-**SD**	This species is an opportunistic predator that feeds on rodents, lagomorphs, birds, and sometimes insects, fruits, as well as seeds (Feldhamer et al., 2003). However, in northern New Brunswick, 95% of total calories consumed by this species consisted of snowshoe hares, grouses, and squirrels in early winter (Cumberland et al., 2001).
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-**SI**-**N**	Its closely related species, fishers, can compete with and predate martens, possibly limiting the distribution of martens in the future with less snow (Krohn, 2012). Yet, it is also true that the both species have been already codistributed in Nova Scotia.
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	The population in Kejimkujik was artificially reintroduced (Parks Canada, 2011c; Krohn, 2012).
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-**SI**-N-SD-Dec GI-**Inc**-SI-N-SD-Dec	Small peripheral populations including the population in Nova Scotia will be unlikely to be sustained under climate change (Carroll, 2007). American martens will continue to retreat from its southern range (Krohn, 2012).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	86	14	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario					
Severe scenario					
	This species' distribution traverses north-central North America (circumboreal forests), being in a more northern side than the				

	distribution of fishers (Banfield, 1976; Feldhamer et al., 2003; Krohn, 2012). Therefore, high temperature might be a partial reason for this distribution, but also marten’s distribution might be restricted by just boreal forest distribution. There have been no relevant studies to this issue. Therefore, physiological thermal niche should be "unknown" in this assessment. Consequently, although marten is probably vulnerable to climate change, the MVA did not determine vulnerability/adaptability of the species.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was not determined due to a lack of information about physiological thermal niche.

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[Assessment sheet] Climate change vulnerability assessments of fisher (*Martes pennanti*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	There is the geographical barrier of the Nova Scotian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral. Yet, there are no highlands (like Cape Breton Highlands) in the park. In this regard, boreal forests (fisher’s habitat) has little adaptation opportunity. To show lack of such potential opportunities, SI and N were chosen in the MVA (Note that fisher could possibly inhabit other vegetation than boreal forests as well).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	The artificial barriers outside the park should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-Dec GI-Inc-SI-N-**SD**-Dec	This species can move up to 60 km from their initial range, and even an average natal dispersal distance is about 10 km (Arthur et al. 1993; Kyle et al., 2001). However, it is also reported that a few individuals have probably dispersed from a reintroduced population in Nova Scotia according to genetic investigation (Kyle et al., 2001). This result is consistent with the idea that this species has limited ability to recolonize from where fishers have once disappeared (Arthur et al., 1993).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species’ distribution traverses north-central North America, but being in a more southern side than the distribution of martens (Banfield, 1976; Feldhamer et al., 2003; Krohn, 2012). During cold winter when temperature is lower than -15°C, this species is likely to rest with large CWD (coarse woody debris) to keep warm (Weir et al., 2005).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species’ distribution traverses north-central North America (Banfield, 1976; Feldhamer et al., 2003; Krohn, 2012). Fishers prefer mesic, conifer-dominated forests and the vicinity of water courses (Banfield, 1976).

C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	This species inhabits climax coniferous forests (Banfield, 1976; Kyle et al., 2001; Fisher and Wilkinson, 2005), though it can also move into subclimax deciduous groves and old burns (Banfield, 1976).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD Dec	This species tends to avoid snowy areas (Kyle et al., 2001; Krohn, 2012).
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	No preference for certain geological features.
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	This species inhabits climax coniferous forests (Banfield, 1976; Kyle et al., 2001; Fisher and Wilkinson, 2005), though it can also move into subclimax deciduous groves and old burns (Banfield, 1976). In eastern Canada, balsam firs and black spruces are popular for this species (Banfield, 1976). Both of the two tree speices are judged as Highly Vulnerable under severe climate change scenario, however, and therefore subscores of Inc and SI were chosen in the MVA.
C4b (Diet)	Inc-SI-N-**SD** Inc-SI-N-**SD**	This species is an opportunistic predator that feeds on rodents, lagomorphs, birds, and sometimes insects, fruits, as well as seeds (Feldhamer et al., 2003). Its diets are more diverse than those of martens because of its larger body size (Feldhamer et al., 2003). For instance, even reptiles and fungi have been recorded as fisher's foods in its southernmost range (Zielinski et al., 1999).
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-**SI**-N-SD Inc-**SI**-N-SD	Its population in southern Nova Scotia exhibited a slightly smaller genetic variation than those in adjacent indigenous populations, probably due to history of an artificial reintroduction (Kyle et al., 2001).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	(N/A)
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-**SD**-Dec GI-Inc-SI-N-SD-**Dec**	Fishers will expand its distribution northwards due to warming climate, and also already expanding trends have been found in reintroduced populations in Connecticut, southern New York, Pennsylvania, and the highlands of West Virginia (Krohn, 2012).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	0	0	0	100

The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------		
Severe scenario				-------------------------------	
	This species' distribution traverses north-central North America (Banfield, 1976; Feldhamer et al., 2003; Krohn, 2012). Fishers prefer mesic, conifer-dominated forests and the vicinity of water courses (Banfield, 1976). This species inhabits climax coniferous forests (Banfield, 1976; Kyle et al., 2001; Fisher and Wilkinson, 2005), though it can also move into subclimax deciduous groves and old burns (Banfield, 1976). In contrast, this species tends to avoid snowy areas (Kyle et al., 2001; Krohn, 2012). Thus, only under severe climate change scenario, positive impact of climate change on this species could be expected. Climax coniferous forests may decline under climate change, in contrast, and this habitat change will be negative for fisher. Therefore, high adaptation of the same species is plausible even under severe scenario.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of white-tailed deer (*Odocoileus virginianus*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scotian peninsula isolated from the mainland. · This is Neutral not SI. [DC]
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species prefers foraging in disturbed and early successional forests (Russell et al., 2001). However, some road-kills of deer were found in New Brunswick (Whitlaw et al., 1998). · This is Neutral not SI due to increased food availability from roadsides etc. [Expert in Kejimkujik]
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	In northern ranges, whitetails showed migration distances ranging from 6 to 23 km (Feldhamer et al., 2003), whereas female whitetails migrated for 18-168 km in northeastern Minnesota (Nelson and Mech, 1992). Some of male whitetails monitored to the end of their second fall moved for distances of around 19 km on average, but female whitails moved very little (Patterson et al., 1999). Thus, there are a great variation in whitetail's migration distances (Brinkman et al., 2005), but overall this species could move for over 10km.
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD**	This species seems to be comfort in an ambient summer temperature ranging between 17 and 18°C (Holter et al., 1975), which is slightly larger than the summer average temperature in Kejimkujik (16.8°C). In contrast, the most optimal winter temperature for this species is between 5 and 20 °C (Holter et al., 1975), whereas the winter average temperature in this park is -4.0°C. Moreover, cold temperatures may increase the likelihood of depredation by coyotes (Feldhamer et al., 2003). Records in Nova Scotia showed that the individual number of this species increased after mild winter and decreased after severe winter (Patterson and Power, 2001). As well, south facing slopes are more common than north facing slopes for this species' habitats in Cape Breton and New Brunswick (Boer, 1978; Nova Scotia Department of Natural Resources, 2012). · I don't believe that deer will be as stressed by summer warmth to the point where it will outweigh the benefits from an increased winter temperature. [Expert in Kejimkujik]
C2bi	GI-Inc-SI-N-SD	

(Historical hydrological niche)	GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	No preference for certain hydrological features.
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	During winter, a combination of forest cover and browse is important for deer, and they choose mature mixedwoods (e.g., white spruces, and balsam firs) rather than submature mixedwoods in New Brunswick (Boer, 1978; Morrison et al., 2002). However, this species generally prefers foraging in disturbed and early successional forests (Russell et al., 2001), and artificial fire experiments confirmed the fact that fires could contribute to browsing by deer (Dills, 1970). In Kejimkujik, (excessively) mature and relatively intact forests have provided little browse for deer, which may be one of reasons for low deer density (Patterson et al., 2002). Hence, disturbances may be beneficial for deer in this park. · We don't have much "excessively" mature forest in KNP. Excessive should be removed. [Expert in Kejimkujik] · More disturbance will benefit deer. [Expert in Kejimkujik]
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD Dec	Deep snow may increase the probability of depredation by coyotes (Feldhamer et al., 2003; Patterson and Messier, 2003) and occassionally lynx (Fuller, 2004). Actually, whitetails tend to avoid snow depth larger than 35cm when migrating (Brinkman et al., 2005).
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	In highlands in Cape Breton and New Brunswick, white-tail deer are infrequent (Kelsall, 1969; Beazley et al., 2008). Particularly, a lack of deer in highlands during winter could be attributed to its body shape that is not adaptive to heavy snow (> 40 cm) (Kelsall, 1969). However, Kejimkujik is characterized with topographically flat area.
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species prefers foraging in disturbed and early successional forests (Russell et al., 2001). However, during winter, a combination of forest cover and browse is important for deer, and they choose mature mixedwoods (e.g., white spruces, and balsam firs) rather than submature mixedwoods in New Brunswick (Boer, 1978; Morrison et al., 2002). As well, softwoods were previously believed to be important for this species during particularly severe winters, but a study in southern New Brunswick suggested that mixedwood stands may be more suitable for deer during less severe winters (Sabine et al., 2001). In Kejimkujik, mature and relatively intact forests have provided little browse for deer, which may be one of reasons for low deer density (Patterson et al., 2002). Therefore, SI was chosen for the CCVI calculation. However, future disturbance intensified by climate change will allow other tree species to flourish, and in this sense climate change will contribute to growth and spread of deer in the park. · It may be a stretch to say deer depend on other species- no obligation to other species. [Expert in Kejimkujik]
C4b	Inc-**SI**-**N**-SD	Foods eaten by white-tailed deer are varied depending on habitats and latitudes, and therefore whitetails are

(Diet)	Inc-**SI**-**N**-SD	opportunistic, concentrate selectors (Feldhamer et al., 2003). Although acorns are important food for this species in oak forests in autumn, whitetails would be herbivorous generalists without such typical foods (Feldhamer et al., 2003). According to rumen analysis with deer in southern and central New Brunswick, they fed on herbs and woody browse in spring but fruits and mast in summer/autumn seasons (Skinner and Telfer, 1974). · More food does not make deer more vulnerable to climate change. [Expert in Kejimkujik] [Follow-up] It is true that more food does not make deer more vulnerable to climate change, and therefore only Neutral score was chosen in the MVA. However, the CCVI assessment tries to determine subscores based on resource specificity of assessed species. Here, to follow Young et al.'s protocol, the subscores of SI as well as N may need to be retained. Moreover, to reflect the possibility of increasing food under changing climates, SD should be chosen.
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	Deer are predated by mainly coyotes (Feldhamer et al., 2003; Patterson and Messier, 2003) and occassionally lynx (Fuller, 2004). In Kejimkujik, coyote colonization was followed by deer population decline (Gompper, 2002).
C5a (Genetic variation)	Inc-**SI**-N-SD Inc-**SI**-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	This species is not a native species in Kejimkujik, though having already naturalized there (Parks Canada, 2011c).
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	The number of deer in north Queens in Nova Scotia has increased due to climate warming since 1850 (Telfer, 2004). · Lots of burning was going on at the time, which increases vegetation and increases their food supply. Therefore, it may not be a direct relationship to climate change. [Expert in Kejimkujik]
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	0	100
Severe scenario	0	0	0	0	100

The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario				------------------------------	
Severe scenario				------------------------------	------------------------------
	This species seems to be comfort in an ambient summer temperature ranging between 17 and 18°C (Holter et al., 1975), which is slightly larger than the summer average temperature in Kejimkujik (16.8°C). In contrast, the most optimal winter temperature for this species is between 5 and 20 °C (Holter et al., 1975), whereas the winter average temperature in this park is -4.0°C. Moreover, cold temperatures may increase the likelihood of depredation by coyotes (Feldhamer et al., 2003). Records in Nova Scotia showed that the individual number of this species increased after mild winter and decreased after severe winter (Patterson and Power, 2001). As well, south facing slopes are more common than north facing slopes for this species' habitats in Cape Breton and New Brunswick (Boer, 1978; Nova Scotia Department of Natural Resources, 2012). This species generally prefers foraging in disturbed and early successional forests (Russell et al., 2001), and artificial fire experiments confirmed the fact that fires could contribute to browsing by deer (Dills, 1970). In Kejimkujik, (excessively) mature and relatively intact forests have provided little browse for deer, which may be one of reasons for low deer density (Patterson et al., 2002). Hence, disturbances may be beneficial for deer in this park to obtain more suitable habitats. Also, deep snow may increase the probability of depredation by coyotes (Feldhamer et al., 2003; Patterson and Messier, 2003) and occassionally lynx (Fuller, 2004). Actually, whitetails tend to avoid snow depth larger than 35cm when migrating (Brinkman et al., 2005). In short, despite the fact that this species might receive heat stress during summer season, warmer winter, stronger forest disturbances, and less snow will positively influence survivals of deer. As well, such an increase trend has already started. Therefore, this species will flourish under climate change at least moderately. As well, under severe climate change scenario, high adaptation could be also possible.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of black bear (*Ursus americanus*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scotian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral.
B2b (Artificial barriers)	GI-Inc-**SI**-N GI-Inc-**SI**-N	Bears are not affected by not busy roads, but they still refrain from crossing main roads where more than 10,000 vehicles run per day (Macmichael, 2007; Robinson et al., 2010). As well, Landry et al. (2001) indicated that wilderness areas around national parks in Atlantic Canada are crucial for maintaining bear populations due to this species' wide minimum critical area.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-**Dec** GI-Inc-SI-N-**SD**-**Dec**	According to a genetic study, a male bear killed in Texas is likely to have migrated across 300 km from New Mexico (Onorato et al., 2004). Such high mobility of males was confirmed by other studies as well (e.g. 15-68 km in Costello (2010)), but females are less mobile, settling within 0-7 km from their home ranges (Costello, 2010).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species is found in forested regions in 39 states of the United States, 11 Canadian provinces and territories, and some parts of Mexico (Feldhamer et al., 2003). Even in Nova Scotia, it is distributed everywhere at high densities (Nova Scotia Government, 2013), and therefore there seems no thermal preference in its habitats.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	No preference for certain hydrological features. Accordingly, in Nova Scotia, it is distributed everywhere at high densities except the southeastern Cape Breton (Macmichael, 2007; Nova Scotia Government, 2013).
C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-**SD**-Dec	This species' preference to early/late successional habitats could be altered depending on seasons and/or places. For instance, early-successional habitat created by logging or fire are preferred during summer, whereas mature forest is preferred during autumn and winter (USDA, n.d.). Also, black bears in post-fire places could consume

		more vegetation and/or moose calves, leading to better growth and reproduction (Schwartz and Frantzmann, 1991; USDA, n.d.).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-**N**	According to a study in west-central Idaho, due to insulative effect of snow cover and/or moist soils sustained by snow cover, American bear tends to select north-facing slopes to overwinter (in dens) (Beecham et al., 1983). However, Hayes and Pelton (1994) pointed out that slope aspect that bears chose was different among previous case studies, possibly depending on availability of dens. Therefore, the positive effect of snow cover for American bear is not clear.
C3 (Physical habitat)	Inc-SI-N-**SD**-**Dec** Inc-SI-N-**SD**-**Dec**	No preference for certain geological features. Furthermore, according to a genetic study, a male bear killed in Texas is likely to have migrated across 300 km from New Mexico (Onorato et al., 2004). Such high mobility of males was confirmed by other studies as well (e.g. 15-68 km in Costello (2010)), suggesting its great ability to be compatible with various geological conditions.
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	This species' preference to early/late successional habitats could be altered depending on seasons and/or places. For instance, early-successional habitats created by logging or fire are preferred during summer, whereas mature forests are selected during autumn and winter (USDA, n.d.). More specifically, fruits and seeds are the main resources (Beeman & Pelton, 1980). Availability of nuts, produced by oaks and beeches, during autumn season is crucial for black bear populations (Beeman & Pelton, 1980; Elowe & Dodge, 1989).
C4b (Diet)	Inc-**SI**-N-**SD** Inc-**SI**-N-**SD**	This species is an omnivorous and opportunistic predator of ungulate (Banfield, 1974; Zagar and Beecham, 2006). More specifically, fruits and seeds are main resources (Beeman and Pelton, 1980). Availability of nuts produced by oaks and beeches during autumn season is crucial for black bear populations (Beeman and Pelton, 1980; Elowe and Dodge, 1989). To show such specific dietary preference, not only SD but also SI were chosen for the CCVI calculation. However, under warming climates, most of these foods will flourish but not decline (c.f., assessment result of oak and beech). Thus, in the MVA, only SD was chosen.
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
The CCVI [%] Moderate scenario Severe scenario	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
	0	0	0	100	0
	0	1	32	67	0
The MVA** Moderate scenario Severe scenario	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
			-------------------------------	-------------------------------	
			-------------------------------	-------------------------------	
	There is no specific attribute showing significantly positive or negative impact of climate change on porcupine. However, this species' preference to early/late successional habitats could be altered depending on seasons and/or places. For instance, early-successional habitats created by logging or fire are preferred during summer, whereas mature forests are selected during autumn and winter (USDA, n.d.). More specifically, fruits and seeds are the main resources (Beeman and Pelton, 1980). Availability of nuts, produced by oaks and beeches, during autumn season is crucial for black bear populations (Beeman and Pelton, 1980; Elowe and Dodge, 1989). Given the fact that red oak and American beech will gain benefits from wamer climates in Nova Scotia, bear might also gain positive effects of climate change indirectly via these temperate edible tree species. However, there will be no directly positive effect of climate change on bear in terms of its thermal niche. High adaptation, like instant increase of deer after mild winter, has not been reported or considered with American bear. Therefore, both of PS and MA, but not HA, were given for bear under the both climate change scenarios.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of balsam fir (*Abies balsamea*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scocian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral. Yet, there are no highlands (like Cape Breton Highlands) in the park. In this regard, this species has little adaptation opportunity, even though it wants to migrate to cool sites. To show lack of such potential opportunities, Inc and SI were chosen in the MVA.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Maximum seed dispersal distance of this species is around 160 m, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-**Inc**-**SI**-N-SD GI-**Inc**-SI-N-SD	Balsam fir is the commonest tree in Nova Scotia (Roland, 1945). However, the annual mean temperature of the entire species' range, 2.9°C (range: -5.3 to 11.9°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 6.5°C. This species grows best under the average summer temperature of around 21°C or lower than this (Fowells, 1965), while the summer temperature in this park is 16.8°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently close to the warmer limit of the species' distribution, and it will be hotter than the limit of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	This species generally grows in moist conditions, and particularly seed germination and seedling growth are sensitive to dry summer weather (Fowells, 1965). However, Pardy (1997) reported that balsam firs could be observed in both drier and wetter sites in Cape Breton. In contrast, in Quebec, black spruce is likely to replace balsam fir in extreme conditions, such as dry and coarse deposits or humid organic deposits (Messaoud et al.,

		2007). Given that balsam fir is the commonest tree in Nova Scotia (Roland, 1945), a little drier conditions in the future will be somewhat negative or irrelevant to this species' vulnerability.
C2c (Disturbance)	**Inc**-SI-N-**SD**-Dec **Inc**-SI-N-**SD**-Dec	This species is shade tolerant but much susceptible to windfall and fire (Fowells, 1965; Achim et al., 2005; Scheller and Mladenoff, 2005). Yet, Telfer (2004) recorded remarkable regeneration of this species in forest gaps which were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. In Quebec, this species was confined to riversides or lakesides, which could buffer influences of fires (Messaoud et al., 2007). As well, spruce budworm outbreaks could reduce growth of this species and finally kill it at high mortality (e.g., 70-100% for mature fir forests) in Cape Breton during latter 1970s (Ostaff and MacLean, 1989), but this species is able to regenerate after such defoliation (MacLean, 1984; Pardy, 1997). · One of the reasons balsam fir is at risk for being less abundant is the warming temperature and insect epidemics. Given that budworm is more a boreal phenomenon, budworm outbreak would be less serious, but balsam fir adelgid would have more of an impact on balsam fir under climate change. [Expert in Cape Breton Highlands] · Fire intensity and frequency is expected to increase, which might increase vulnerability of balsam fir. One half of Cape Breton Highlands park has a larger fire history. [Expert in Cape Breton Highlands]
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	Generally, balsam fir grows on Podzol, Podzolic, Gray Wooded or gley, covering silt loams and stony loams (Fowells, 1965). This species is likely to be distributed at pH ranging between 4.0 and 6.0 (Fowells, 1965). Organic matters could lead dominance of black spruces rather than balsam firs (Messaoud et al., 2007).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is shade tolerant (Fowells, 1965; Achim et al., 2005; Scheller and Mladenoff, 2005).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated.
C4d (Other spp for disp)	Inc-**SI**-**N** Inc-**SI**-**N**	This is a wind-dispersed species, but rodents spread its seeds as well (Fowells, 1965).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	

C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD				
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	· To date, the only tree species that I have noticed to be ‘stressed – loss of vigour’ more-or-less province (Nova Scotia)-wide is balsam fir. [Additional expert]			
D2 (Modeled change)	GI-**Inc**-SI-N-SD-Dec **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	100	0	0
Severe scenario	0	50	50	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario	-------------------------------	-------------------------------			
Severe scenario	-------------------------------				
	Balsam fir is the commonest tree in Nova Scotia (Roland, 1945). However, the annual mean temperature of the entire species’ range, 2.9°C (range: -5.3 to 11.9°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 6.5°C. This species grows best under the average summer temperature of around 21°C or lower than this (Fowells, 1965), while the summer temperature in this park is 16.8°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently close to the warmer limit of the species' distribution, and it will be hotter than the limit of the distribution under moderate and severe climate change scenarios (c.f., Appendix). In Nova Scotia, a little drier conditions in the future will be somewhat negative or irrelevant to this species’ vulnerability. On the other hand, this species is shade tolerant but much susceptible to windfall and fire (Fowells, 1965; Achim et al., 2005; Scheller and Mladenoff, 2005). Yet, Telfer (2004) recorded remarkable regeneration of this species in forest gaps which were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. In Quebec, this species was confined to riversides or lakesides, which could buffer influences of fires (Messaoud et al., 2007a). As well, spruce budworm outbreaks could reduce growth of this species and finally kill it at high mortality (e.g., 70-100% for mature fir forests) in Cape Breton during latter 1970s (Ostaff and MacLean, 1989), but this species is able to regenerate after such defoliation (MacLean, 1984; Pardy, 1997). Hence, although slight hydrological changes and some disturbances may not be decisive factors for extirpation of balsam fir, temperature increase will be detrimental for the species in Kejimkujik National Park. Even under moderate climate change scenario, this species could be highly vulnerable, according to the comparison in GDD5.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of red maple (*Acer rubrum*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scotian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species can regenerate by sprouting after cutting and is often observed in post-harvest sites in New Brunswick (Franklin et al., 2000; Veinotte et al., 2003).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Sugar maple seeds can be dispersed for around 100 m but rarely beyond 5 km (He and Mladenoff, 1999; Clark et al., 2003). This species may have spread at the pace of 80-90 m/yr (McLachlan et al., 2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** Dec GI-Inc-SI-**N**-**SD** Dec	In Nova Scotia including Kejimkujik National Park, it is the most common hardwood (Roland, 1980; Saunders, 1996). However, the annual mean temperature of the entire species' range, 10.8°C (range: -0.3 to 23.9°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 6.5°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently close to cooler limit of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Although this species is often observed in extreme soil-moisture conditions, either very wet or very dry (Fowells, 1965), multiple studies suggested that it somewhat prefers swamps, riversides and moist soils (Fowells, 1965; Farrar, 1995). Saeki et al. (2011) documented that swamps and wet/mesic upland forests were primary habitats for this species before European settlement in North America but that even dry upland forests are also included in current (i.e., post- European settlement) habitats. In Nova Scotia including Kejimkujik National Park, it is the most common hardwood (Roland, 1980; Saunders, 1996).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species was regarded as being weak for fire damage (Fowells, 1965). Nevertheless, disturbances (e.g., fire, hurricanes) have contributed to an increasing number of red maple trees (Walter & Yawney, 1990; Saunders,

<table>
<tr><td></td><td></td><td colspan="4">1996), probably because red maple is an early-successional colonist with wind-dispersed samaras (McLachlan et al., 2005). In support of this, Telfer (2004) recorded regeneration of this species in forest gaps that were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954.</td></tr>
<tr><td>C2d
(Ice/Snow)</td><td>GI-Inc-SI-**N**
GI-Inc-SI-**N** SD</td><td colspan="4">This species is not resilient to damages of ice and snow (Fowells, 1965).</td></tr>
<tr><td>C3
(Physical habitat)</td><td>Inc-SI-N-**SD**-Dec
Inc-SI-N-**SD**-Dec</td><td colspan="4">Saeki et al. (2011) documented that swamps and wet/mesic upland forests were primary habitats for this species before European settlement in North America but that even dry upland forests are also included in current (i.e., post-settlement) habitats. In other words, such a habitat generalist trait has led to a wide spread distribution of this species (Saeki et al., 2011). In Nova Scotia including Kejimkujik National Park, it is the most common hardwood (Roland, 1980; Saunders, 1996), likely because this species can grow on a wide range of soil formations (Fowells, 1965).</td></tr>
<tr><td>C4a
(Other spp for habitat)</td><td>GI-Inc-SI-**N**
GI-Inc-SI-**N**</td><td colspan="4">This species can tolerate moderately to shade environments (Farrar, 1995) and can grow in combination with more than 70 commercial tree species (Fowells, 1965).</td></tr>
<tr><td>C4b
(Diet)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4">(N/A)</td></tr>
<tr><td>C4c
(Pollination)</td><td>Inc-**SI**-**N**
Inc-**SI**-**N**</td><td colspan="4">This species was supposed to be just wind-pollinated, but insects could help its pollination (USDA, 2011).</td></tr>
<tr><td>C4d
(Other spp for disp)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="4">Wind-dispersed species (Fowells, 1965).</td></tr>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="4"></td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4">A habitat generalist trait of this species has led to a wide spread distribution in the past, being reflected in high diversity of chloroplast haplotypes throughout this species’ range (Saeki et al., 2011). However, there is insufficient information about genetic variations within maple populations in Nova Scotia yet.</td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-N-**SD**-Dec
GI-Inc-SI-**N**-SD-Dec</td><td colspan="4">These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).</td></tr>
<tr><td rowspan="2">The CCVI [%]
Moderate scenario</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>88</td><td>12</td></tr>
</table>

Severe scenario	0	0	0	26	75
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario				-------------------------------	
Severe scenario					-------------------------------
	In Nova Scotia including Kejimkujik National Park, it is the most common hardwood (Roland, 1980; Saunders, 1996). However, the annual mean temperature of the entire species' range, 10.8°C (range: -0.3 to 23.9°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 6.5°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently close to cooler limit of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). This species was regarded as being weak for fire damage (Fowells, 1965). Nevertheless, disturbances (e.g., fire, hurricanes) have contributed to an increasing number of red maple trees (Walter & Yawney, 1990; Saunders, 1996), probably because red maple is an early-successional colonist with wind-dispersed samaras (McLachlan et al., 2005). In support of this, Telfer (2004) recorded regeneration of this species in forest gaps that were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. Meanwhile, this species is not resilient to damages of ice and snow (Fowells, 1965). Therefore, it will flourish under climate change due to temperature increase, disturbances, and less snow accumulation. So, it was judged to be moderately adaptable and highly adaptable under moderate and severe climate change scenarios respectively. Yet, the thermal niche is relatively wide, and incremental temperature increase may have limited effect on the adaptation. This is why the class of HA was not given under moderate climate change scenario.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of sugar maple (*Acer saccharum*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scotian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral. Yet, there are no highlands (like Cape Breton Highlands) in the park. In this regard, this species has little adaptation opportunity, even though it wants to migrate to cool sites under severe climate change scenario. To show lack of such potential opportunities, Inc and SI were chosen in the MVA.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Sugar maple seeds can be dispersed for around or more than 100 m (Johnson, 1988; He and Mladenoff, 1999). Maximum seed dispersal distance of this species is around 200 m, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-**SI**-N-SD	This species is commonly found with beeches on better soils in Kejimkujik National Park (Roland, 1980). However, the annual mean temperature of the entire species' range, 7.5°C (range: -0.4 to 19.5°C) (Natural Resources Canada, 2014), is higher than the mean temperature of the park, 6.5°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the cooler side of the species' distribution, but it will be in the middle of the distribution under moderate climate change scenario (c.f., Appendix). Furthermore, it will be in the warmer side of the distribution under severe scenario. According to a forecast in New Brunswick and central Nova Scotia, it is plausible that this species will experience heat stress after 2025, due to warming, lower snow depth and expansion of pathogens (Phillips, 2009).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	Preferring moist and well-drained soils (Fowells, 1965; Farrar, 1995). River floodplains and stream banks are primary habitats for this species (Saeki et al., 2011). In drier areas in Nova Scotia and New Brunswick, this species may be more susceptible to droughts as well (Phillips, 2009).

C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	This species was previously regarded as just a late-successional species, and the number of its seedlings has decreased after some burnings (Swan, 1970). Some shade is needed for this species, and its seedlings may dry out without any shade (Betts and Forbes, 2005). However, the latest studies observed that it is able to regenerate competitively after disturbances like hurricanes, forest fires and clear-cuttings, indicating this species as a trans-successional species (Nolet et al., 2008; Vargas-Rodriguez and Platt, 2012). MTRI and Parks Canada (2014) proposed that significant increase of deer could reduce sugar maple in Kejimkujik National Park by browsing.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-**Inc**-**SI**-N	Snow could significantly assist this species to avoid fires and also enjoy moist conditions (Henne et al., 2007). Snow removal could be harmful to sugar maple, urging replacement of this species by other tree species (Comerford et al., 2013). Also, Phillips (2009) proposed that less snow around the Bay of Fundy would lead to more frequent thaw/freeze damage to this species.
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	This species can thrive on all soil types in either of acid or alkaline, as far as these soils are rich, moist and well drained (Fowells, 1965). River floodplains and stream banks are primary habitats for this species (Saeki et al., 2011).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is exceeding in shade-tolerance among hardwoods (except American beech) (Godman et al., 1990; Nolet et al., 2008).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	(N/A)
C4c (Pollination)	Inc-**SI**-**N** Inc-**SI**-**N**	This species was supposed to be bee-pollinated, but recently this species is likely to pollinate without the helps of insects (Godman et al., 1990).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Wind-dispersed species (Fowells, 1965). Although its postdispersed seeds are predated by small mammals like eastern chipmunks, seed dispersal by these animals has not been confirmed (Hsia and Francl, 2009).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-**SI**-N-SD Inc-**SI**-N-SD	A population in Kejimkujik showed a smaller (but not significantly) allelic diversity than those in other populations, and also the population in Kejimkujik was genetically separated from others in canonycal analysis (Young et al., 1993). Saeki et al. (2011) stated that limited diversity of this species' chloroplast haplotypes throughout the species' range could be attributed to its restricted geographic range during the Last Glacial Maximum without vast coastal plains (i.e., a strong bottleneck effect).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	(N/A)
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2	GI-Inc-**SI**-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural

(Modeled change)	GI-Inc-**SI**-N-SD-Dec	Resources Canada, 2014).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	27	73	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	
Severe scenario		-------------------------------	-------------------------------		
	This species is commonly found with beeches on better soils in Kejimkujik National Park (Roland, 1980). However, the annual mean temperature of the entire species' range, 7.5°C (range: -0.4 to 19.5°C) (Natural Resources Canada, 2014), is higher than the mean temperature of the park, 6.5°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the cooler side of the species' distribution, but it will be in the middle of the distribution under moderate climate change scenario (c.f., Appendix). Furthermore, it will be in the warmer side of the distribution under severe scenario. According to a forecast in New Brunswick and central Nova Scotia, it is plausible that this species will experience heat stress after 2025, due to warming, lower snow depth and expansion of pathogens (Phillips, 2009). In line with this, snow could significantly assist this species to avoid fires and also enjoy moist conditions (Henne et al., 2007). Snow removal could be harmful to sugar maple, urging replacement of this species by other tree species (Comerford et al., 2013). River floodplains and stream banks are primary habitats for this species (Saeki et al., 2011). In drier areas in Nova Scotia and New Brunswick, this species may be more susceptible to droughts as well (Phillips, 2009). Therefore, although a little temperature increase may be beneficial or not be relevant to this species' survival, remarkable warming will create less moist conditions, less snow cover, and more frequent forest fires, possibly damaging this species in this park. In this regard, under only severe climate change scenario, this species was considered between moderately vulnerable and presumably stable.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of yellow birch (*Betula alleghaniensis*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scocian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral. Yet, there are no highlands (like Cape Breton Highlands) in the park. In this regard, this species has little adaptation opportunity, even though it wants to migrate to cool sites. To show lack of such potential opportunities, Inc and SI were chosen in the MVA.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Maximum seed dispersal distance of this species is around 400 m, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-N-SD	The annual mean temperature of the entire species' range, 5.0°C (range: -0.7 to 17.9°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 6.5°C. In Nova Scotia, yellow birch grows well on northern or eastern slopes, where temperature is cooler (Fowells, 1965; Saunders, 1996). In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the cooler side of the species' distribution, but it will be in the warmer side of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species is distributed on moist soils (Farrar, 1995). In less moist sites, yellow birch is likely to be replaced by other tolerant species gradually (Fowells, 1965). Also, droughts can be critical for germination and seedling development of this species (Jackson and Booth, 2002).
C2c	**Inc**-SI-N-**SD**-Dec	This species could occur at any point of forest successions, but it is regarded as a climax species (Fowells,

<table>
<tr><td>(Disturbance)</td><td>Inc-SI-N-SD-Dec</td><td colspan="4">1965). However, disturbances to some degrees (including fire and windthrow) in forest floor are beneficial for germination of this species (Fowells, 1965; Betts and Forbes, 2005). Windthrow is important to maintain this species’ occurrence (Schulte and Mladenoff, 2005). Small forest gaps are also helpful for development of this species’ seedlings (Fowells, 1965). In contrast, because its thin bark can be easily burned, this species may be injured in forest fire (Fowells, 1965). Rootlet mortality could be drastically increased by higher soil temperature in summer (Fowells, 1965). MTRI and Parks Canada (2014) proposed that significant increase of deer could reduce yellow birch in Kejimkujik National Park by browsing.</td></tr>
<tr><td>C2d
(Ice/Snow)</td><td>GI-Inc-SI-N
GI-Inc-SI-N</td><td colspan="4">Secondary seed dispersal of this species on snow allows it to move for hundreds of feet from mother trees (Fowells, 1965: Saunders, 1996). As well, early spring thaw-freeze events have led to dieback of yellow birches in the Maritime Regions during 1930s-1950s, and little snow cover pronounces the negative effects of such events (Bourque et al., 2005). Climate change, especially temperature variability, will prolong length of such thaw events (Zhu et al., 2002).</td></tr>
<tr><td>C3
(Physical habitat)</td><td>Inc-SI-N-SD-Dec
Inc-SI-N-SD-Dec</td><td colspan="4">This species occurs on podzolic soils, and its best habitat is moderately well-drained sandy loams (Fowells, 1965). Hinds (2000) described that this species often inhabits acid soils in New Brunswick.</td></tr>
<tr><td>C4a
(Other spp for habitat)</td><td>GI-Inc-SI-N
GI-Inc-SI-N</td><td colspan="4">This species could occur at any point of forest successions, but it is regarded as a climax species (Fowells, 1965). It is tolerant of most other birch species but not much competitive with other tree species (Fowells, 1965).</td></tr>
<tr><td>C4b
(Diet)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>C4c
(Pollination)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4">Wind-pollinated (Fowells, 1965).</td></tr>
<tr><td>C4d
(Other spp for disp)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4">These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).</td></tr>
<tr><td>The CCVI [%]</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
</table>

Moderate scenario	0	0	0	100	0
Severe scenario	0	74	26	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario		-------------------------------	-------------------------------		
Severe scenario		-------------------------------			
	The annual mean temperature of the entire species' range, 5.0°C (range: -0.7 to 17.9°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 6.5°C. In Nova Scotia, yellow birch grows well on northern or eastern slopes, where temperature is cooler (Fowells, 1965; Saunders, 1996). In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the cooler side of the species' distribution, but it will be in the warmer side of the distribution under moderate and severe climate change scenarios (c.f., Appendix). This species is distributed on moist soils (Farrar, 1995). In less moist sites, yellow birch is likely to be replaced by other tolerant species gradually (Fowells, 1965). Also, droughts can be critical for germination and seedling development of this species (Jackson and Booth, 2002). Furthermore, this species could occur at any point of forest successions, but it is regarded as a climax species (Fowells, 1965). However, disturbances to some degrees (including fire and windthrow) in forest floor are beneficial for germination of this species (Fowells, 1965; Betts and Forbes, 2005). Windthrow is important to maintain this species' occurrence (Schulte and Mladenoff, 2005). Small forest gaps are also helpful for development of this species' seedlings (Fowells, 1965). In contrast, because its thin bark can be easily burned, this species may be injured in forest fire (Fowells, 1965). Rootlet mortality could be drastically increased by higher soil temperature in summer (Fowells, 1965). Secondary seed dispersal of this species on snow allows it to move for hundreds of feet from mother trees (Fowells, 1965: Saunders, 1996). As well, early spring thaw-freeze events have led to dieback of yellow birches in the Maritime Regions during 1930s-1950s, and little snow cover pronounces the negative effects of such events (Bourque et al., 2005). Climate change, especially temperature variability, will prolong length of such thaw events (Zhu et al., 2002). Hence, although temperature increase will not be critical for this species, possibly hotter summer may be harmful on yellow birch (moderately vulnerable). Under severe climate change scenario, less snow accumulation also afftects this species negatively, and hence it was judged moderately vulnerable.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of white birch (*Betula papyrifera*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scocian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral. Yet, there are no highlands (like Cape Breton Highlands) in the park. In this regard, this species has little adaptation opportunity, even though it wants to migrate to cool sites. To show lack of such potential opportunities, Inc and SI were chosen in the MVA.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species can regenerate by sprouting after cutting and often observed in post-harvest sites in New Brunswick (Fowells, 1965; Franklin et al., 2000).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-**SD**-Dec GI-Inc-SI-**N**-**SD**-Dec	This species disperses seeds for considerable distances thanks to its light seed weight, but most seeds may fall in just neighborhoods of their mother trees (Fowells, 1965). A maximum seed dispersal distance of this species is around 5 km, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-**Inc**-**SI**-N-SD GI-**Inc**-SI-N-SD	This species is distributed in Alaska and most of Canada, reaching northward nearly to the tree growth limit (Fowells, 1965). It is unlikely that white birch grows at an average July temperature higher than 21°C (Fowells, 1965). The annual mean temperature of the entire species' range, 3.9°C (range: -4.8 to 12.5°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 6.5°C. This species showed declined growth and diebacks likely due to its sensitivity to temperature and moisture in warmer and less moist years than normal ones in northern Michigan (Jones, 1993). In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently close to the warmer limit of the species' distribution, and it will be hotter than the limit of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii	GI-Inc-**SI**-N-**SD**	This species could be distributed on soils in a wide range of moisture conditions, though it tends to be more

(Physiological hydrological niche)	GI-Inc-**SI**-N-**SD**	common in somewhat drier sites (Fowells, 1965). Wang et al. (1998) reported that this species is tolerant of drought. Because white birch is physiologically tolerant of extreme site conditions, it is distributed in upper ridges of the plateau in Cape Breton as well (Bourque et al., 2000). Pardy (1997) reported that balsam fir often coexists with white birch on drier sites in this island. In contrast, this species showed declined growth and diebacks likely due to its sensitivity to temperature and moisture in warmer and less moist years than normal ones in northern Michigan (Jones, 1993).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species is not shade-tolerant, being often found in forest edges, lakeshores, and roadsides (Farrar, 1995; Scheller and Mladenoff, 2005). This species can regenerate by sprouting after fire and cutting (Fowells, 1965; Franklin et al., 2000). Fire could contribute to establishments of this species' stands, but moderate fires could be also harmful for already established stands by burning trees (Fowells, 1965; Couillard et al., 2012). Wang et al. (1998) reported that this species is tolerant of drought. On the other hand, rootlet mortality and birch dieback-like symptom are expected with increased soil temperatures (Fowells, 1965).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-**Inc**-**SI**-N	White birch decline in northeastern North America may be ascribed to early spring thaw-freeze events, which were reported with yellow birches, due to thier shallow roots (Mohan et al., 2009; Auclair et al., 2010). Little snow cover pronounces the negative effects of such events (Bourque et al., 2005). Climate change, especially temperature variability, will prolong length of such thaw events (Zhu et al., 2002).
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	This species grows on podzol soils, but sometimes it could grow on brown podzolic soils as well (Fowells, 1965). Shallow and stony soils, bog together with peat soils are available for white birch (Fowells, 1965). In Cape Breton, it was documented that birch is generally intolerant of nutrient stress (Smith, 1998). However, because white birch is physiologically tolerant of extreme site conditions, it is distributed widely, covering even in upper ridges of the plateau in Cape Breton (Bourque et al., 2000; Gullison, 2002).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is more intolerant than most other tree species in the northeastern United States, except aspens, pin cherries and gray birches (Fowells, 1965).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated.
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Wind-dispersed species (Fowells, 1965).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6	Inc-SI-N-SD	

(Phenol response)	Inc-SI-N-SD				
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-**Inc**-SI-N-SD-Dec **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	100	0	0
Severe scenario	0	0	100	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario	-------------------------------	-------------------------------			
Severe scenario	-------------------------------				
	This species is distributed in Alaska and most of Canada, reaching northward nearly to the tree growth limit (Fowells, 1965). It is unlikely that white birch grows at an average July temperature higher than 21°C (Fowells, 1965). The annual mean temperature of the entire species' range, 3.9°C (range: -4.8 to 12.5°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 6.5°C. This species showed declined growth and diebacks likely due to its sensitivity to temperature and moisture in warmer and less moist years than normal ones in northern Michigan (Jones, 1993). In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently close to the warmer limit of the species' distribution, and it will be hotter than the limit of the distribution under moderate and severe climate change scenarios (c.f., Appendix). Meanwhile, this species could be distributed on soils in a wide range of moisture conditions, though it tends to be more common in somewhat drier sites (Fowells, 1965). Wang et al. (1998) reported that this species is tolerant of drought. Because white birch is physiologically tolerant of extreme site conditions, it is distributed in upper ridges of the plateau in Cape Breton as well (Bourque et al., 2000). Pardy (1997) reported that balsam fir often coexists with white birch on drier sites in this island. In contrast, this species showed declined growth and diebacks likely due to its sensitivity to temperature and moisture in warmer and less moist years than normal ones in northern Michigan (Jones, 1993). This species is not shade-tolerant, being often found in forest edges, lakeshores, and roadsides (Farrar, 1995; Scheller and Mladenoff, 2005). This species can regenerate by sprouting after fire and cutting (Fowells, 1965; Franklin et al., 2000). Fire could contribute to establishments of this species' stands, but moderate fires could be also harmful for already established stands by burning trees (Fowells, 1965; Couillard et al., 2012). Wang et al. (1998) reported that this species is tolerant of drought. On the other hand, rootlet mortality and birch dieback-like symptom are expected with increased soil temperatures (Fowells, 1965). Therefore, although a little drier climates and light disturbances may not be negative for white birch, temperature increase makes it highly vulnerable to both of moderate and severe climate change scenarios. Under moderate climate change scenario, positive effects of a little drier climates and light disturbances could partly conteract the negative influence of temperature increase, and in this sense both the classes of Highly Vulnerable and Moderately Vulnerable (HV/MV) were given.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of American beech (*Fagus grandifolia/Fagus americana*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scotian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-Dec GI-Inc-SI-N-**SD**-Dec	A past migration speed of this species was estimated as roughly 80-90 m/yr (sustained 4km per reproduction), probably by long-distance dispersal (Cogbill, 2004; McLachlan et al., 2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** Dec GI-Inc-SI-**N**-**SD**	In North America, *F. grandifolia* is distributed in and around the temperate zone (Fang and Lechowicz, 2006). The annual mean temperature of the entire species' range, 9.8°C (range: 0.7 - 21.0°C) (Natural Resources Canada, 2014), is higher than the mean temperature of this park, 6.4°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the cooler side of the species' distribution, and it will be in the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). Sufficient growing season warmth was crucial for this species' northwards migration, and a lack of growing season warmth has prevented its migration to the Atlantic Islands (Fang and Lechowicz, 2006).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	Moist soils with low base saturation allow beeches to occupy and dominate in late-successionlal forests (Kitamura and Kawano, 2001; Canham, 2004). This species tends to prefer moist conditions more strongly at its northern limit than its southern limit (Fang and Lechowicz, 2006).
C2c (Disturbance)	**Inc**-SI-N-SD-Dec **Inc**-SI-N-SD-Dec	This species is very vulnerable to fire injury due to its thin bark and large surface roots (Fowells, 1965). In line with this, its abundance was lowered after wildfire, being replaced by species like sugar maple, red maple,

		hemlock, and red spruce (Telfer, 2004). Also, in forest gaps, sugar maple is more likely to grow well than beech (Beaudet et al., 2007).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-N	Snow could somewhat assist this species to avoid fires and also enjoy moist conditions (Henne et al., 2007).
C3 (Physical habitat)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	This species is usually observed in the Gray-Brown Podzolic and the Laterite, but not limestone walleys, and timber forests including many beech trees are found in acidic conditions of pH ranging between 4.1 and 6.0 (Fowells, 1965).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is very tolerant and competitive (Fowells, 1965; Kitamura and Kawano, 2001; Canham, 2004).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	(N/A)
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Koch et al., 2010).
C4d (Other spp for disp)	Inc-**SI**-N Inc-**SI**-N	This species' seeds are secondary dispersed by pigeons, blue jays and rodents (Kitamura and Kawano, 2001; Cogbill, 2004).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-**N**-SD Inc-SI-**N**-SD	By isozyme analysis, Houston and Houston (2000) observed comparable genetic variations in two beech populations in southwestern Nova Scotia with those of other populations in other areas.
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	(N/A)
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-**SD**-Dec GI-Inc-SI-N-**SD**-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	0	100	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario				-------------------------------	
Severe scenario			-------------------------------	-------------------------------	
	In North America, *F. grandifolia* is distributed in and around the temperate zone (Fang and Lechowicz, 2006). The annual mean temperature of the entire species' range, 9.8°C (range: 0.7 - 21.0°C) (Natural Resources Canada, 2014), is higher than the mean				

	temperature of this park, 6.4°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the cooler side of the species' distribution, and it will be in the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). Sufficient growing season warmth was crucial for this species' northwards migration, and a lack of growing season warmth has prevented its migration to the Atlantic Islands (Fang and Lechowicz, 2006). This species tends to prefer moist conditions more strongly at its northern limit than its southern limit (Fang and Lechowicz, 2006). This species is very vulnerable to fire injury due to its thin bark and large surface roots (Fowells, 1965). In line with this, its abundance was lowered after wildfire, being replaced by species like sugar maple, red maple, hemlock, and red spruce (Telfer, 2004). Also, in forest gaps, sugar maple is more likely to grow well than the beech (Beaudet et al., 2007). Snow could somewhat assist this species to avoid fires and also enjoy moist conditions (Henne et al., 2007). Thus, this species will benefit from moderate temperature increase, while negative effects of more intensified disturbances as well as less snow accumulation could cancel the positive effect of temperature increase under severe climate change scenario. Furthermore, warming above the temperature of 10°C will be no longer beneficial for this species in terms of average annual temerature. Thus, under severe scenario, beech population might not be able to grow better than that under moderate scenario, and we gave it MA and PS. [Note] Gomer (1999) concluded that American beech would decline under climate change due to low tolerance to disturbances and limited dispersal ability (i.e., seeds are too large for the species' migration under climate change). However, our assessments are focusing on species' vulnerability/adaptability inside Kejimkujik National Park, and hence such dispersal ability is irrelevant to our judgment. Rather, physiological thermal niche would be relevant to species' survival in the park. This is why our result is contrasting to that of Gomer (1999).

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of Eastern larch/American larch/Tamarack (*Larix laricina*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scocian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral. Yet, there are no highlands (like Cape Breton Highlands) in the park. In this regard, this species has little adaptation opportunity, even though it wants to migrate to cool sites. To show lack of such potential opportunities, Inc and SI were chosen in the MVA.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Artificial disturbances, such as logging and farming, in the last 200 years have favoured such a pioneer species, allowing it to expand its distribution to neighboring uplands in southern New Brunswick (Ying and Morgenstern, 1991).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-**SI**-N-SD-Dec GI-Inc-**SI**-N-SD-Dec	Only 2% of larch seeds were disseminnated for 60 m or more in an observation in Minnesota (Duncan, 1954). The numbers of filled seeds dispersed for 9 m and 18 m were around 11% and 6% of that dispersed just under mother trees respectively in Alaska, indicating limited seed dispersal ability of this species in comparison with other coniferous species (Fowells, 1965; Brown et al., 1988).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-N-SD GI-**Inc**-SI-N-SD	This species is distributed from Alaska south to Maryland and West Virginia, suggesting the widest distribution of American coniferous tree species (Fowells, 1965; Park and Fowler, 1982). However, according to a study in Ontario, this species is likely to be highly differentiated in terms of cold hardiness, specializing to each microclimate (Joyce, 1988). The annual mean temperature of the entire species' range, 2.3°C (range: -7.3 to 10.3°C) (Natural Resources Canada, 2014), is much lower than the mean temperature of the park, 6.5°C. This species dominates wet acid peat softwoods in cool/cold areas in the Acadian Forest Region (Loo and Ives, 2003). The highest temperature in this species' distribution is between 29 and 43°C (Fowells, 1965). In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the warmer side of the species' distribution, and it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be hotter than the warmer limit of the distribution.

C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species is associated with bogs and swamps especially in the southern part of the species' distribution, while it could be distributed in a wide range of sites in more northern parts (Fowells, 1965; Park and Fowler, 1982). Bogs are suitable habitats for larch in New Brunswick (Burzynski et al., 1986; Hinds, 2000). High watertables in floodplain wetlands also could contribute to protecting this species from fire-related damages (Brown et al., 1988). However, prolonged water periods, like flood, may decrease germination rate of this species (Duncan, 1954; Fowells, 1965).
C2c (Disturbance)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	Generally, eastern larch is a pioneer and intolerant species, beginning forest successions in bog lands (Fowells, 1965; Duncan, 1954). This species dominates wet acid peatsoftwoods in the Acadian Forest Region, and there are stand-replacing fires and small patch blowdowns (Loo and Ives, 2003). However, strong fires and winds could be negative for this species because of its shallow roots (Fowells, 1965). Larch sawfly and larch beetle have also influenced the forests by defoliation and/or damaging seeds (Fowells, 1965; Loo and Ives, 2003). As well, larch seeds are often damaged by chalcids, which are likely to be killed by low temperature (e.g., mortality rate is 100% in -20°C for 12 weeks) according to a study in Ontario (Prevost, 2002). In contrast, disturbances by browsing mammals are not influential on this species (Duncan, 1954).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Snowfall amount greatly varies within this species' distribution between 76 and 406 cm (Fowells, 1965).
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species dominates wet acid peat softwoods with poor organic soils in the Acadian Forest Region (Fowells, 1965; Hinds, 2000; Loo and Ives, 2003). Duncan (1954) suggested that this species could grow in uplands even in the southern side of this species' distribution, given favourable moisture conditions without harsh interspecific competition. The same author also proposed that pH (at least in the range between 4.5 and 7.5) has little influences on germination of this species.
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species dominates wet acid peat softwoods with black spruce in the Acadian Forest Region (Fowells, 1965; Loo and Ives, 2003). Eastern larch is a very fast growing species, though the growth is negatively correlated with latitude of seedlings' origins (Park and Fowler, 1982)
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Ying and Morgenstern, 1990).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a	Inc-SI-N-SD	

<table>
<tr><td>(Genetic variation)</td><td>Inc-SI-N-SD</td><td colspan="5"></td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="5"></td></tr>
<tr><td>D2
(Modeled change)</td><td>**GI**-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="5">These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).</td></tr>
<tr><td rowspan="3">The CCVI [%]
Moderate scenario
Severe scenario</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td colspan="2">Increase Likely</td></tr>
<tr><td>0</td><td>0</td><td>100</td><td>0</td><td colspan="2">0</td></tr>
<tr><td>0</td><td>0</td><td>100</td><td>0</td><td colspan="2">0</td></tr>
<tr><td rowspan="4">The MVA**
Moderate scenario
Severe scenario</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td colspan="2">Highly Adaptable</td></tr>
<tr><td></td><td>-------------------------------</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>-------------------------------</td><td></td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="6">This species is distributed from Alaska south to Maryland and West Virginia, suggesting the widest distribution of American coniferous tree species (Fowells, 1965; Park and Fowler, 1982). However, according to a study in Ontario, this species is likely to be highly differentiated in terms of cold hardiness, specializing to each microclimate (Joyce, 1988). The annual mean temperature of the entire species’ range, 2.3°C (range: -7.3 to 10.3°C) (Natural Resources Canada, 2014), is much lower than the mean temperature of the park, 6.5°C. This species dominates wet acid peat softwoods in cool/cold areas in the Acadian Forest Region (Loo and Ives, 2003). The highest temperature in this species’ distribution is between 29 and 43°C (Fowells, 1965). In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the warmer side of the species' distribution, and it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be hotter than the warmer limit of the distribution. Furthermore, this species is associated with bogs and swamps especially in the southern part of the species’ distribution, while it could be distributed in a wide range of sites in more northern parts (Fowells, 1965; Park and Fowler, 1982). Bogs are suitable habitats for larch in New Brunswick (Burzynski et al., 1986; Hinds, 2000). High watertables in floodplain wetlands also could contribute to protecting this species from fire-related damages (Brown et al., 1988). However, prolonged water periods, like flood, may decrease germination rate of this species (Duncan, 1954; Fowells, 1965). Summing up, this species is vulnerable to thermal and hydrological changes toward warmer and drier climates. Considering that the degree of vulnerability increases depending on mainly temperature increase, the species was judged moderately vulnerable and highly vulnerable under moderate and severe climate change scenarios respectively.</td></tr>
</table>

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

References cited in just this sheet (references that were already cited in the main text as common documents for many species are not shown here.)

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[Assessment sheet] Climate change vulnerability assessments of ironwood (*Ostrya virginiana*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scotian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Effective and maximum seed dispersal distances are 175 m and 300 m respectively (Berland et al., 2011). Its seeds are disseminated by wind and secondarily by birds (Delcourt and Delcourt, 1994).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD** Dec	This species is rare in Kejimkujik National Park (Roland, 1980). It seems to prefer much warm places in Kejimkujik National Park, considering the higher annual mean temperature of 10.5°C (range: 2.3 - 21.7°C) of the entire species' range (Natural Resources Canada, 2014) than the mean temperature of 6.5°C in the park.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	This species is distributed across wide ranges of climates and soils (i.e. from mesic to xeric parts) with annual precipitations ranging from 460 mm to 1,630 mm (Metzger, 1990; Delcourt and Delcout, 1994). It often grows on fairly dry soils, including rocky ones, being insensitive to droughts (University of Kentucky, 2004).
C2c (Disturbance)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	This species is moderately tolerant to fires (Delcourt and Delcourt, 1994; Berland et al., 2011), and one empirical study has reported this species as a principal invader into burned sites (Swan, 1970). Cold hardiness and genetic plasticity may allow it to be resistant to dieback resulting from damage by wind, ice, or snow storms (Rogers, 1923; Delcourt and Delcourt, 1994). Yet, Betts and Forbes (2005) proposed that this species requires some shade for optimal growth.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Cold hardiness and genetic plasticity may allow it to be resistant to dieback resulting from damage by snow storms (Rogers, 1923; Delcourt and Delcourt, 1994).
C3	Inc-SI-N-**SD**-Dec	This species grows on all of the major orders in the eastern United States (i.e., Spodosols, Alfisols, Mollisols,

(Physical habitat)	Inc-SI-N-**SD**-Dec	Ultisols, Entisols and Inceptisols) (Metzger, 1990). Yet, it might prefer slightly acidic soils (University of Kentucky, 2004).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is quite shade tolerant and can persist in forest understory (Delcourt and Delcourt, 1994; Berland et al., 2011).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	(N/A)
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Kelly, 2012).
C4d (Other spp for disp)	Inc-**SI**-**N** Inc-**SI**-**N**	Its seeds are disseminated by winds and secondarily by birds (Delcourt and Delcourt, 1994).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	0	100
Severe scenario	0	0	0	0	100
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario				-------------------------------	
Severe scenario					-------------------------------
	This species is rare in Kejimkujik National Park (Roland, 1980). It seems to prefer much warm places in Kejimkujik National Park, considering the higher annual mean temperature of 10.5°C (range: 2.3 - 21.7°C) of the entire species' range (Natural Resources Canada, 2014) than the mean temperature of 6.5°C in the park. There is then no other attribute showing significantly negative impact of climate change on this species, and therefore this species' population in this park will grow well in response to temperature increase.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

References cited in just this sheet (references that were already cited in the main text as common documents for many species are not shown here.)

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[Assessment sheet] Climate change vulnerability assessments of white spruce (*Picea glauca*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scocian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral. Yet, there are no highlands (like Cape Breton Highlands) in the park. In this regard, this species has little adaptation opportunity, even though it wants to migrate to cool sites. To show lack of such potential opportunities, Inc and SI were chosen in the MVA.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	White spruces could disseminate its seeds for 100 m on average but sometimes over than 300 m (Fowells, 1965). According to a modelling study, seed rain of this species halves at a distance of 30m, but around 3% of dispersed seeds could move for more than 800 m (Wirth et al., 2008). Maximum seed dispersal distance of this species is around 200 m, according to Scheller and Mladenoff (2005). Moreover, a cpDNA phylogeographical study suggested that postglacial migration rates of 1,500-2,000 m/yr, presumed by a fossil pollen analysis, was an overestimation (Anderson et al., 2006).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-**Inc**-**SI**-N-SD GI-**Inc**-SI-N-SD	The annual mean temperature of the entire species’ range, 1.2°C (range: -11.9 to 10.6°C) (Natural Resources Canada, 2014), is much lower than the mean temperature of the park, 6.5°C. However, some of this species’ range has experienced considerably hot temperature (e.g., 43°C in southwestern Manitoba) (Fowells, 1965), indicating a high climatic flexibility of this species (Farrar, 1995). Yet, even this species showed inhibited photosynthesis with heat treatment at 42°C or higher (Bigras, 2000). In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently close to the warmer limit of the species' distribution, and it will be hotter than the limit of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	

niche)		
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species inhabits wet insular Nova Scotia but also semi-arid continental areas in southwestern Manitoba (Fowells, 1965). White spruce occurs more frequently on drier uplands in Alaska (Wirth et al., 2008), but in Nova Scotia it develops best along streams, lakes or coast (Saunders, 1996). Lack of moisture could be a main reason for controlling this species' southern limits (Barber et al., 2004). Therefore, drier environments should be negative for this species in Kejimkujik.
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	This species is intermediately shade-tolerant and classified as a climax species, but still it is unlikely to compete well with hardwoods (Fowells, 1965; Scheller and Mladenoff, 2005). In other words, some gaps are needed for regeneration of this species (e.g., abandoned agricultural fields in Cape Breton) (Smith, 1998; Bouman et al., 2004). It is susceptible to windthrow but more tolerant of winds than black spruce and balsam fir on uplands (Fowells, 1965). Fires could allow white spruce to replace black spruce, if there is no effect of permafrost, in Alaska (Wirth et al., 2008). However, white spruce is generally regarded as a fire-intolerant species, and its populations in central Quebec may have been declining due to fire disturbances as well as postfire growth of black spruce stands (Lafontaine et al., 2010). In Cape Breton during latter 1970s, spruce budworm outbreaks killed it at relatively moderate mortality (i.e., 27% (Ostaff and MacLean, 1989) or 50% (Smith, 1998)), whilst spruce beetles have simultaneously killed another spruces which corresponded around 39% of total volume (Ostaff and MacLean, 1989).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-**N** SD	Most parts of this species' distribution are in the permafrost zone in northern Canada (Fowells, 1965), though it was documented, for instance, that white spruce was distributed without permafrost in some parts in Alaska (Wirth et al., 2008). Wamer climates may generally lead to earlier snowmelting, enabling this species to grow better (Wilmking et al., 2004), while snow-free conditions could bring about winter desiccation and cold-induced photoinhibition at alpine-treeline in Yukon (Danby and Hik, 2007). Secondary seed dispersal of this species on snow may be relevant to this species' colonization as well (Wirth et al., 2008).
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	This species could occur on a wide range of pH and various types of soils which are characterized with glacial, lacustrine, marine, or alluvial origins, whereas it grows best on podozolized gamma gley loams or clays (Fowells, 1965). As well, white spruce requires much more nutrient than other associated tree species, being able to respond well to fertilizer treatments (Fowells, 1965).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is intermediately shade-tolerant and classified as a climax species, but still it is unlikely to compete well with hardwoods (Fowells, 1965; Scheller and Mladenoff, 2005).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Andalo et al., 2005).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Many birds attempt to obtain seeds of white spruce (Fowells, 1965). Also, it was documented that white spruce was preferred in comparison with black spruce by red squirrels, though spruce seeds dispered by squirrels were unlikely to germinate successfully (Brink and Dean, 1966). Secondary seed dispersal of this

		species on snow may be relevant to this species' colonization as well (Wirth et al., 2008).			
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**				
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD				
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N				
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD				
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-**Inc**-SI-N-SD-Dec **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	100	0	0
Severe scenario	0	11	89	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario	-------------------------------	-------------------------------			
Severe scenario	-------------------------------				
	The annual mean temperature of the entire species' range, 1.2°C (range: -11.9 to 10.6°C) (Natural Resources Canada, 2014), is much lower than the mean temperature of the park, 6.5°C. However, some of this species' range has experienced considerably hot temperature (e.g., 43°C in southwestern Manitoba) (Fowells, 1965), indicating a high climatic flexibility of this species (Farrar, 1995). Yet, even this species showed inhibited photosynthesis with heat treatment at 42°C or higher (Bigras, 2000). In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently close to the warmer limit of the species' distribution, and it will be hotter than the limit of the distribution under moderate and severe climate change scenarios (c.f., Appendix). This species inhabits wet insular Nova Scotia but also semi-arid continental areas in southwestern Manitoba (Fowells, 1965). In Nova Scotia, it develops best along streams, lakes or coast (Saunders, 1996). Lack of moisture could be a main reason for controlling this species' southern limits (Barber et al., 2004). Therefore, drier environments should be negative for this species in Kejimkujik. Overall, white spruce population will significantly decline under climate change, if not be extirpated, mainly due to temperature increase but also due to hydrological change. Under moderate climate change scenario, however, both of HV and MV were given, reflecting a little wide thermal niche.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of black spruce (*Picea mariana*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scocian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral. Yet, there are no highlands (like Cape Breton Highlands) in the park. In this regard, this species has little adaptation opportunity, even though it wants to migrate to cool sites. To show lack of such potential opportunities, Inc and SI were chosen in the MVA.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-**SI**-**N**-SD-Dec GI-Inc-**SI**-**N**-SD-Dec	Seeds of this species can be dispersed for just short distances of up to 79 m (USDA, n.d.). However, indirect evidences of long-distance seed dispersal (tens of metres or more) of black spruces have been also reported (e.g., Payette and Delwaide, 1994).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-N-SD GI-**Inc**-SI-N-SD	The annual mean temperature of the entire species' range, 0.9°C (range: -9.0 to 9.9°C) (Natural Resources Canada, 2014), is much lower than the mean temperature of the park, 6.5°C. However, this species' range is latitudinally wide from 41°N to 68°N, indicating a high thermal flexibility of this species (Fowells, 1965). USDA (n.d.) also suggested elevation is less important for determining this species' distribution than local topography and drainage. Further, reproduction of this species (e.g, cone crop, number of seeds) was scarcely affected by climate, according to a study covering a wide latitudinal range in the boreal zone in Quebec (Messaoud et al., 2007b). In Quebec, balsam fir stands have been gradually replaced by black spruce stands under colder and drier climate together with more frequent fires since the last 2,500 years (Messaoud et al., 2007a). In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the warmer side of the species' distribution, and it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be hotter than the warmer limit of the distribution.
C2bi	GI-Inc-SI-N-SD	

(Historical hydrological niche)	GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	In Nova Scotia, this species is common in swamps, bogs or poorly drained areas (Roland, 1945). Pardy (1997) reported that balsam fir often coexists with black spruce on relatively wetter sites in Cape Breton. As well, Parks Canada (2010c) reported that this species is on hydric sites in Cape Breton Highlands at late stages in forest succession.
C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	Black spruce is intermediately tolerant of shade (Smith, 1998). It grows at slower pace than balsam fir and white birch, and therefore regeneration would take much time after budworm outbreaks (Pardy, 1997; Smith, 1998). In contrast, this species is more competitive than balsam fir (Messaoud et al., 2007a). Crown and surface fires kill this species, but it could regenerate soon after light fires (Fowells, 1965; Rajora and Pluhar, 2003; USDA, n.d.). Its seeds adapt to fire and can be opened by heat (Fowells, 1965). However, fires could allow other species (e.g., white spruce) to replace black spruce, if there is no effect of permafrost, in Alaska (Wirth et al., 2008). Black spruce is also susceptible to wind because of its shallow root system (Fowells, 1965; USDA, n.d.). In Cape Breton during latter 1970s, spruce budworm outbreaks killed black spruce at relatively moderate mortality (i.e., 50%) (Smith, 1998).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	In most areas of this species' distribution, there are snow depths of around 50-75 cm in the end of February (Fowells, 1965). However, in southern or western peripheries of the distribution, snow depths could be less than 38 cm (Fowells, 1965). In areas where the total annual precipitation is less than 635 mm, spring snowmelt could compensate for water shortage for black spruces (Fowells, 1965). Given much more precipitation in Kejimkujik, this effect may be irrelevant.
C3 (Physical habitat)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	This species can be found on organic as well as mineral soils (Fowells, 1965). Loams, sandy loams and rocky soils are available for black spruces as well (Fowells, 1965). In Atlantic Canada, this species is distributed on sandy and gravelly outwash plains, river terraces, eskers, and similar landforms with acidic and podzolized soils (Fowells, 1965).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Black spruce is intermediately tolerant of shade (Smith, 1998). It grows at slower pace than balsam fir and white birch (Pardy, 1997; Smith, 1998).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated.
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Its cones are often moved by red squirrels (Fowells, 1965). However, a later study reported that black spruce was not preferred in comparison with white spruce by red squirrels, and even spruce seeds dispered by squirrels were unlikely to germinate successfully (Brink and Dean, 1966).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-N	White spruce is likely to replace black spruce under warming climates in Alaska, likely because the former species is slightly more fitting to a warm climate than the latter one (Wirth et al., 2008). However, under severe climate change, even white spruces will no longer flourish.

C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	A lineage originated from New England and the central Appalachians might have migrated northeastwards to Newfoundland and Labrador, according to a wide-scale analysis of mtDNA of this species (Jaramillo-Correa et al., 2004). However, levels of genetic variations in Nova Scotia have not been clarified yet.			
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N				
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD				
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-**Inc**-SI-N-SD-Dec **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	100	0	0
Severe scenario	0	50	50	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario		-------------------------------			
Severe scenario	-------------------------------				
	The annual mean temperature of the entire species' range, 0.9°C (range: -9.0 to 9.9°C) (Natural Resources Canada, 2014), is much lower than the mean temperature of the park, 6.5°C. However, this species' range is latitudinally wide from 41°N to 68°N, indicating a high thermal flexibility of this species (Fowells, 1965). USDA (n.d.) also suggested elevation is less important for determining this species' distribution than local topography and drainage. Further, reproduction of this species (e.g, cone crop, number of seeds) was scarcely affected by climate, according to a study covering a wide latitudinal range in the boreal zone in Quebec (Messaoud et al., 2007b). In Quebec, balsam fir stands have been gradually replaced by black spruce stands under colder and drier climate together with more frequent fires since the last 2,500 years (Messaoud et al., 2007a). In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the warmer side of the species' distribution, and it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be hotter than the warmer limit of the distribution. In Nova Scotia, this species is common in swamps, bogs or poorly drained areas (Roland, 1945). Pardy (1997) reported that balsam fir often coexists with black spruce on relatively wetter sites in Cape Breton. As well, Parks Canada (2010c) reported that this species is on hydric sites in Cape Breton Highlands at late stages in forest succession. Black spruce is intermediately tolerant of shade (Smith, 1998). Crown and surface fires kill this species, but it could regenerate soon after light fires (Fowells, 1965; Rajora and Pluhar, 2003; USDA, n.d.). Its seeds adapt to fire and can be opened by heat (Fowells, 1965). However, fires could allow other species (e.g., white spruce) to replace black spruce, if there is no effect of permafrost, in Alaska (Wirth et al., 2008). Black spruce is also susceptible to wind because of its shallow root system (Fowells, 1965; USDA, n.d.). Overall, even though it is adaptable to light fires and heats, temperature increase, drier condition and stronger winds in Kejimkujik National Park will make it vulnerable. Under severe climate change scenario, the temperature increase may be critical. Therefore, MV and HV were given for this speices under moderate and severe climate change scenarios.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of red spruce (*Picea rubens*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scotian peninsula isolated from the mainland. · Lakes in Kejmkujik National Park may be a barrier. [Expert in Kejimkujik] · Do we need to consider outside barriers? We didn't consider that with brook trout, and the trees aren't moving. [Expert in Kejimkujik] [Follow-up] In a sense that there are no physical barriers, the subscore of B2a should be neutral here. Yet, there are no highlands (like Cape Breton Highlands) in the park. In this regard, this species has little adaptation opportunity, even though it wants to migrate to cool sites. To show lack of such potential opportunities, Inc and SI were chosen in the MVA.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	· Here in Nova Scotia one could argue that spruce communities have been damaged/reduced, not only by fire and windthrow but equally or more substantially by harvesting. [Additional expert] [Follow-up] Because harvesting is generally regulated inside KEjimkujik National Park, the subscore should be neutral here.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	The mean dispersal distance of this species was reported as around 61 m (Govindaraju, 1988). However, its congeneric species, black spruce, disseminates its seeds for a mean distance of 31 m, while 15.2% and 2.9% of the seeds were predicted by a modelling study to be dispersed for longer distances of 300 m and 800 m respectively (Wirth et al., 2008).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species is extensively distributed and rather common in Nova Scotia including Kejimkujik National Park (Roland, 1980; Saunders, 1996). Yet, it generally prefers cool places in this region (Saunders, 1996; Schauffler and Jacobson, 2002). In support of this, the annual mean temperature of the entire species' range, 4.4°C (range:-0.5 to 13.9°C) (Natural Resources Canada, 2014), is lower than the mean temperature of this park, 6.4°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the middle of the species' distribution, and it will be in the warmer side of the distribution under moderate and severe climate

		change scenarios (c.f., Appendix). · It is vulnerable to temperature fluctuations, creating frost cracks. [Expert in Kejimkujik] · We must think about whether the tree can produce viable propagules and if the tree can grow to maturity and reproduce. Steenberg's model shows it won't be able to compete. [Expert in Kejimkujik] · It might grow better in hotter temperatures. [Expert in Kejimkujik] [Follow-up] The study by Steenberg et al. was focusing on forests in Halifax. Thus, target area is different from ours. So, we don't adopt the result of Steenberg et al.'s study here. However, even if we consult their study, red spruce will not decline so significantly. According to Fig. 2 in Steenberg et al. (2013), landscape presence of red spruce, with no harvest, is around 78% under current climate and around 73% under future climate (SRES-A2). That is, in the future, red spruce will still persist well.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Extensively being distributed and rather common in Nova Scotia including Kejimkujik National Park, but not the Cape Breton uplands (Roland, 1980; Saunders, 1996). Yet, this species can grow best on well-drained soils (Saunders, 1996). This is one of typical species in mature forests on moist upland sites, being often observed in moist sites like north-facing slopes and lakesides in Ontario and Quebec (Farrar, 1995). · The fungi associated with spruce could be affected, if soils are affected by increased precipitation. Thus, this subfactor should not be neutral on the vulnerability of red spruce. [Expert in Fundy] · It is neutral, because I can't see climate change affecting this subfactor to any great degree. [Additional expert] · In most cases, I don't think lakes here in Nova Scotia are large enough to act as a tree species barrier [Additional expert]. [Follow-up after consultation in Fundy NP] Negative effects of reduced precipitation on red spruce has been studied (Koo et al., 2014), and also heavy rainfall in August is beneficial for reproduction of ectomycorrhizal-basidiomycete communities in red spruce stands (Bills et al., 1986). In contrast, effects of increase in precipitation on fungi in red spruce stands have not been clarified yet. However, mean annual precipitation of the entire distribution of red spruce is 1,134 mm [5-95%: 979-1,350 mm] (Natural Resources Canada, 2014), while the current annual precipitation in Kejimkujik National Park is 1,416 mm. Therefore, more increase in precipitation in this park will make this site less suitable for the species in terms of precipitation. In this respect, the subscore of C2bii was determined as SI and N.
C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	This is one of typical species in mature forests on moist upland sites (Farrar, 1995), and spruce communities have been reduced and/or damaged sometimes by extensive fire or intensified winds (Harrington, 1985;

		Adams and Stephenson, 1989). However, red spruce can be tolerant to moderate disturbances and forest canopy openings (White and Mackenzie, 1985). In support of this, Telfer (2004) recorded regeneration of this species in forest gaps which were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. Moderate distrubance has led to hybridization between black spruce and red spruce, which is more climax species than black spruce, in New Brunswick (Manley, 1972; Betts and Forbes, 2005). Hybridization with black spruce could decrease budworm-related defoliation rate, but still hybridization could be thereatening for the pure gene pool of this species (Betts and Forbes, 2005). Furthermore, warm climates allow spruce bark beetle to complete one generation cycle in a single year but also survive winter easily (Bentz et al., 2010). Hence, global warming could contribute to population growth of spruce beetle (Bentz et al., 2010). As well, increase in growing degree days (GDD) will lead to greater fitness of this species (Phillips, 2013). In contrast, low spring temperature retards water uptake by spruce trees, and particularly spruces on north-facing slopes have been stressed (Berg et al., 2006). Therefore, warm spring temperature could lesson such seasonal stresses on spruces, possibly reducing probability of beetle infestations (Berg et al., 2006). However, benefits of warmer climates may outweigh demerits of climate change for spruce beetle. Thus, such beetle outbreaks could devastate red spruce populations. · Eastern dwarf mistletoe may become a problem in climate change. It affects growth, though seed can still be produced. We are likely to get more disturbances, not less, and red spruce won't like that. This will change the fire regime. Red spruce still needs a period of tranquility so gap disturbance may not benefit it. [Expert in Kejimkujik]
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	· Ice storms have shown to break the tips of red spruce (i.e.: 1995/96 event in Point Pleasant Park in Halifax). The effect of ice storms may vary depending on locations. [Expert in Kejimkujik] · If ice storms are affecting this species, it's likely that other species are impacted to an equal or greater extent. [Expert in Kejimkujik] [Follow-up] If we reflect the negative effect of ice storm in this subfactor, maybe "SD" would be chosen because ice effect will be weakened by increased temperature. However, SD is not available in the CCVI program. As well, we do not know exactly the effect in Kejimkujik National Park, and therefore neutral score is retained here.
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	Extensively being distributed and rather common in Nova Scotia including Kejimkujik National Park, but not the Cape Breton uplands (Roland, 1980; Saunders, 1996). Yet, this species prefers the podzolic soils with low pH ranging between 4.0 and 5.5 (Fowells, 1965). · Red spruce is distributed across Kejimkujik National Park. [Expert in Kejimkujik]
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Being tolerant to interspecific competitions particularly in Canada (Fowells, 1965; White et al., 1985).

C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	(N/A)
C4c (Pollination)	Inc-SI-N Inc-SI-N	All spruce species are wind-pollinated (Haselhorst and Buerkle, 2013).
C4d (Other spp for disp)	Inc-SI-N Inc-SI-N	This species' seeds are mainly disseminated by wind (Govindaraju, 1988), but they could be scatterhoarded by some animals like red squirrels (Dempsey and Keppie, 1993). · The bulk of dispersal is not dependent on other species. Squirrels don't go long distances, they hoard seeds in their own territory. [Expert in Fundy]
C4e (Other spp interaction)	Inc-SI-N Inc-SI-N	· The fungi associated with spruce could be affected, if soils are affected by increased precipitation. Thus, this subfactor should not be neutral on the vulnerability of red spruce. [Expert in Fundy] · This is neutral, simply because assessing such interspecific competitive interactions is purely speculative. [Additional expert]
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	The Rossignol Lake, which is close to Kejimkujik National Park, exhibited higher (but statistically not significant) genetic diversity than those of other populations in the Maritimes and Ontario (Rajora et al., 2000). · Neutral score may be suitable, given that genetic variation in a population around Kejimkujik National Park was higher than those of other populations *in*significantly. [Expert in Kejimkujik NP] · It is neutral, because climate change modelling by IPCC is purely speculative and therefore it would be difficult to ascertain impact on red spruce in Kejimkujik National Park. [Additional expert] [Follow-up] Thresholds among the subscores in C5a are not specified, and assessors are supposed to choose subscores by interpreting each genetic study (Young et al., 2011). Thus, in our assessment, for species whose populations show significantly smaller genetic variations compared to those of other populations, "Inc" is given in our assessment. In contrast, "SI" are given for the species with insignificantly smaller variations. In this regard, SD should be given for the species with insignificantly larger variations than those of other populations. The Rossignol Lake, which is close to Kejimkujik National Park, exhibited the highest diversity among five examined populations in the Maritimes (Rajora et al., 2000). As well, estimated proportion of inbreeding events was the smallest for the same population among the five populations (Rajora et al., 2000). Thus, such genetic characteristics should be reflected in the C5a subfactor. So, SD is still retained here. However, it is also true that in the MVA the subfactor of C5a was not considered as a relevant subfactor.
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	(N/A)
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	

D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	**GI**-Inc-SI-N-SD-Dec **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	100	0	0
Severe scenario	0	0	100	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario		-------------------------------			
Severe scenario	-------------------------------	-------------------------------			
	This species is extensively distributed and rather common in Nova Scotia including Kejimkujik National Park (Roland, 1980; Saunders, 1996). Yet, it generally prefers cool places in this region (Saunders, 1996; Schauffler and Jacobson, 2002). In support of this, the annual mean temperature of the entire species' range, 4.4°C (range:-0.5 to 13.9°C) (Natural Resources Canada, 2014), is lower than the mean temperature of this park, 6.4°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the middle of the species' distribution, and it will be in the warmer side of the distribution under moderate and severe climate change scenarios (c.f., Appendix). Also, this species can grow best on well-drained soils (Saunders, 1996). This is one of typical species in mature forests on moist upland sites, being often observed in moist sites like north-facing slopes and lakesides in Ontario and Quebec (Farrar, 1995). Such spruce communities have been reduced and/or damaged sometimes by extensive fire or intensified winds (Harrington, 1985; Adams and Stephenson, 1989). However, red spruce can be tolerant to moderate disturbances and forest canopy openings (White and Mackenzie, 1985). In support of this, Telfer (2004) recorded regeneration of this species in forest gaps which were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. Moderate distrubance has led to hybridization between black spruce and red spruce, which is more climax species than black spruce, in New Brunswick (Manley, 1972; Betts and Forbes, 2005). Furthermore, warm climates allow spruce bark beetle to complete one generation cycle in a single year but also survive winter easily (Bentz et al., 2010). Hence, global warming could contribute to population growth of spruce beetle (Bentz et al., 2010). As well, increase in growing degree days (GDD) will lead to greater fitness of this species (Phillips, 2013). In contrast, low spring temperature retards water uptake by spruce trees, and particularly spruces on north-facing slopes have been stressed (Berg et al., 2006). Therefore, warm spring temperature could lesson such seasonal stresses on spruces, possibly reducing probability of beetle infestations (Berg et al., 2006). However, benefits of warmer climates may outweigh demerits of climate change for spruce beetle. Thus, such beetle outbreaks could devastate red spruce populations. In summary, temperature increase together with intensified distrubances will be harmful to this species in this park, though it has some resilience capacity to disturbances. Given the fact that the future temperature will be still within the speices' thermal niche and that the effects of disturbances include various uncertain factors, the both classes of HV and MV were chosen for this species in severe climate change scenario.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of red pine (*Pinus resinosa*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scocian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral. Yet, there are no highlands (like Cape Breton Highlands) in the park. In this regard, this species has little adaptation opportunity, even though it wants to migrate to cool sites. To show lack of such potential opportunities, Inc and SI were chosen in the MVA.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-**SI**-N-SD-Dec GI-Inc-**SI**-N-SD-Dec	Its effective seeding distance is 12 m, though seeds can be disseminated up to 900 feet (Fowells, 1965; He and Mladenoff, 1999).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-N-SD GI-**Inc**-**SI**-N-SD	This species grows well under cool-to-warm summers and cold winters (Fowells, 1965). The annual mean temperature of the entire species' range, 4.8°C (range: -0.4 to 13.5°C) (Natural Resources Canada, 2014), is lower than than the mean temperature of this park, 6.4°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the middle of the species' distribution, and it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be hotter than the warmer limit of the distribution.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	The lightest soils (sandy soils) with low to moderate precipitaion are considerably preferred by this species, though it could be observed on swamp borders and lakesides as well (Roland, 1980; Fowells, 1965). Mean annual precipitation of the entire distribution of red pine is 909 mm [5-95%: 670-1,277 mm] (Natural Resources Canada, 2014), while the current annual precipitation in Kejimkujik National Park is 1,416 mm. Therefore, more increase in precipitation in this park will make this site less suitable for the species in terms of

		precipitation.
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species can regenerate well after certain fires, windthrows and on bedrock slabs (Fowells 1965; Engstrom and Mann, 1991; Malliak and Roberts, 1994). Particularly, moderate fires are optimal disturbances for this species, removing inter-specific competitions with other tree species (Flanningan and Bergeron, 1998; Sutton et al., 2002).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	This species is distributed in the Podzol region with pH ranging between 4.5 and 6.0 (Fowells, 1965), and its seedlings prefers mineral soil exposure to grow (Flanningan and Bergeron, 1998).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Although red pine is not competitive (Fowells, 1965; Flanningan and Bergeron, 1998), it could be associated with various tree and shrub species (Fowells, 1965).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	(N/A)
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	This species is self-pollinated without insects/animals (Fowler, 1965).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Wind-dispersed species (Greene and Johnson, 1993).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-**SD** Inc-SI-N-**SD**	Relatively high haplotypic diversity was found in populations in Nova Scotia, suggesting that these areas were previously northern refugia of this species (Walter and Epperson, 2005).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	(N/A)
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	**GI**-Inc-SI-N-SD-Dec **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	100	0	0
Severe scenario	0	0	100	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario		-------------------------------			
Severe scenario	-------------------------------				

	This species grows well under cool-to-warm summers and cold winters (Fowells, 1965). The annual mean temperature of the entire species’ range, 4.8°C (range: -0.4 to 13.5°C) (Natural Resources Canada, 2014), is lower than than the mean temperature of this park, 6.4°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the middle of the species' distribution, and it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be hotter than the warmer limit of the distribution. Increase in precipitation in this park will make this site less suitable for the species in terms of precipitation. This species can regenerate well after certain fires, windthrows and on bedrock slabs (Fowells 1965; Engstrom and Mann, 1991; Malliak and Roberts, 1994). Particularly, moderate fires are optimal disturbances for this species, removing inter-specific competitions with other tree species (Flanningan and Bergeron, 1998; Sutton et al., 2002). Thus, although increase of disturbance intensity may be a little beneficial for this species, temperature increase and possibly precipitation increase will be detrimental for red pine. Hence, this species is moderately vulnerable to moderate climate change scenario while highly vulnerable to severe climate change scenario (If frequent fires could be expected like in dried inland climates, the positive effects of fire disturbances should be more relevant to the survival of the species. Therefore, in such cases, the conclusion would have been a little more optimistic).

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of white pine (*Pinus strobus*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scocian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral. Yet, there are no highlands (like Cape Breton Highlands) in the park. In this regard, this species has little adaptation opportunity, even though it wants to migrate to cool sites under severe climate change scenario. To show lack of such potential opportunities, Inc and SI were chosen in the MVA.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Its effective seed dispersal is around 100 m (He and Mladenoff, 1999). Some of the seeds can be gathered and cached by animals (Wall, 2003).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-**SI**-**N**-SD	This species is commonly found in Nova Scotia including Kejimkujik National Park (Roland, 1980; Boland, 2012). As well, the annual mean temperature of the entire species' range, 5.8°C (range: -1.1 to 17.2°C) (Natural Resources Canada, 2014), is slightly lower than the mean temperature of this park, 6.4°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the cooler side of the species' distribution, and it will be close to the middle of the distribution under moderate climate change scenario. Further, it will be in the warmer side of the same distribution under severe climate change scenario (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species can grow on a wide range of soils, though it grows best on moist, well drained sandy loam (Farrar, 1995; Joyce and Rehfeldt, 2013).
C2c	Inc-SI-N-**SD**-Dec	It can tolerate of several disturbance types and survive in open canopies (Farrar, 1995; Weyenberg et al., 2004).

(Disturbance)	Inc-SI-N-**SD**-Dec	Actually, there are multiple post-fire places where this species has grown (Saunder, 1996; Weyenberg et al., 2004). In support of this, Telfer (2004) recorded regeneration of this species in forest gaps that were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	Commonly found in Nova Scotia including Kejimkujik National Park, but not Cape Breton (Roland, 1980). Yet, this species prefers certain soil bases, such as granites (Fowells, 1965).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	It is a moderately shade-tolerant species, usually being mixed with other species like red oak (Fowells, 1965; Farrar, 1995).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	(N/A)
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Walter and Epperson, 2004).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Wind-dispersed species (Walter and Epperson, 2004).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	**Inc**-SI-N-SD **Inc**-SI-N-SD	Its population in Caledonia, which is close to Kejimkujik National Park, showed the lowest observed heterozygosity among ten examined popultions in the north-eastern range of this species' distribution (Mehes et al., 2009).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	(N/A)
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-**SD**-Dec GI-Inc-**SI**-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	0	24	76	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	
Severe scenario			-------------------------------		
	This species is commonly found in Nova Scotia including Kejimkujik National Park (Roland, 1980; Boland, 2012). As well, the annual				

	mean temperature of the entire species' range, 5.8°C (range: -1.1 to 17.2°C) (Natural Resources Canada, 2014), is slightly lower than the mean temperature of this park, 6.4°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the cooler side of the species' distribution, and it will be close to the middle of the distribution under moderate climate change scenario. Further, it will be in the warmer side of the same distribution under severe climate change scenario (c.f., Appendix). This species can grow on a wide range of soils, though it grows best on moist, well drained sandy loam (Farrar, 1995; Joyce and Rehfeldt, 2013). It can tolerate of several disturbance types and survive in open canopies (Farrar, 1995; Weyenberg et al., 2004). Actually, there are multiple post-fire places where this species has grown (Saunder, 1996; Weyenberg et al., 2004). In support of this, Telfer (2004) recorded regeneration of this species in forest gaps that were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. Hence, temperature increase will be beneficial under moderate climate change scenario but negative under severe scenario. However, even under the latter scenario, strengthened disturbance regime will contribute to adaptation of the species. Thus, PS/MA and just PS were chosen under moderate and severe scenarios respectively.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of red oak (*Quercus rubra*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scocian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-**SD**-Dec GI-Inc-SI-**N**-**SD**-Dec	Its effective seeding distance is 30 m but possibly reach 3000 m (He and Mladenoff, 1999). Jays collect and disperse viable nuts of this species for 4-5 km (Crow, 1988; USDA, n.d.). Maximum seed dispersal distance of this species is around 1 km, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** Dec GI-Inc-SI-**N**-**SD**	The annual mean temperature of the entire species' range, 9.8°C (range: 1.3 - 19.7°C) (Natural Resources Canada, 2014), is higher than the mean temperature of the park, 6.5°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently close to the cooler limit of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species is commonly seen on light or well-drained soils (Roland, 1945; Saunders, 1996; Boland, 2012). It can regenerate better on mesic soils than exposed soils, being relatively sensitive to droughts among oak species (Crow, 1988).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species is tolerant to fires (Crow, 1988; Saunders, 1996; Abrams, 2003). Its seedlings require lights to grow (Farrar, 1995). Deer browsing was also suspected as an influential factor on regeneration of red oak, though deer exclosure experiments since 2011 did not show any significant effect on the regeneration in Kejimkujik National Park, likely because of stronger effects of other factors (MTRI and Parks Canada, 2014).
C2d	GI-Inc-SI-**N**	

(Ice/Snow)	GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	It is found on a wide range of soils, from sands and stone-free deep soils to shallow and rocky soils (Fowells, 1965; Saunder, 1996). However, slope direction and/or topography (e.g., flat or steep slope) could affect this species' growth (Fowells, 1965). In New Brunswick, sandy/gravelly acid woodland and shores are utilized as habitats for this species (Hinds, 2000).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is intolerant to competition (Fowells, 1965; Farrar 1995), but still it is not associated with specific co-existing species.
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	(N/A)
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Grob, 2008).
C4d (Other spp for disp)	Inc-**SI**-**N** Inc-**SI**-**N**	Jays collect and disperse viable nuts of this species for 4-5 km, although even other birds and mammals eat the nuts (Crow, 1988; USDA, n.d.).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	0	100
Severe scenario	0	0	0	0	100
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario				-------------------------------	-------------------------------
Severe scenario				-------------------------------	-------------------------------
	The annual mean temperature of the entire species' range, 9.8°C (range: 1.3 - 19.7°C) (Natural Resources Canada, 2014), is higher than the mean temperature of the park, 6.5°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently close to the cooler limit of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). This species is tolerant to fires (Crow, 1988; Saunders, 1996; Abrams, 2003). Its seedlings require				

	lights to grow (Farrar, 1995). Overall, this oak species could benefit from temperature increase as well as more intensified disturbances than now, but moderate temperature increase (~ 3.3°C plus) might be the most beneficial than more drastic temperature increase according to the annumal mean temperature data. In this regard, both classes of MA and HA were given for this species under both moderate and severe climate change scenarios.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of Eastern hemlock (*Tsuga canadensis*) in Kejimkujik National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	There is the geographical barrier of the Nova Scotian peninsula isolated from the mainland. However, because the geographical barrier of the Chignecto Isthmus should not be generally considered here according to the expert consulation in Kejimkujik National Park, the subcore in this subfactor was determined neutral.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Effective seeding distance of this species is supposed to be around 30 m (He and Mladenoff, 1999), whereas occassionally it can disperse seeds over many tens of km (Davis, 1989). Maximum seed dispersal distance of this species is around 100 m, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	This species is extensively distributed and rather common in Kejimkujik National Park (Roland, 1980). Yet, this species generally prefers northern slopes (Roland, 1945; Farrar, 1995; Saunders, 1996). The annual mean temperature of the entire species' range, 6.3°C (range:-1.0 to 18.3°C) (Natural Resources Canada, 2014), is almost same as the mean temperature of the park, 6.5°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the cooler side of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	Extensively being distirbuted and rather common in Kejimkujik national park (Roland, 1980). Yet, this species prefers moist sites with good drainage (Roland, 1945; Farrar, 1995; Saunders, 1996; Haas and McAndrews, 2000).
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec **Inc**-SI-**N**-SD-Dec	It is shade-tolerant (Farrar, 1995) and therefore not strongly depend on forest gaps. This species is highly vulnerable to fire, and it may have been distributed more abundantly before fire disturbances (Fowells, 1965; Roland, 1980; Foster and Zebryk, 1993). In contrast, fires have contributed to colonizations of some hemlock populations in southwestern Nova Scotia, and therefore fires may be both negative and positive for this species

<table>
<tr><td></td><td></td><td colspan="4">depending on some other factors (Mosseler et al., 2003). Wind also could harm larger-size hemlocks (Fowells, 1965). According to Mosseler et al. (2003), intense deer browsing may be the most serious pressure on this species’ regeneration currently across its distribution. Given that deer will flourish especially under severe climate change scenario, here "Inc" was chosen under severe scenario. Furthermore, Kejimkujik National Park has recently experienced severe defoliation of hemlock attacked by pale winged gray moth (Fanning, 2005).</td></tr>
<tr><td>C2d
(Ice/Snow)</td><td>GI-Inc-SI-**N**
GI-Inc-SI-**N**</td><td colspan="4"></td></tr>
<tr><td>C3
(Physical habitat)</td><td>Inc-SI-**N**-**SD**-Dec
Inc-SI-**N**-**SD**-Dec</td><td colspan="4">Extensively being distributed and rather common in Kejimkujik National Park (Roland, 1980). Yet, this species particularly perfers acidic, sandy, rocky, or glacial till soils (Roland, 1945; Natural Resources Canada, 2014). In New Brunswick, this species is common in rocky and moist soils ion north facing slopes/ravines/ridges (Hinds, 2000).</td></tr>
<tr><td>C4a
(Other spp for habitat)</td><td>GI-Inc-SI-**N**
GI-Inc-SI-**N**</td><td colspan="4">This species was considered to lose in competitions with very shade-tolerant trees (e.g., sugar maple, beech, and red spruce) (Rogers, 1978). However, this species is also shade-tolerant (Farrar, 1995), being codistributed with white pine, red spruce, yellow birch, and sugar maple (Saunders, 1996).</td></tr>
<tr><td>C4b
(Diet)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4">(N/A)</td></tr>
<tr><td>C4c
(Pollination)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="4">Wind-pollinated (Potter et al., 2012).</td></tr>
<tr><td>C4d
(Other spp for disp)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="4">Wind-dispersed species (Davis et al., 1991).</td></tr>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="4"></td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-**N**-SD
Inc-SI-**N**-SD</td><td colspan="4">No significantly less variation was detected in Nova Scotia in comparion with those of other hemlock populations in this species’ distribution (Potter et al., 2012). The cited authors then found an indirect evidence of a relatively recent population expansion, but not bottleneck. Lemieux et al. (2011) also reported comparable genetic variation in populations in southwestern Nova Scotia with other populations by using polymorphic chloroplast DNA markers.</td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4">(N/A)</td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-N-**SD**-Dec
GI-**Inc**-SI-N-SD-Dec</td><td colspan="4">These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).</td></tr>
<tr><td>The CCVI [%]</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
</table>

Moderate scenario	0	0	0	100	0
Severe scenario	0	0	100	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	
Severe scenario		-------------------------------	-------------------------------		
	This species is extensively distributed and rather common in Kejimkujik National Park (Roland, 1980). Yet, this species generally prefers northern slopes (Roland, 1945; Farrar, 1995; Saunders, 1996). The annual mean temperature of the entire species' range, 6.3°C (range:-1.0 to 18.3°C) (Natural Resources Canada, 2014), is almost same as the mean temperature of the park, 6.5°C. In terms of Growing-Degree Days (GDD5), Kejimkujik National Park is currently in the cooler side of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). Also, this species prefers moist sites with good drainage (Roland, 1945; Farrar, 1995; Saunders, 1996; Haas and McAndrews, 2000). This species is highly vulnerable to fire, and it may have been distributed more abundantly before fire disturbances (Fowells, 1965; Roland, 1980; Foster and Zebryk, 1993). Wind also could harm larger-size hemlocks (Fowells, 1965). It is shade-tolerant (Farrar, 1995) and therefore not strongly depend on forest gaps. This species is highly vulnerable to fire, and it may have been distributed more abundantly before fire disturbances (Fowells, 1965; Roland, 1980; Foster and Zebryk, 1993). In contrast, fires have contributed to colonizations of some hemlock populations in southwestern Nova Scotia, and therefore fires may be both negative and positive for this species depending on some other factors (Mosseler et al., 2003). Wind also could harm larger-size hemlocks (Fowells, 1965). According to Mosseler et al. (2003), intense deer browsing may be the most serious pressure on this species' regeneration currently across its distribution. Furthermore, Kejimkujik National Park has recently experienced severe defoliation of hemlock attacked by pale winged gray moth (Fanning, 2005). In conclusion, although temperature increase will be beneficial for fostering growth of this species' population, Unlike Cape Breton Highlands and Fundy National Parks, the current remperature has not been a decisive limiting factor of the species' distribution. In contrast, less moist conditions and stronger disturbances (deer browsing) than now will be harmful to this species. Under severe climate change scenario in particular, the negative impact of deer browsing will increase with less snow accumulation. Therefore, such negative impacts will outweigh positive impacts of climate change on the species under severe climate change. To reflect this change, contrasting responses were chosen between the two climate change scenarios.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of Bicknell's thrush (*Catharus bicknelli*) in Cape Breton Highalnds National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species' habitats are highly fragmented (Rimmer et al., 2005a). In the Maritimes, this species is confined to highlands like Cape Breton Highlands (altitude > around 450 m) (de Boer, 2008). Yet, the fragmentation may be attributable to the species' physiological thermal niche, and therefore just neutral score was chosen in B2a.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Deforestation in this species' wintering sites could be a partial reason for decline of this species (Parks Canada, 2010c). In the Maritimes, however, this species inhabits even clearcut sites or plantations (de Boer, 2008).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species winters in broadleaf forests on the island of Hispaniola (Dominican Republic), and therefore it is a migratory bird species (Lambert and McFarland, 2004; Rimmer et al., 2005a; Lambert et al., 2008).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	**GI**-**Inc**-SI-N-SD **GI**-**Inc**-SI-N-SD	This species is mainly distributed in New York and northern New England in breeding season, while there are small patches in Quebec, New Brunswick as well as Nova Scotia (Lambert and McFarland, 2004). In this sense, the main distribution is located in more southern positions than Cape Breton. However, these southern habitats are at high elevations. A linear negative relationship between latitude elevation for Bicknell's Thrush occurrence (-81.6 m/1◦ latitude) suggested that this species' distribution was primarily determined temperature gradients (Lambert et al, 2005). According to this equation, a suitable habitat for this species in Cape Breton Highlands should be at 660 m a.s.l. or higher than it, and therefore this park is likely to be too warm for this species.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species is not associated with aquatic habitats at any life stages (Rimmer et al., 2005b).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species could utilize young or partly disturbed forests as well as regenerating stands (Rimmer et al., 2005a; Lambert et al., 2008). Suitable vegetation for this species has been maintained by not only cool summer temperature but also strong winds in New Hampshire (Hale, 2006). In the Maritimes, this species inhabits even clearcut sites or plantations (de Boer, 2008). Its nests are often in dense stands of young to mid-successional fir trees (de Boer, 2008). In contrast, Parks Canada (2010c) suggested that moose impacts on forest succession

		could compromise breeding sites of this species within Cape Breton Highlands. Moose is vulnerable to climate change, and therefore the negative impact of moose browsing will be reduced in changing climates. In these regards, climate change will be somewhat beneficial for the species in terms of distrubance regimes.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Heavy winter ice accumulation could contribute to positive disturbance effects on this species' habitats (Rimmer et al., 2005a). Yet, this species does not stay in Cape Breton in winter, and therefore snow effects should be irrelevant to vulnerability of this species in this park.
C3 (Physical habitat)	Inc-SI-N-**SD**-**Dec** Inc-SI-N-**SD**-**Dec**	Lambert et al. (2005) and Rimmer et al. (2005a) reported that this species breeds in highlands (altitude > around 900 m), including exposed ridgelines, in the northeastern United States. Lambert et al. (2005) proposed a linear relationship of "the lowest elevation of Bicknell's Thrush's distribution = -81.63 (latitude) + 4,475 m". Likewise, in the Maritimes, this species inhabits highlands like Cape Breton Highlands (altitude > around 450 m) (de Boer, 2008). Yet, this habitat preference should be ascribed to temperature, but not physical habitats.
C4a (Other spp for habitat)	GI-Inc-**SI**-N GI-**Inc**-**SI**-N	In the northeastern United States, this species is known to breed in dense forests of balsam fir (*Abies balsamea*) and/or red spruce (*Picea rubens*) (Lambert et al., 2005; Rimmer et al., 2005a). Likewise, in the Maritimes, this species inhabits with stunted coniferous trees (balsam fir mixed with spruce and birch in particular) or plantations consisting of similar tree species (Rimmer et al., 2005a; de Boer, 2008). Even in Quebec, balsam fir is a key species for harboring Bicknell's thrush (Connolly, 2000). Because balsam fir as well as red spruce will be vulnerable to severe climate change scenario, not only "SI" but also "Inc" were chosen in this scenario.
C4b (Diet)	Inc-SI-**N**-SD Inc-SI-**N**-SD	This species is insectivorous during breeding season (Rimmer et al., 2005b). Arthropod biomass significantly affected reproduction activity of this species in Vermont (Strong et al., 2004).
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	There are already declines of populations in the United States (Rimmer et al., 2005). For instance, 7% population decline per year was constantly observed in New Hampshire during 1993-2003 (Lambert et al., 2008).
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	According to a GIS-based simulation study, a temperature increase of 1 °C could decrease this species' habitats by 48% to 66% in the northeastern United States (Lambert and McFarland, 2004). Rodenhouse et al. (2008)

		also projected such negative trends. According to the latest study by Ralston and Kirchman (2013), this species' distribution will be expanded under SRES-A2 scenario but shrunk under SRES-B2 scenario, in 2080 respectively. Yet, the authors did not give detailed explanations for this discrepancy between the scenarios. Furthermore, the same study predicted that the centroid of the distribution will move northwards by 180-190 km under the both scenarios in 2080.			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	50	50	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario	-------------------------------	-------------------------------			
Severe scenario	-------------------------------				
	This species' habitats are highly fragmented (Rimmer et al., 2005a). In the Maritimes, this species is confined to highlands like Cape Breton Highlands (altitude > around 450 m) (de Boer, 2008). This species is mainly distributed in New York and northern New England in breeding season, while there are small patches in Quebec, New Brunswick as well as Nova Scotia (Lambert and McFarland, 2004). In this sense, the main distribution is located in more southern positions than Cape Breton. However, these southern habitats are at high elevations. A linear negative relationship between latitude elevation for Bicknell's Thrush occurrence (-81.6 m/1◦ latitude) suggested that this species' distribution was primarily determined temperature gradients (Lambert et al, 2005). According to this equation, a suitable habitat for this species in Cape Breton Highlands should be at 660 m a.s.l. or higher than it, and therefore this park is likely to be too warm for this species. In the northeastern United States, this species is known to breed in dense forests of balsam fir (*Abies balsamea*) and/or red spruce (*Picea rubens*) (Lambert et al., 2005; Rimmer et al., 2005a). Likewise, in the Maritimes, this species inhabits with stunted coniferous trees (balsam fir mixed with spruce and birch in particular) or plantations consisting of similar tree species (Rimmer et al., 2005a; de Boer, 2008). Even in Quebec, balsam fir is a key species for harboring Bicknell's thrush (Connolly, 2000). Climate change will be somewhat beneficial for the species in terms of distrubance regimes, but temperature increase will affect Bicknell's thrush directly and indirectly (via decrease of suitable habitats). Thus, this species is highly vulnerable to climate change. Because impacts of climate change might not be strong under moderate climate change scenario, however, both of HV and MV were given for the species.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of hermit thrush (*Catharus guttatus*) in Cape Breton Highalnds National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Open woodlands including cut-over areas are possibly utilized by this species (Godfrey, 1986; Erskine, 1992). This species was highly abundant in burned sites, but not clearcuts, in Quebec (Imbeau et al., 1999). In contrast, according to a study in northern New Hampshire, it was distributed in mature forests and shelterwoods, but not clearcuts (King and DeGraaf, 2000). In the central Appalachians, this species inhabited mature mixed forests that were disturbed by road building (Dellinger et al., 2007). In eastern Ontario and southern Quebec, this species reacted to forest covers negatively and fragmentation positively (Trzcinski et al., 1999). However, the artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Cape Breton species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species is a migratory bird, which stays in Baja California, Guatemala, and southern Florida during winter (Godfrey, 1986). However, this species is regarded as a short-distance migrant (MacMynowski and Root, 2007).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species' breeding area ranges from central Alaska to southern California or western Maryland (Godfrey, 1986), and therefore Cape Breton is climatically situated in a middle part of the species' range. In high boreal ecoclimatic region in central Labrador, this species' abundance was positively correlated with temperature during June and July in 2000, but not in 2001 or 2002 (Simon, 2005).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	This species could inhabit a wide range of hydrological niches, from bogs/swamps to dry sandy sites (Godfrey, 1986). In contrast, according to a study in central Labrador, this species was associated with lakes (Simon, 2005).
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	Open woodlands including cut-over areas are possibly used by this species (Godfrey, 1986; Erskine, 1992). In the southwestern United States, this species was more abundant before fires than thereafter (Bock and Block, 2005). In contrast, this species was highly abundant in burned sites, but not clearcuts, in Quebec (Imbeau et al.,

		1999). According to a study in northern New Hampshire, this species was distributed in mature forests and shelterwoods, but not clearcuts (King and DeGraaf, 2000). In the central Appalachians, this species inhabited mature mixed forests that were disturbed by road building (Dellinger et al., 2007).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species might dislike snow (Stouffer and Dwyer, 2003). Available food could be restricted due to snow cover for particularly ground foraging bird species (Diggs, 2008). Yet, this species does not stay in Cape Breton during winter, and therefore the subfactor of C2d is regarded as neutral (irrelevant).
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	This species inhabits mixed forests as well as coniferous forests (Godfrey, 1986). There were no significant deviations among responses of this species to coniferous, deciduous, and mixedwood stands in Quebec (Girard et al., 2004). In contrast, this species was strongly associated with hemlock in central Conneticut (Tingley et al., 2002). According to a study in central Labrador, this species was the most abundant in lichen woodlands (Simon, 2005). In the central Appalachians, this species inhabited mature mixed forests, but not mature deciduous forests (Dellinger et al., 2007).
C4b (Diet)	Inc-SI-N-**SD** Inc-SI-N-**SD**	This species feeds on seeds as well as invertebrates (arthropods) (Long and Stouffer, 2003; MacMynowski and Root, 2007). The preferred food, arthropods, could be unavailable during cold winter (Diggs, 2008). In other words, such food is probably available even during winter season, if temperature is warm enough (e.g., 11.7°C in January 2000 in Louisiana) (Brown and Long, 2006).
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	A mean arrival date of this species at summer sites in New York has been significantly earlier for 1951-1993 than 1903-1950 by around one month, but a similar significant change was not detected in Massachusetts (Butler, 2003). Spring migration time (mean arrival date) of hermit thrush significantly changed with spring temperature increase (MacMynowski and Root, 2007; Miller-Rushing et al., 2008).
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	As long as coniferous forests are manintained for the purpose of fibre production, this species is likely to be persistent in the Maritimes (Erskine, 1992). However, global warming will be negative for such coniferous

		forests there (Erskine, 1992).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	50	50
Severe scenario	0	0	0	0	100
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------		
Severe scenario		-------------------------------	-------------------------------		
	This species' breeding area ranges from central Alaska to southern California or western Maryland (Godfrey, 1986), and therefore Cape Breton is climatically situated in a middle part of the species' range. In high boreal ecoclimatic region in central Labrador, this species' abundance was positively correlated with temperature during June and July in 2000, but not in 2001 or 2002 (Simon, 2005). This species inhabits mixed forests as well as coniferous forests (Godfrey, 1986). There were no significant deviations among responses of this species to coniferous, deciduous, and mixedwood stands in Quebec (Girard et al., 2004). In contrast, this species was strongly associated with hemlock in central Conneticut (Tingley et al., 2002). According to a study in central Labrador, this species was the most abundant in lichen woodlands (Simon, 2005). In the central Appalachians, this species inhabited mature mixed forests, but not mature deciduous forests (Dellinger et al., 2007). Therefore, although temperature increase per se may not be influential on the species, declines of boreal conifer species will lead to, in part, reduction of suitable habitats for the same species under future climates. This effect of climate change on hermit thrush, which inhabits mixed forests, may be weaker than that on other species that inhabit just boreal forests. Therefore, vulnerability degree was judged less seriously than that of such boreal bird/mammal species.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of chimney swift (*Chaetura pelagica*) in Cape Breton Highalnds National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Wake (2013) suggested that this species is tightly linked with chimneys in urban areas. This species is most likely to be found in urban areas in the Maritimes as well, while mature forests with large hollow trees could be also habitats for this species in rural areas (de Boer, 2008). On the other hand, road-kills of migrating swifts were found relatively frequently in Indiana (Glista et al., 2008). However, the artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Cape Breton species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species winters in South America (the upper Amazon River drainage) (Godfrey, 1986; Dionne et al., 2008), and therefore it is a long-distance migratory bird.
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD**	This species is distributed from southern Canada (e.g., Saskatchewan and Nova Scotia) to the southern United States (e.g., southeastern Texas and central Florida) during breeding season (Godfrey, 1986), and therefore Cape Breton is climatically situated in the northern limit of the species' range. In accordance with this, this species is evenly distributed across the Maritimes except Prince Edward Island (de Boer, 2008). However, it was also noted that, at the northern limit of this species' distribution in Canada, chimneys or similar hollow habitats are important for it, offering warmer and thermally more stable conditions than outsides during cool nights (Wake, 2013). Actually, according to an experimental study, most swifts have become torpid or died at the cold temperature of 0◦C (Ramsey, 1970). Furthermore, in Illinois, these swifts often did not leave from chimneys for a long time in cold or rainy days, when just few insects were available in the air (Zammuto and Franks, 1981).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	This species feeds on insects that are associated with wetlands (Wake, 2013).

C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-**SD**-Dec	This species generally prefers open water/land (Godfrey, 1986). This species is most likely to be found in urban areas in the Maritimes, while mature forests with large hollow trees could be also habitats for this species in rural areas (de Boer, 2008). In contrast, even this species could die due to hurricanes in combination with low temperatures in Nova Scotia (Dionne et al., 2008). Wake (2013) postulated that such hurricane-related mortality has been or would be increased due to climate change. However, too weak winds (slower than 8 km/h) lead to fewer insects in the air, and therefore swifts are more likely to stay in chimneys in calmer days (Zammuto and Franks, 1981).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Large hollow trees could be also habitats for this species in rural areas (de Boer, 2008). However, Wake (2013) mentioned that seemingly available horrow trees were not utilized by this species in both logged and unlogged stands.
C4b (Diet)	Inc-**SI**-N-SD Inc-**SI**-N-SD	This species catches flying insects (e.g., mosquitoes, midges, gnats, mayflies) (Godfrey, 1986; Erskine, 1992; Wake, 2013). 98% components of sampled chimney swift guano was Coleoptera and Hemiptera in Ontario (Nocera et al., 2012).
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	The first arrival dates after this species' spring migration were significantly and negatively correlated with temperature in both two sites (New York and Massachusetts) (Butler, 2003). However, similar phenological flexibility has not been reported in or around Cape Breton Highlands National Park.
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Climate change could be included as a partial reason for remarkable decline of this species' populations in North America, but the detail has never been clarified yet (Wake, 2013). The cited author proposed, as just one possibility, that climate change could alter phenology and abundance of insects, which are primary foods for chimney swifts.
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	77	23
Severe scenario	0	0	0	0	100
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	
Severe scenario				-------------------------------	
	This species is distributed from southern Canada (e.g., Saskatchewan and Nova Scotia) to the southern United States (e.g., southeastern Texas and central Florida) during breeding season (Godfrey, 1986), and therefore Cape Breton is climatically situated in the northern limit of the species' range. At the northern limit of this species' distribution in Canada, chimneys or similar hollow habitats are important for it, offering warmer and thermally more stable conditions than outsides during cool nights (Wake, 2013). Actually, according to an experimental study, most swifts have become torpid or died at the cold temperature of 0◦C (Ramsey, 1970). Furthermore, in Illinois, these swifts often did not leave from chimneys for a long time in cold or rainy days, when just few insects were available in the air (Zammuto and Franks, 1981). Therefore, temperature increase will be beneficial for the species. Yet, it is evenly distributed across the Maritimes except Prince Edward Island already (de Boer, 2008), and drastic growth of the species' population is unlikely to occur anymore. In this regard, the option of HA was not chosen.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

References cited in just this sheet (references that were already cited in the main text as common documents for many species are not shown here.)

Butler, C. J. (2003). The disproportionate effect of global warming on the arrival dates of short‐distance migratory birds in North America. Ibis, 145(3), 484-495.

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[Assessment sheet] Climate change vulnerability assessments of olive-sided flycatcher (*Contopus borealis/cooperi*) in Cape Breton Highalnds National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Forest practices may have allowed this species to utilize forest-edge habitats, as before, in the Maritimes (Godfrey, 1986; Erskine, 1992; de Boer, 2008). Godfrey (1986) observed this bird staying usually throughout a summer season in a neighborhood of town in Nova Scotia. In northern New Hampshire, this species was observed in shelterwoods, but neither mature stands nor clearcuts (King and DeGraaf, 2000). In Montana, this species was distributed densely in artificially disturbed forests, but estimated nest success there was around half of that observed in naturally burned forests (Robertson and Hutto, 2007). In the Acadian forest region, this species was associated with old spruce-fir forest types (Mosseler et al., 2003). The artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Cape Breton species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species winters in South America (Godfrey, 1986), and therefore it is a long-distance migratory bird species.
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species is distributed from central Alaska to the southern United States like northern New Mexico during breeding season (Godfrey, 1986), and therefore Cape Breton is climatically situated in a middle part of the species' range. de Boer (2008) also documented that this species was distributed evenly across the Maritimes.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Suitable habitats for this species are associated with wetland areas, such as rivers and bogs, in the Maritimes (de Boer, 2008). In contrast, this species' habitats were associated with open woodlands, but not wetlands in the Great Lakes – St. Lawrence forest region (Hart et al., 2012).
C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-**SD**-Dec	This species is seen in open woodlands and disturbed places where a few trees are left after cutting or forest fires (Godfrey, 1986; Erskine, 1992; Hart et al., 2012). In northern New Hampshire, this species was observed in shelterwoods, but neither mature stands nor clearcuts (King and DeGraaf, 2000). In easatern Quebec, this species was abundant in 1980s, when much of forest there was dying due to budworm infestation (Bolgiano,

		2004). In Montana, this species was distributed densely in artificially disturbed forests, but estimated nest success there was around half of that observed in naturally burned forests, probably due to abundant nest predators in the former forest type (Robertson and Hutto, 2007). In the southwestern United States, this species was more abundant after fires (Bock and Block, 2005). Too dense stands without thinning could be harmful for this species, according to a study in Oregon (Spies et al., 2007). In northwestern California, acknowledging the fact that this species is often seen in postfire sites, Meehan and George (2003) reported that wildfires could be still negative for this species' reproduction. In central Vermont, detected individual number of this species was not changed significantly between before- and post- ice storms, suggesting no effects of ice storms on this species (Faccio, 2003). In Acadian forest region, this species was associated with old spruce-fir forest types (Mosseler et al., 2003).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	In central Vermont, detected individual number of this species was not changed significantly between before- and post- ice storms, suggesting no effects of ice storms on this species (Faccio, 2003).
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	
C4a (Other spp for habitat)	GI-Inc-**SI**-N GI-**Inc**-**SI**-N	This species is more common in coniferous forests than deciduous forests (Godfrey, 1986; Erskine, 1992). In northern/western Canada, this species was abundant in mature black spruce forests (Kirk et al., 1996). In the Maritimes, this species' habitats are generally surrounded by coniferous forests or mixed forests (de Boer, 2008). In Acadian forest region, this species was associated with old spruce-fir forest types (Mosseler et al., 2003), and snags are important for this species' foraging (Robertson and Hutto, 2007). Because balsam fir as well as spruces will be vulnerable to severe climate change scenario, not only "SI" but also "Inc" were chosen in this scenario.
C4b (Diet)	Inc-SI-**N**-SD Inc-SI-**N**-SD	This species is insectivore feeding on arthropods of Arachnida, Orthoptera, Hemiptera, Coleoptera, Lepidoptera, Diptera, and Hymenoptera (Meehan and George, 2003; Hutchings and Festa-Bianchet, 2009).
C4c (Pollination)	Inc-SI-N Inc-SI-N	(N/A)
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	In Maine, the arrival date of this species has barely changed (by just two days) between the two periods, 1899-1911 and 1994-1997 (Wilson et al., 2000).
D1	GI-Inc-SI-N-SD-Dec	

(Documented response)	GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	In North Pacific region in the United States, this species' populations were predicted to decline in the future climate scenarios of 2070 due to its strong association with coniferous forests (Veloz et al., 2013).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	0	0	74	26
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario		-------------------------------	-------------------------------		
Severe scenario		-------------------------------			
	This species is distributed from central Alaska to the southern United States like northern New Mexico during breeding season (Godfrey, 1986), and therefore Cape Breton is climatically situated in a middle part of the species' range. de Boer (2008) also documented that this species was distributed evenly across the Maritimes. Meanwhile, this species is more common in coniferous forests than deciduous forests (Godfrey, 1986; Erskine, 1992). In northern/western Canada, this species was abundant in mature black spruce forests (Kirk et al., 1996). In the Maritimes, this species' habitats are generally surrounded by coniferous forests or mixed forests (de Boer, 2008). In Acadian forest region, this species was associated with old spruce-fir forest types (Mosseler et al., 2003), and snags are important for this species' foraging (Robertson and Hutto, 2007). Therefore, although temperature increase per se may not be influential on the species directly, declines of spruce and/or fir populations may contribute to the species' vulnerability.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of blue jay (*Cyanocitta cristata*) in Cape Breton Highalnds National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Originally, matured hardwoods were good habitats for this species in the Maritimes, though it could also adapt to artificially modified environments (Erskine, 1992). The artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Cape Breton species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	Some individuals of this species migrate southwards from the Maritimes probably in order to find available food during winter, though other individuals stay there (Godfrey, 1986; Erskine, 1992).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD**	This species is distributed from southern Canada to the southern United States like southern Florida (Godfrey, 1986), and therefore warming may be beneficial for this species in Cape Breton Highlands. Lower and upper lethal temperatures for this species are -30.0◦C and 42.5◦C during non-breeding season but 8.0◦C and 42.0◦C during breeding season (Monahan, 2009).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	Originally, matured hardwoods were good habitats for this species in the Maritimes, but it could adapt to artificially modified environments as well (Erskine, 1992). According to a study comparing before/after an ice storm in Quebec, the abundance of this species was significantly reduced, suggesting that more frequent ice storms could be deteremental for such bird species (Blais et al., 2001). According to a literature review on prescribed fire impacts on this species in eastern deciduous forests in North America, its abundance has been not changed or inconclusive (Artman et al., 2005).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	According to a study comparing before/after an ice storm in Quebec, the abundance of this species was significantly reduced, suggesting that more frequent ice storms could be deteremental for such bird species (Blais et al., 2001). As well, snowfall may restrict food availability for this species, like spruce grouse.

C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** SD GI-Inc-**SI**-**N** SD	This species generally inhabits mixed and deciduous forests, particularly oak and beech forests, but it nests in conifers in the northern part of the Maritimes (Godfrey, 1986; Erskine, 1992). Because red oak and American beech are adaptable to climate change in Cape Breton Highlands National Park, the subscore of C4a should also contribute to jay's adaptation. In this regard, the subscore of SI was replaced by SD in terms of the MVA.
C4b (Diet)	Inc-SI-N-**SD** Inc-SI-N-**SD**	This species is omnivorous, eating fruits, insects, acorns and sometimes other birds (Godfrey, 1986).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	Spring migration time (mean arrival date) of blue jay significantly changed with spring temperature increase (Miller-Rushing et al., 2008).
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	It is likely that this species could adapt to environmental changes including global warming in the Maritimes (Erskine, 1992).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	0	100
Severe scenario	0	0	0	0	100
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario				-------------------------------	
Severe scenario				-------------------------------	-------------------------------
	This species is distributed from southern Canada to the southern United States like southern Florida (Godfrey, 1986), and therefore warming may be beneficial for this species in Cape Breton Highlands. Lower and upper lethal temperatures for this species are -30.0◦C and 42.5◦C during non-breeding season but 8.0◦C and 42.0◦C during breeding season (Monahan, 2009). This species generally inhabits mixed and deciduous forests, particularly oak and beech forests, but it nests in conifers in the northern part of the Maritimes (Godfrey, 1986; Erskine, 1992). Because red oak and American beech are adaptable to climate change in Cape Breton Highlands National Park, the subscore of C4a should also contribute to jay's adaptation. In this regard, the subscore of SI was replaced by SD in terms of the				

	MVA. Summing up, not only temperature increase but also vegetation change (to oak and beech stands) may be beneficial for blue jay. Therefore, the option of MA was chosen for the same species under the both climate change scenarios, and also another option of HA was chosen under severe climate change scenario to show such potentially high adaptability.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of spruce grouse (*Dendragapus/Falcipennis canadensis*) in Cape Breton Highalnds National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Even small straits could be hinderances for this species' movements, and it did not naturally expand its distribution to Newfoundland (Erskine, 1992). However, the natural barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park. Thus, the subcore in this subfactor was determined neutral even for Cape Breton species.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Open areas, including regenerating second-growth forests, are preferred by spruce grouse (Godfrey, 1986; Erskine, 1992).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	This species permanently inhabits northern North America, including Alaska, northeastern Oregon, and Maine (Godfrey, 1986). According to a two-year study in Ontario, median dispersal distances of this species during autumn season ranged between 336 and 714 m, and dispersals over than 2,000 m were also recorded (Beaudette and Keppie, 1992).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species permanently inhabits northern North America, including Alaska, northeastern Oregon, and Maine (Godfrey, 1986), and therefore Cape Breton is climatically situated in a middle part of the species' range.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	Wet lowland spruce and/or tamarack edges with bogs are useful habitats for this species in the southern/southeastern peripheries of this species' distribution (Williamson et al., 2008). Therefore, such wet sites could be kind of shelters in warm conditions. Bendell and Bendell-Young (2002) reported that this species' eggs lost water more quickly than ruffed grouse's eggs, suggesting that such moisture requirements of eggs could be a partial reason why this species inhabits moist coniferous forests. Anich et al. (2013) also reported that this species' dependence on coniferous swamps may be attributed to such eggs that can be easily dried. Yet, they also proposed another possibility of the fact that this species tends to gather in such swamps because of few mammalian predators there.
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	Open areas, including regenerating second-growth forests, are preferred by spruce grouse (Godfrey, 1986; Erskine, 1992). Relatively dense but early successional forests are frequently used by this species (Williamson et al., 2008). In Alaska, a mid-successional forest harbored more spruce grouses than a mature coniferous forest

		or early-successional shrub-saplings (Paragi et al., 1997).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	Snowfall may restrict food availability for spruce grouse (Johnsgard, 2008).
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species has also no specific geological preference, though it is a sedentary bird species.
C4a (Other spp for habitat)	GI-Inc-**SI**-N GI-**Inc**-**SI**-N	(Short-needled) coniferous forests are better for this species than hardwood or temperate forests in the Maritimes (Godfrey, 1986; Erskine, 1992; Williamson et al., 2008). In Maine and Minnesota, reproduction rate of the spruce grouse was lower in black spruce stands than jack pine stands, and the former stands needed immigration to keep the population size (Whitecomb et al., 1996). On the other hand, in the northern Wisconsin, protecting black spruce swamps was proposed as a crucial step to maintain this species' habitats, given the fact that 18 out of 25 detected nests were beneath black spruce trees (Anich et al., 2013). It means that this species utilzes multiple different coniferous species including upland pines and lowland spruces (Anich et al., 2013). Because black spruce as well as jack pine will be vulnerable to severe climate change scenario (c.f., Natural Resources Canada, 2014), not only “SI” but also “Inc” were chosen in this scenario.
C4b (Diet)	Inc-**SI**-**N**-SD Inc-**SI**-**N**-SD	Coniferous tree (short-needle pine in particular) needles and buds are often fed by this species, though berries are also consumed if available (Godfrey, 1986; Williamson et al., 2008).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Global warming will enhance growing temperate forests in the Maritimes, possibly being influencial on spruce grouse in a long term in a negative way (Erskine, 1992).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	0	25	75	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable

Moderate scenario		-------------------------------	-------------------------------		
Severe scenario		-------------------------------			
	Wet lowland spruce and/or tamarack edges with bogs are useful habitats for this species in the southern/southeastern peripheries of this species' distribution (Williamson et al., 2008). Therefore, such wet sites could be kind of shelters in warm conditions. Bendell and Bendell-Young (2002) reported that this species' eggs lost water more quickly than ruffed grouse's eggs, suggesting that such moisture requirements of eggs could be a partial reason why this species inhabits moist coniferous forests. Anich et al. (2013) also reported that this species' dependence on coniferous swamps may be attributed to such eggs that can be easily dried. Yet, they also proposed another possibility of the fact that this species tends to gather in such swamps because of few mammalian predators there. Open areas, including regenerating second-growth forests, are preferred by spruce grouse (Godfrey, 1986; Erskine, 1992). Relatively dense but early successional forests are frequently used by this species (Williamson et al., 2008). In Alaska, a mid-successional forest harbored more spruce grouses than a mature coniferous forest or early-successional shrub-saplings (Paragi et al., 1997). (Short-needled) coniferous forests are better for this species than hardwood or temperate forests in the Maritimes (Godfrey, 1986; Erskine, 1992; Williamson et al., 2008). In Maine and Minnesota, reproduction rate of spruce grouse was lower in black spruce stands than jack pine stands, and the former stands needed immigration to keep the population size (Whitecomb et al., 1996). On the other hand, in the northern Wisconsin, protecting black spruce swamps was proposed as a crucial step to maintain this species' habitats, given the fact that 18 out of 25 detected nests were beneath black spruce trees (Anich et al., 2013). It means that this species utilzes many different coniferous species including upland pines and lowland spruces (Anich et al., 2013). This is because coniferous tree (short-needle pine in particular) needles and buds are often fed by this species (Godfrey, 1986; Williamson et al., 2008). Therefore, given that spruces species are vulnerable to climate change in Cape Breton Highlands National Park, spruce grouse is also vulnerable to climate change. However, other foods like berries are also available for the same species, and there is no concern of direct influence of temperature increase on grouse in the Maritimes. Hence, the option of HV was not chosen here.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of boreal chickadee (*Parus/Poecile hudsonicus*) in Cape Breton Highalnds National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species could freely move within remaining mature-forest patches in Quebec, where clearcutting has fragmented boreal forests (Hadley and Desrochers, 2008). However, exposed edges were avoided by this species within regenerating stands during cold days (Hadley and Desrochers, 2008). Clear-cutting of coniferous forests have decreased available habitats for this species in New Brunswick (Erskine, 1992). The artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Cape Breton species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-**Dec** GI-Inc-SI-N-**SD**-**Dec**	There is probably no evidence about this species' migration. Yet, a reseacher following flocks of this species had to move for around 870 m within 53 min on average in Quebec (Hudley, 2006). Therefore, this species could disperse for at least 1-10 km and possibly more.
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	This species is distributed from the northern tree limit line in Alaska to the northernmost United States (e.g., central-northern Washington, northern New Hampshire, and Maine) (Godfrey, 1986; Erskine, 1992). Nova Scotia is close to the southern limit of this species' range at macrogeographic scale (Lait et al., 2012), though Cape Breton is not so close to the limit. Winter survival could be a major controlling factor for this species' population growth in the Maritimes (Erskine, 1992). Yet, this species is supposed to be capable to cope with extremely harsh conditions like −45◦C (Hadley and Desrochers, 2008).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	Mature coniferous forests are crucial for this species (Bolgiano, 2004). Clear-cutting of coniferous forests has decreased available habitats for this species in New Brunswick (Erskine, 1992). However, in Newfoundland, this species was significantly more abundant in 40- and 60-year stands than in old growth forests (> 80 -year)

<table>
<tr><td></td><td></td><td colspan="5">(Thompson et al., 2003).</td></tr>
<tr><td>C2d
(Ice/Snow)</td><td>GI-Inc-SI-**N**
GI-Inc-SI-**N** SD</td><td colspan="5">Snowfall may restrict food availability for this species, like spruce grouse.</td></tr>
<tr><td>C3
(Physical habitat)</td><td>Inc-SI-N-**SD**-**Dec**
Inc-SI-N-**SD**-**Dec**</td><td colspan="5"></td></tr>
<tr><td>C4a
(Other spp for habitat)</td><td>GI-Inc-SI-**N**
GI-Inc-SI-**N**</td><td colspan="5">This species inhabits coniferous and mixed forests, but possibly it could utilize decidous trees to forage (Godfrey, 1986; Erskine, 1992). Clear-cutting of coniferous forests has decreased available habitats for this species in New Brunswick (Erskine, 1992).</td></tr>
<tr><td>C4b
(Diet)</td><td>Inc-SI-N-**SD**
Inc-SI-N-**SD**</td><td colspan="5">According to a field survey in Alaska, this species stored various food, including insect larvaes, spruce seeds, and aphids (Haftorn, 1974). During budworm outbreaks, this species tends to be more abundant than usual (Bolgiano, 2004).</td></tr>
<tr><td>C4c
(Pollination)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5"></td></tr>
<tr><td>C4d
(Other spp for disp)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="5"></td></tr>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="5">This species could hybridize with black-capped chickadee (*Poecile atricapillus*), and such hybridization might be more frequent under warmer climates in Atlantic Canada (Lait et al., 2012).</td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5">This species in Newfoundland together with Nova Scotia was characterized unique mitochondrial haplotypes (Gill et al., 1993). According to Lait and Burg (2013), a population situated between New Brunswick and Nova Scotia harbored relatively high intra-population genetic diversity at mtDNA and nuclear microsatellite loci again. These results indicate that this population was derived from eastern refugia of this species after the Last Glacial Maximum (Lait and Burg, 2013). Although they did not examine samples in Cape Breton, these multiple results strongly implicates the fact that populations in Cape Breton may show at least a comparable genetic variation.</td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-**SI**-N-SD-Dec
GI-Inc-**SI**-N-SD-Dec</td><td colspan="5">This species' range in North America has shifted northwards by 43 km, according to a comparative study between 1967-1971 vs. 1998-2002 (Hitch and Leberg, 2006). Considering the fact that Nova Scotia is close to the southern limit of this species' range at macrogeographic scale (Lait et al., 2012), this shift could lead to population decline in Nova Scotia.</td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="5">As long as coniferous forests are manintained for the purpose of fibre production, this species is likely to be persistent in the Maritimes (Erskine, 1992). However, global warming will be negative for such coniferous forests there (Erskine, 1992).</td></tr>
<tr><td>The CCVI [%]</td><td colspan="2">Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
</table>

Moderate scenario	0	0	0	100	0
Severe scenario	0	0	0	100	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario					
Severe scenario					
	This species is distributed from the northern tree limit line in Alaska to the northernmost United States (e.g., central-northern Washington, northern New Hampshire, and Maine) (Godfrey, 1986; Erskine, 1992). Nova Scotia is close to the southern limit of this species' range at macrogeographic scale (Lait et al., 2012), though Cape Breton is not so close to the limit. Winter survival could be a major controlling factor for this species' population growth in the Maritimes (Erskine, 1992). Yet, this species is supposed to be capable to cope with extremely harsh conditions like −45◦C (Hadley and Desrochers, 2008). Hence, there are inconsistent pieces of information about the species' physiological thermal niche, and accordingly its vulnerability/adaptability was not determined in the MVA.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of gray jay (*Perisoreus canadensis*) in Cape Breton Highalnds National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Clear-cutting of mature coniferous forests may decrease available habitats for this species in New Brunswick (Erskine, 1992). However, forest openings are also included in available habitats of this species (Godfrey, 1986). Highways could contribute to mortality of this species in Algonquin Provincial Park in Ontario (Norris et al., 2013). The artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Cape Breton species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-Dec GI-Inc-SI-N-**SD**-Dec	In winter, this species still remain in breeding sites or sometimes move to somewhat south of these summering sites (Godfrey, 1986). Banded leavers of this species were found from their natal territories by intervals of 1.3-11.3 km in their first autumn in Quebec and Ontario (Strickland, 1991).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-**Inc**-**SI**-N-SD GI-**Inc**-**SI**-N-SD	In Algonquin Provincial Park, where is climatically similar to or a slightly cooler than Cape Breton Highlands National Park, temperature increase has negatively influenced reproduction activity of gray jays during 1980-2006 (Waite and Strickland, 2006).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species was more abundant in mesic upland forests than dry upland forests in Washington Cascade Range, but the difference was not significant (Lehmkuhl et al., 2007).
C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	This species is a representative bird species of mature coniferous forests (Desrochers, 2010). Clear-cutting of mature coniferous forests may decrease available habitats for this species in New Brunswick (Erskine, 1992). However, forest openings are also included in available habitats of this species (Godfrey, 1986).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	Snowfall may restrict food availability for this species, like spruce grouse.
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	

C4a (Other spp for habitat)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	Gray jays are usually associated with spruce and fir forests (Godfrey, 1986; Erskine, 1992). This species is distributed in entirely the Maritimes except where coniferous trees are lacking (Erskine, 1992). Thus, for the CCVI calculation, "SI" as well as "N" were chosen. However, for the MVA, only "SI" was chosen under severe climate change scenario, given that balsam fir as well as spruces will be vulnerable to severe climate change scenario
C4b (Diet)	Inc-SI-N-**SD** Inc-SI-N-**SD**	This species is likely to eat a variety of items, including dried fruits, and animal carcassess (Ouellet, 1970). For instance, this species prey on eggs, nestlings of other bird species like American robin or hermit thrush (Gutzwiller et al., 2002). Also, it predates some frog species (Tordoff, 1980).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	Although samples were not examined from Nova Scotia (including Cape Breton), Els et al. (2012) mentioned a possibility of putative refugium of which was in the Maritimes based on a result of phylogeographical analysis with mtDNA.
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	This species' range in North America has shifted northwards by 19 km, according to a comparative study between 1967-1971 vs. 1998-2002 (Hitch and Leberg, 2006). In Algonquin Provincial Park, where is climatically similar to or a slightly cooler to Cape Breton Highlands National Park, temperature increase has negatively influenced reproduction activity of gray jays during 1980-2006 (Waite and Strickland, 2006). This is likely because warmer autumns have led to perishability of stored food by gray jays (Waite and Strickland, 2006).
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%] Moderate scenario Severe scenario	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
	0	0	0	100	0
	0	0	23	77	0
The MVA** Moderate scenario Severe scenario	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
		--------------------------------	--------------------------------		
	--------------------------------	--------------------------------			
	In Algonquin Provincial Park, where is climatically similar to or a slightly cooler than Cape Breton Highlands National Park,				

	temperature increase has negatively influenced reproduction activity of gray jays during 1980-2006 (Waite and Strickland, 2006). Gray jays are usually associated with spruce and fir forests (Godfrey, 1986; Erskine, 1992). This species is distributed in entirely the Maritimes except where coniferous trees are lacking (Erskine, 1992). This species is a representative bird species of mature coniferous forests (Desrochers, 2010). Clear-cutting of mature coniferous forests may decrease available habitats for this species in New Brunswick (Erskine, 1992). However, forest openings are also included in available habitats of this species (Godfrey, 1986). Such negative changes may be noticeable under severe climate change scenario, while they might be unclear under moderate climate change scenario.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of American redstart (*Setophaga ruticilla*) in Cape Breton Highalnds National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Second growth forests and open woodlands are also available for this species, and extensive clear-cutting or agriculture have had scarcely influences this species at least in the Maritimes (Godfrey, 1986; Erskine, 1992). In southwestern Ontario, heavy forest cut affected this species positively, indicating a possibility of utilizing created gaps by this species (Holmes et al., 2004). The artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Cape Breton species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species is a migratory bird, which stays in Central or South America (including southern Canada) during winter (Godfrey, 1986).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species is distributed from southeastern Alaska to the southern United States like central Georgia during breeding season (Godfrey, 1986), and therefore Cape Breton is climatically situated in a middle part of the species' range. Forging frequency of this species has dropped by 44% at the ambient temperature of 30°C or more in California during autumn (Austin and Miller, 1982), though such high temperature is unlikely to occur in Cape Breton Highlands.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	Rainfall change (i.e., intensifying winter drought) caused by climate change in tropical zone influences spring departure of this species (Studds and Marra, 2011). Appropriate wintering habitats (more mesic sites) are limited, and such wintering habitat quality could influence arrival schedules and physical condition of migrating redstarts from south to north in spring (Marra et al., 1998). Therefore, ultimately, such hydrological changes in South America could influence vulnerability of this species in Cape Breton Highlands as well (Small-Lorentz et al., 2013). For instance, more precipitation in Jamaica or eastern Mexico is associated with advanced phenology of this species in Ontario or Alberta (McKellar et al., 2013). However, little is known about negative/positive impacts of hydrological changes in wintering sites on this species' survival in breeding

		sites like Cape Breton, and such impacts are not taken into account in this study.
C2c (Disturbance)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	Second growth forests and open woodlands are also available or preferred by this species, and extensive clear-cutting or agriculture have had scarcely influences this species at least in the Maritimes (Godfrey, 1986; Erskine, 1992). In southwestern Ontario, heavy forest cut affected this species positively, indicating a possibility of utilizing created gaps by this species (Holmes et al., 2004). According to a literature review on prescribed fire impacts on this species in eastern deciduous forests in North America, its abundance has been not changed or inconclusive (Artman et al., 2005). Overall, early- to mid- successional forests are suitable for this species' survival (Holmes and Sherry, 2001).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species often inhabits both mixed and deciduous forests (e.g., alders), but it could also be found in open woodlands or green spaces in urban areas (Godfrey, 1986; Erskine, 1992).
C4b (Diet)	Inc-SI-**N**-SD Inc-SI-**N**-SD	Insects with small wings (e.g., Diptera, Hymenoptera, Coleoptera, and Homoptera) are main prey for this species during its breeding season in New Hampshire (Holmes et al., 1978).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	A Newfoundland population of this species was distinctively differentiated from other populations in the mainland at mtDNA, though Cape Breton was not examined in the same study (Colbeck et al., 2008). The cited authors then suggested that it would need more studies to confirm if the Maritimes was an important refugium for such bird species during Last Glacial Maximum or not.
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	There are a number of relevant studies. According to a study in Ontario, this species did not show significant changes of migration timing during 1975-2000, when global warming was remarkable (Mills, 2005). Given the fact that some other species showed significant changes, though, phenology of American redstart seems to be regarded as somewhat insensitive to climate change. In contrast, the same species showed significantly shorter inter-migratory period (later spring migration and earlier autumn migration) than before (difference > 15 days) between 1961 and 2006 in Pennsylvania (Van Buskirk et al., 2009). According to Marra et al. (2005), median capture date of American redstart during its spring migration changed depending on temperature increase positively/negatively, and this trend was contrastive between sites (Pennsylvania vs. Ontario).

<table>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4">Threats on this species' population survival should be concerned in wintering or migration areas rather than in the Maritimes (Erskine, 1992). In support of this, appropriate wintering habitats (more mesic sites) are limited, and such wintering habitat quality could influence arrival schedules and physical condition of migrating redstarts from south to north in spring (Marra et al., 1998). For instance, higher plant productivity (measured by Normalized Difference Vegetation Index) in Caribbean led to higher abundance of this species in eastern North America during 1982-2007 (Wilson et al., 2011).</td></tr>
<tr><td rowspan="3">The CCVI [%]
Moderate scenario
Severe scenario</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td rowspan="4">The MVA**
Moderate scenario
Severe scenario</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td></td><td></td><td>------------------------------</td><td>------------------------------</td><td></td></tr>
<tr><td></td><td></td><td>------------------------------</td><td>------------------------------</td><td></td></tr>
<tr><td colspan="5">There is no much relevant subfactors to the species’ vulnerability/adaptability. Second growth forests and open woodlands are available or preferred by this species, and extensive clear-cutting or agriculture have had scarcely influences this species at least in the Maritimes (Godfrey, 1986; Erskine, 1992). In southwestern Ontario, heavy forest cut affected this species positively, indicating a possibility of utilizing created gaps by this species (Holmes et al., 2004). According to a literature review on prescribed fire impacts on this species in eastern deciduous forests in North America, its abundance has been not changed or inconclusive (Artman et al., 2005). Overall, early- to mid- successional forests are suitable for this species' survival (Holmes and Sherry, 2001). Because climate change will possibly bring about more intensified and/or frequent disturbances than now, it was judged as neutral or moderately beneficial for the species here.</td></tr>
</table>

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

References cited in just this sheet (references that were already cited in the main text as common documents for many species are not shown here.)

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[Assessment sheet] Climate change vulnerability assessments of greater yellowleg (*Tringa melanoleuca*) in Cape Breton Highalnds National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species migrates through the southern interior and along the Pacific/Atlantic oceans to the southern United States and South America (Godfrey, 1986).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-**Inc**-**SI**-N-SD GI-**Inc**-**SI**-N-SD	Greater Yellowlegs are distributed in mid latitudinal parts in Canada during breeding season, and Cape Breton is situated at the southern limit of this species' distribution (Godfrey, 1986). This species in the Maritimes breeds in Cape Breton Highlands as well as forested bogs on cool slopes of east-central Nova Scotia (Erskine, 1992).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	This species' habitats are generally associated with salt marshes, ponds, rivers, while it breeds in forested bogs, ponds, lakes and muskegs (Godfrey, 1986; Erskine, 1992). According to Ranalli (2010), open water areas with depth of 5-15 cm were preferred by this species in Kentucky. However, it should be noted that open woodlands that are not close to water are also used for breeding (Godfrey, 1986).
C2c (Disturbance)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	This species' habitats are generally associated with salt marshes, ponds, rivers, while it breeds in forested bogs, ponds, lakes and muskegs (Godfrey, 1986; Erskine, 1992). Open woodlands are also used for breeding (Godfrey, 1986).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	This species' habitats are generally associated with salt marshes, ponds, rivers, while it breeds in forested bogs, ponds, lakes and muskegs (Godfrey, 1986; Erskine, 1992). According to Ranalli (2010), open water areas with depth of 5-15 cm were preferred by this species in Kentucky.
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	

C4b (Diet)	Inc-SI-**N**-SD Inc-SI-**N**-SD	This species feeds on aquatic invertebrates (infauna) and also possibly other species like frogs (Ball et al., 1995; Alvarez et al., 2013). This species feeds on marine crustaceans, but not some kinds of crabs (e.g., fiddler crabs) (Anderson and Bartlett, 1996).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	In Manitoba, arrival dates of this species after spring migration have exceptionally been delayed than before (Murphy-Klassen et al., 2005). This trend was not significantly correlated with temperature, but still being contrastive with the trend that most other species have shown advancing arrival dates recently (Murphy-Klassen et al., 2005).
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	A long-term survival of this species may depend on if this species' wintering habitats are available in Latin America (Erskine, 1992).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	50	0
Severe scenario	0	0	5	44	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario		------------------------------	------------------------------		
Severe scenario		------------------------------	------------------------------		
	Greater Yellowlegs are distributed in mid latitudinal parts in Canada during breeding season, and Cape Breton is situated at the southern limit of this species' distribution (Godfrey, 1986). This species in the Maritimes breeds in Cape Breton Highlands as well as forested bogs on cool slopes of east-central Nova Scotia (Erskine, 1992). Because there are no other specific attributes that are relevant to the species' vulnerability/adaptability, the MVA gave MV and PS here to reflect just the physiological thermal niche. A long-term survival of this species may depend on if this species' wintering habitats are available in Latin America (Erskine, 1992).				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

References cited in just this sheet (references that were already cited in the main text as common documents for many species are not shown here.)

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[Assessment sheet] Climate change vulnerability assessments of American robin (*Turdus migratorius*) in Cape Breton Highalnds National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species utilizes farms, woodlots and thickets in rural areas but also ornamental plants in populated areas (Godfrey, 1986; Erskine, 1992). In contrast, densely forests areas are not much used (Godfrey, 1986; Erskine, 1992).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species is a migratory bird, which stays from southern Canada, Guatemala to southern Florida during winter (Godfrey, 1986).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species is distributed from the tree limit line in Alaska to the southern United States or Mexico during breeding season (Godfrey, 1986), and therefore Cape Breton is climatically situated in a middle part of the species' range.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	According to a study in northern Maine, nests of this species were likely to be situated close to wet sites (e.g., streams, spring seeps) (Knupp et al., 1977). In contrast, dry upland and riparian forests were more likely to be used than mesic upland forests in Washington Cascade Range, probably because open canopies were more common in dry uplands and riparian forests than the other (Lehmkuhl et al., 2007).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	Open fields, but not densely forests areas, are generally used by this species (Godfrey, 1986; Erskine, 1992). According to a literature review on prescribed fire impacts on this species in eastern deciduous forests in North America, its abundance has been coherently increased (Artman et al., 2005). Russell et al. (2009) also observed the most positive effect of prescribed fires on this species among 12 bird species. However, such fires are unlikely to occur easily in Cape Breton, and therefore fire effects should not be overestimated. Faccio (2003) found not siginificant decline of American robin populations after ice-storm in Vermont.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Faccio (2003) found not siginificant decline of American robin populations after ice-storm in Vermont. Ice and snow could also lead to poor food availability for this species during winter in Illinois (Huschen and Horn, 2012). Yet, this species does not winter in Cape Breton Highlands, and therefore such effects are not considered in this assessment.

C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species utilizes farms, woodlots and thickets in rural areas but ornamental plants in populated areas (Godfrey, 1986; Erskine, 1992). In contrast, densely forests areas are not much used (Godfrey, 1986; Erskine, 1992). According to a study in northern Maine, this species utilized both deciduous and coniferous forests (Knupp et al., 1977).
C4b (Diet)	Inc-SI-N-**SD** Inc-SI-N-**SD**	This species is omnivorous, eating mainly fruits, insects, worms (Godfrey, 1986). American robin is known as a primary predator and a seed disperser of blueberries, but such berries cannot grow or produce fruits well in Cape Breton due to its cooler climate than that of the mainland in Nova Scotia (Gibson, 2011).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	There are a number of relevant studies. This species has migrated from its wintering sites (lower altitude/latitude) to its breeding site (at 2,945 m a.s.l.) earlier than before (by around 14 days), possbly due to climate change, during the last 25 years in Colorado Rocky Mountains (Inouye et al., 2000). In contrast, laying date as well as clutch size have not significantly changed in North America over 50 years, when temperature has not significantly increased (Torti and Dunn, 2005). In Maine, the arrival date of this species has barely changed (by just three days) between the two periods, 1899-1911 and 1994-1997 (Wilson et al., 2000). Miller-Rushing et al. (2008) reported that North Atlantic Oscilliation index was significantly negatively correlated with the first arrival date of this species' migration.
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	It is likely that this species continues to be a common bird in the Maritimes because of its high adaptation ability (Erskine, 1992).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	0	100
Severe scenario	0	0	0	0	100
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	

Severe scenario			-------------------------------	-------------------------------	
	This species is distributed from the tree limit line in Alaska to the southern United States or Mexico during breeding season (Godfrey, 1986), and therefore Cape Breton is climatically situated in a middle part of the species' range. This species is omnivorous, eating mainly fruits, insects, worms (Godfrey, 1986). American robin is known as a primary predator and a seed disperser of blueberries, but such berries cannot grow or produce fruits well in Cape Breton due to its cooler climate than that of the mainland in Nova Scotia (Gibson, 2011). In other words, climate change will be possibly beneficial for the robin by improving availability of food (blueberries), though artificial introduction of blueberry will not take place in the national park due to its land use regulation. Therefore, both of PS and MA were given for the species under the two climate change scenarios.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

References cited in just this sheet (references that were already cited in the main text as common documents for many species are not shown here.)

Artman, V. L., Hutchinson, T. F., & Brawn, J. D. (2005). Fire ecology and bird populations in eastern deciduous forests. Studies in Avian Biology, 30, 127.

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[Assessment sheet] Climate change vulnerability assessments of red-eyed vireo (*Vireo olivaceus*) in Cape Breton Highalnds National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Second growth forests and logged areas could be available for this species (Godfrey, 1986).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species is a migratory bird, which stays in possibly South America during winter (Godfrey, 1986).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD**	This species is distributed from southern Canada to the southern United States like central Florida during breeding season (Godfrey, 1986), and therefore warming may be beneficial for this species in Cape Breton Highlands.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	Both climax hardwood species (e.g., sugar maple, yellow birch, American beech) and early-successional hardwood species (e.g., aspen, white birch) are available for this species' habitats (Godfrey, 1986; Erskine, 1992). Second growth forests and logged areas could be used (Godfrey, 1986). Faccio (2003) found significant decline of red-eye vireo populations after ice-storm in Vermont. In contrast, according to a meta-analysis, there have been inconsistent reports about if this species avoids or exploits forest edges (Lindell et al., 2007). Likewise, according to a literature review on prescribed fire impacts on this species in eastern deciduous forests in North America, its abundance has been decreased or not changed (Artman et al., 2005).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Faccio (2003) found significant decline of red-eye Vireo populations after ice-storm in Vermont.
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	
C4a (Other spp for habitat)	GI-Inc-SI-**N** SD GI-Inc-SI-**N** SD	Generally, deciduous trees and tall shrubs are utilized in this species' habitats (Godfrey, 1986; Erskine, 1992).

<table>
<tr><td></td><td></td><td colspan="5">Because such vegetation (plant structures) will be stable or flourish under warmer climates in general, the subscore of C4a was determined to be “Somewhat Decrease (vulnerability)” in the MVA.</td></tr>
<tr><td>C4b
(Diet)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5">This species feeds on vast number of insects and sometimes berries as well (Godfrey, 1986).</td></tr>
<tr><td>C4c
(Pollination)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5"></td></tr>
<tr><td>C4d
(Other spp for disp)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5"></td></tr>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5"></td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5"></td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5">There are a number of relevant studies. Although other migratory birds arrived at their wintering sites significantly earlier during 1951-1993 than 1903-1950 probably due to global warming, there was little change in arrival date by red-eye vireos between the two periods (Butler, 2003). This is probably because long-distance migratory birds rely on photoperiods while short-distance birds easily detect meteorological changes (Butler, 2003). Spring migration times (arrival dates) of long-distance migratory birds including red-eye vireos did not significantly change with temperature increase (Miller-Rushing et al., 2008). In contrast, this species showed great date shift of arrival at breeding sites, among examined 18 bird species, in response to spring temperature increase (Hurlbert and Liang, 2012). Such phenological changes may be different among sites as well as seasons (Swanson and Palmer, 2009).</td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="5"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="5">It is likely that this species continues to be a common bird in the Maritimes because of its high tolerance of habitats (Erskine, 1992).</td></tr>
<tr><td rowspan="3">The CCVI [%]
Moderate scenario
Severe scenario</td><td colspan="2">Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td colspan="2">0</td><td>0</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td colspan="2">0</td><td>0</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td rowspan="4">The MVA**
Moderate scenario
Severe scenario</td><td colspan="2">Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td colspan="2"></td><td></td><td>-------------------------------</td><td>-------------------------------</td><td></td></tr>
<tr><td colspan="2"></td><td></td><td></td><td>-------------------------------</td><td></td></tr>
<tr><td colspan="6">This species is distributed from southern Canada to the southern United States like central Florida during breeding season (Godfrey, 1986), and therefore warming may be beneficial for this species in Cape Breton Highlands. Generally, deciduous trees and tall shrubs are used in this species' habitats (Godfrey, 1986; Erskine, 1992). Because such vegetation will be stable or flourish under warmer</td></tr>
</table>

	climates, climate change will be possibly beneficial for vireo. However, the positive effects of climate change are indirect and not clearly supported by scientific evidence, the species' adaptability was expressed by PS and/or MA, but not HA.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

References cited in just this sheet (references that were already cited in the main text as common documents for many species are not shown here.)

Artman, V. L., Hutchinson, T. F., & Brawn, J. D. (2005). Fire ecology and bird populations in eastern deciduous forests. Studies in Avian Biology, 30, 127.

Butler, C. J. (2003). The disproportionate effect of global warming on the arrival dates of short-distance migratory birds in North America. Ibis, 145(3), 484-495.

Faccio, S. D. (2003). Effects of ice storm-created gaps on forest breeding bird communities in central Vermont. Forest Ecology and Management, 186(1), 133-145.

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[Assessment sheet] Climate change vulnerability assessments of Canada warbler (*Wilsonia canadensis*) in Cape Breton Highalnds National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Abundance of this species was more strongly associated with clearcuts or shelterwoods than mature stands in northern New Hampshire (King and DeGraaf, 2000). In contrast, this species inhabits matured or middle-aged forests in the Maritimes (Erskine, 1992). de Boer (2008) also documented that both young and mature forests could allow us to find this species in the same region.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species winters in South America (e.g., Columbia, Venezuela and central Peru) (Godfrey, 1986), and therefore it is a long-distance migratory bird.
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	This species is distributed from southern Canada (e.g., Alberta and Nova Scotia) to the southern United States (e.g., western Georgia) during breeding season (Godfrey, 1986), and therefore Cape Breton is climatically situated in the northern limit of the species' range. de Boer (2008) also documented that this species was commonly observed in cool forests in the Maritimes and that cool temperatures are important for its nesting. These pieces of information are inconsistent with each other, but there are no more available information about the species' physiological thermal niche. Therefore, in the current assessment, the subscore of the C2aii was undetermined.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	Shrubby areas along streams, swamps and other moist places are utilized as this species' habitats (Godfrey, 1986; Lambert and Faccio, 2005). Forested wetlands could contribute to high productivity of this species (Lambert and Faccio, 2005). de Boer (2008) also documented that this species was commonly observed in dense understory of moist forests in the Maritimes and that high humidity is important for its nesting.
C2c (Disturbance)	Inc-**SI**-N-**SD**-**Dec** Inc-**SI**-N-**SD**-**Dec**	Abundance of this species was more strongly associated with clearcuts or shelterwoods than mature stands in northern New Hampshire (King and DeGraaf, 2000). In contrast, this species inhabits matured or middle-aged forests in the Maritimes (Erskine, 1992). de Boer (2008) also documented that both young and mature forests could allow us to find this species in the same region. However, in old upland forests, this species generally occurs often with canopy gaps (Lambert and Faccio, 2005). Further, in uplands, this species is a disturbance

		specialist (Lambert and Faccio, 2005). According to Hobson and Shieck (1999), this species was more abundant in relatively old postharvest sites, where 28 years have passed since the harvest, than other young posthavest sites or postfire sites in Alberta. This is likely because older sites may harbor a larger number of available trees/shrubs for this warbler (Hobson and Shieck, 1999). Decline of this species' populations across Canada was strongly associated with decline of spruce budworms during 30 years, though the reason for this close link was not empirically clarified (Sleep et al., 2009). Venier et al. (2012) also did not support this relationship between Canada warbler and spruce budworm at nationwide scale during a longer period (40 years), though they found a significant relationship in Nova Scotia. COSEWIC (2008) suugested that, although warbler could inhabit even regerating stands that have experienced disturbances, deer grazing could also affect warbler's habitat negatively. Yet, in Cape Breton Highlands, where moose have already disturbed vegetation significantly, the effect of grazing may be relatively weaker in the future than now if moose population will decline.
C2d (Ice/Snow)	GI-Inc-SI-N GI-Inc-SI-N	In uplands, this species is a disturbance specialist, often inhabiting forest patches after disturbance, including ice damage (Lambert and Faccio, 2005). In other words, ice storms are beneficial for this species on a landscape level (Faccio, 2003), but Faccio (2003) could not detect significant effects of ice storms on detected individual number of this species in central Vermont. Yet, this species does not stay in Cape Breton in winter, and therefore ice effects should be irrelevant to vulnerability of this species in this park.
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	Both uplands and lowlands are used as habitats by this species (Lambert and Faccio, 2005).
C4a (Other spp for habitat)	GI-Inc-SI-N SD GI-Inc-SI-N SD	This species inhabits forests with intricate structures including willows, alders, shrubs and/or uneven forest floors, because it forages and nests on ground or shrub layer (Lambert and Faccio, 2005). The same species is generally associated with broad-leaved forests as well as shrubs (e.g., alder and willow) in the Maritimes as well (Godfrey, 1986; Erskine, 1992). de Boer (2008) also documented that this species was commonly observed in mixed-forests consisting of coniferous trees as well as broad-leaved trees in the same region. COSEWIC (2008) reported that this species can inhabit a wide range of vegetation. Furthermore, dead trees (i.e., snags) significantly contributed to high abundance of this species in northern New Hampshire (King and DeGraaf, 2000). Global warming is likely to be beneficial for broad-leaved forests in the Maritimes, and therefore this bird species will also persist (Erskine, 1992). Based on this possibility, the subscore of C4a was "Neutral" and "Somewhat Decrease (vulnerability)" in the MVA.
C4b (Diet)	Inc-**SI**-N-SD Inc-**SI**-N-SD	This species feeds on sessile invertebrates (mainly mosquitos and flies) (Lambert and Faccio, 2005; Wolfe and Ralph, 2009). This dietary plasticity allows this species to be insensitive to climatic variability (Wolfe and Ralph, 2009).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-N Inc-SI-N	

<table>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4">There are a number of relevant studies. Although other migratory birds arrived at their wintering sites significantly earlier during 1951-1993 than 1903-1950 probably due to global warming, there was little change in arrival date by Canada warblers between the two periods (Butler, 2003). This is probably because long-distance migratory birds rely on photoperiods while short-distance birds easily detect meteorological changes (Butler, 2003). According to Marra et al. (2005), median capture date of Canada warblers during its spring migration was negatively correlated with temperature increase, though this relation was not significant in both Pennsylvania and Ontario. In contrast, spring migration times (arrival dates) of this species was negatively correlated with temperature increase in Massachusetts, and this relation was statistically siginificant (Miller-Rushing et al., 2008). In Maine, the arrival date of this species has barely changed (by just two days) between the two periods, 1899-1911 and 1994-1997 (Wilson et al., 2000).</td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4">Global warming is likely to be beneficial for broad-leaved forests in the Maritimes, and therefore this bird species will be also persist (Erskine, 1992).</td></tr>
<tr><td rowspan="3">The CCVI [%]
Moderate scenario
Severe scenario</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>86</td><td>14</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>16</td><td>84</td></tr>
<tr><td rowspan="4">The MVA**
Moderate scenario
Severe scenario</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">This species is distributed from southern Canada (e.g., Alberta and Nova Scotia) to the southern United States (e.g., western Georgia) during breeding season (Godfrey, 1986), and therefore Cape Breton is climatically situated in the northern limit of the species' range. de Boer (2008) also documented that this species was commonly observed in cool forests in the Maritimes and that cool temperatures are important for its nesting. These pieces of information are inconsistent with each other, but there are no more available information about the species' physiological thermal niche. Therefore, in the current assessment, the subscore of the C2aii was undetermined. Accordingly, the species’ vulnerability/adaptability was also undetermined in the MVA.</td></tr>
</table>

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of American eel (*Anguilla rostrata*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	Erected barriers in freshwater courses could interrupt upward migration of juvenile eels (COSEWIC, 2012). Considering the steepness of Cape Breton Highlands and lack of precise information about natural barriers (i.e., uncertainty of the barrier effects), GI, Inc, and SI may be candidate subscores to show the barrier for eel. Yet, this species inhabits warm water, and natural barriers, like those among cold refugia for brook trout, are not likely to affect it. Thus, GI schore was not chosen, and only Inc as well as SI were chosen. Also, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered, and only SI was chosen (assuming that Inc should be chosen for the species without highlands).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Dams and overfishing were documented as actual threats for this species (COSEWIC, 2012). Artificial barriers, like hydroelectric facilities, are considered as a partial reason for remarkable decline of eel populations in the upper St. Lawrence River and Lake Ontario system (COSEWIC, 2012). However, such reports were not explicitly given for eels in Cape Breton.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	Silver eels could migrate from Nova Scotia to the Sargasso Sea for distances of around 2,000 km (COSEWIC, 2012).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD**	The most optimal temperature for American eels ranges between 16.7 and 17.4◦C, while higher temperature of 22-25◦C is best for its growth (Jessop, 2010). Cape Breton is likely to be situated at a little more northern side of this species' most optimal habitats (at around 37-38° N), which means that this place is thermally stressful for American eels (Laflamme et al., 2012). This possibility was supported by relatively high RNA/DNA ratio as well as low Fulton's condition factor (Laflamme et al., 2012).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	This species inhabits a wide variety of habitats including both shallow and deep waters (COSEWIC, 2012).
C2c (Disturbance)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	This species inhabits a wide variety of habitats including marine and freshwater circumstances (COSEWIC, 2012). In other words, as far as depending on previously documented information, disturbance intensity seems

		to be irrelevant to vulnerability of this species.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	Prolonged snow periods in coastal areas could lead to limited growth periods for eels (Jessop et al., 2004).
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species inhabits a wide variety of habitats including marine and freshwater circumstances (COSEWIC, 2012). Growing eels generally use rocks, sands or mud substrates with woody debris and submerged vegetation, while overwintering eels stay in mud bottoms in bay or estuary habitats (COSEWIC, 2012). This species has a high tolerance to pH, but still low pH like the range of 4.7-5.0 could be fatal for elvers (Jessop, 2000). In other words, every lake and river may include some comfortable habitats for this species (COSEWIC, 2012).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C4b (Diet)	Inc-SI-**N**-**SD** Inc-SI-**N**-**SD**	Leptocephali feeds on dissolved organic carbon (DOC) including fecal pellets as well as discarded shelters of larvacean tunicates (COSEWIC, 2012). Elvers could forage insect larvaes, and yellow eels are benthic omnivores, feeding on fish, crayfish, insect larvaes, plants and so on (COSEWIC, 2012).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	An invasive swim bladder nematode parasite, *Anguillicola crassus*, has been identified even in Cape Breton, possibly leading to mass mortality (Aieta and Oliveira, 2009). However, this parasite's distribution seems to be not affected by temperature (Aieta and Oliveira, 2009).
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	A population genetic study sampled yellow eels in Margaree Harbour in Cape Breton, but any information about genetic variation in this population was not documented (Côté et al., 2013).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Broadly, warming in Sub-Tropical Gyre (STG) spawning area as well as oceanographic changes could bring about negative impacts on American eels (Knights, 2003). For instance, it was suggested that eel larvae populations in Atlantic could be negatively affected by climate change through bottom-up trophic regulation (decreased primary production) (Bonhommeau et al., 2008). In contrast, recent warming in continental areas in northern hemisphere, like temperatures > 20◦C, could be beneficial for eel's growth (Knights, 2003). However, the former negative impacts may outweigh the latter positive influence (Knights, 2003), and also details have not been clarified yet (COSEWIC, 2012). From a Mi'kmaq Perspective for Cape Breton Highlands National

		Park, eels ' reactions to future climate change is documented to be unknown (Denny and Paul, 2010).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	86	14
Severe scenario	0	0	0	27	73
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	
Severe scenario				-------------------------------	
	The most optimal temperature for American eels ranges between 16.7 and 17.4◦C, while higher temperature of 22-25◦C is best for its growth (Jessop, 2010). Cape Breton is likely to be situated at a little more northern side of this species' most optimal habitats (at around 37-38° N), which means that this place is thermally stressful for American eels (Laflamme et al., 2012). This possibility was supported by relatively high RNA/DNA ratio as well as low Fulton's condition factor (Laflamme et al., 2012). Therefore, while erected barriers in freshwater courses could interrupt upward migration of juvenile eels (COSEWIC, 2012), temperature increase *per se* will contribute to adaptation of eel in Cape Breton Highlands National Park. Because a small thermal change might not be noticeable because of the interrupting subfactor, not only MA but also PS were chosen here. Also, the positive impacts of climate change on eel may be smaller than those on some other warmwater fish species (e.g., white perch), and hence HA was not given for eel.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of Atlantic salmon (*Salmo salar*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	Steep gradients and many small waterfalls, like in North River, may be hinderances for fish which try to ascend rivers in Cape Breton (Landry et al., 2005; Amiro et al., 2006). Considering the steepness of Cape Breton Highlands and lack of precise information about natural barriers (i.e., uncertainty of the barrier effects), GI, Inc, and SI may be candidate subscores to show the barrier for eel. Yet, this species inhabits warm water, and natural barriers, like those among cold refugia for brook trout, are not likely to affect it. Thus, GI schore was not chosen, and only Inc as well as SI were chosen. Also, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered, and only SI was chosen (assuming that Inc should be chosen for the species without highlands).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Salmon habitats in the eastern Cape Breton Island are relatively not impacted by human activities, and water quality has been kept in a good condition (Amiro et al., 2006). Also, salmon rivers often run through highly exploited landscapes, though anthropogenic impacts on this species are not fully understood (Aas et al., 2011).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	Salmon go down to the sea and stay there over one or multiple winter(s), and thereafter they return to their natal rivers in Cape Breton (Amiro et al., 2006; Hubley et al., 2008). According to a survey on kelts in the mainland of Nova Scotia using acoustic telemetry, the migration rate varied between 1.61 km/day to 16.2 km/day (a mean rate = 3.7 km/day) (Hubley et al., 2008).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	This species is native to temperate and subarctic regions of the north Atlantic Ocean (Aas et al., 2011). There is a number of studies relevant to thermal characteristics of the Atlantic salmon. For instance, temperature higher than 25-28°C could give thermal stress on salmon, whereas this species may be able to survive at low temperature probably below 0°C (Elliott, 1991). In contrast, cold temperature of 6-7°C or lower than this could be critical for Atlantic salmon, supressing its growth (Sigholt and Finstad, 1990; Elliott, 1991). The most vulnerable stage of this species to climate change is, however, an egg stage. Salmon eggs could be critically damaged by temperatures colder than 0°C or hotter than 16°C (Elliott and Elliott, 2010). In the Cheticamp River in Cape Breton Highlands National Park, a mean daily water temperature was mostly below 20°C in 2004, and such a thermal condition was judged as not critical for salmon (Landry et al., 2005). In the Margaree River in Cape Breton, different temperature regimes between tributary sites could not explain different growth rates of salmon juveniles, but still the faster growth rate of salmon juveniles at the Southwest main site than other sites was attributed to a warm water temperature in combination with high productivity (Strothotte et al.,

		2005). Although the most known salmon populations in eastern Cape Breton are declining or below conservation requirements, ecosystem change including climate change has not been recognized as a serious threat for these populations (Gibson and Bowlby, 2009). Likewise, in western Cape Breton, thermal conditions are not regarded as threats for salmon (Breau et al., 2009). Hence, anticipated temperature increase will not be adverse in summer but somewhat beneficial in winter for salmon in the park.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-**SD**-Dec	Atlantic salmon is photonegative during winter but photopositive during summer, which was also observed in Nova Scotia (Cunjak, 1988). Therefore, some vegetation may be beneficial for this species.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	Maintainance of limited activity of Atlantic salmon during winter in Nova Scotia was, in part, regarded as adaptation to icy and frozen water conditions (Cunjak, 1988). Earlier snowmelt could be beneficial for salmon migration in early summer (Aas et al., 2011).
C3 (Physical habitat)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	Atlantic salmon in Nova Scotia are threatened by medium to high acidity (Amiro et al., 2006). Acid neutralization capacity (ANC) is limited in Cape Breton Highlands, where base cations of Ca^{2+} and Mg^{2+} are not fully dissolved (Clair et al., 2007). However, sulphate deposition has been relatively limited in Cape Breton, and this is why most lakes in this island have maintained pH without significant acidification (Ginn et al., 2007). Exceptionally, few lakes are much sensitive to acid substances like SO_4^{2-} and showing low pH (e.g., pH = around 5.0 in Glasgow Lake) (Gerber et al., 2008). Therefore, significant habitat restrictions due to pH are unlikely to have occurred in Cape Breton Highlands. Also, salmon habitats for especially spawning could be characterized with excavatable substrate by female salmon together with sufficient oxygenation (Aas et al., 2011). Such habitats are often found in the tails of pools (Aas et al., 2011).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C4b (Diet)	Inc-SI-**N**-SD Inc-SI-**N**-SD	Juvenile salmon are opportunistic feeders, eating mainly mayflies, stoneflies, caddisflies, chironomids, blackflies and terrestrial invertebrates (Aas et al., 2011).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a	Inc-**SI**-**N**-SD	O'Reilly (2006) reviewed population genetic studies of Atlantic salmon in eastern Canada. Although a salmon

(Genetic variation)	Inc-SI-N-SD	population in Margarette River in Cape Breton was a genetically normal population, another population in North River was highly differentiated from other populations in Atlantic Canada at allozyme loci (Verspoor, 2005). Meanwhile, restriction enzyme analysis with mitochondrial genome showed moderate levels of genetic variations within two salmon populations in Cape Breon Island in comparison with other populations in New Brunswick as well as the mainland of Nova Scotia (Verspoor et al., 2005).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Although the most known salmon populations in eastern Cape Breton are declining or below conservation requirements, ecosystem change including climate change has not been recognized as a serious threat for these populations (Gibson and Bowlby, 2009).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	0	31	69	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	
Severe scenario				-------------------------------	
	This species is native to temperate and subarctic regions of the north Atlantic Ocean (Aas et al., 2011). There is a number of studies relevant to thermal characteristics of Atlantic salmon. For instance, temperature higher than 25-28°C could give thermal stress on salmon, whereas this species may be able to survive at low temperature probably below 0°C (Elliott, 1991). In contrast, cold temperature of 6-7°C or lower than this could be critical for Atlantic salmon, supressing its growth (Sigholt and Finstad, 1990; Elliott, 1991). The most vulnerable stage of this species to climate change is, however, an egg stage. Salmon eggs could be critically damaged by temperatures colder than 0°C or hotter than 16°C (Elliott and Elliott, 2010). In the Cheticamp River in Cape Breton Highlands National Park, a mean daily water temperature was mostly below 20°C in 2004, and such a thermal condition was judged as not critical for salmon (Landry et al., 2005). In the Margaree River in Cape Breton, different temperature regimes between tributary sites could not explain different growth rates of salmon juveniles, but still the faster growth rate of salmon juveniles at the Southwest main site than other sites was attributed to a warm water temperature in combination with high productivity (Strothotte et al., 2005). Although the most known salmon populations in eastern Cape Breton are declining or below conservation requirements, ecosystem change including climate change has not been recognized as a serious threat for these populations (Gibson and Bowlby, 2009). Likewise, in western Cape Breton, thermal conditions are not regarded as threats for salmon (Breau et al., 2009). Hence, anticipated temperature increase will not be adverse in summer but somewhat beneficial in winter for salmon in the park. Earlier snowmelt could be beneficial for salmon migration in early summer (Aas et al., 2011). Given these effects, climate change will be beneficial for salmon particularly under severe climate change scenario. Yet, salmon is not a warmwater fish, and temperature increase will not lead to drastic growth of				

	salmon populations. Therefore, the option of HA was not chosen.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of western moose (*Alces alces andersoni*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	**GI**-**Inc**-**SI**-**N** **GI**-**Inc**-**SI**-**N**	A geographical barrier of Cape Breton Island isolated from the mainland exists, but there is a possibility of migration of this species between this island and the mainland by swimming (Bridgland et al., 2007). This species inhabits boreal land region and taiga region in Cape Breton Highlands National Park (Parks Canada, 2010a; Parks Canada, 2012). Moose in taiga cannot migrate to cooler places anymore, while moose in boreal forests could migrate to taiga (higher elevations) to some degrees. This is why GI, Inc, and SI were considered here. · Moose are also in the Acadian region. Parks Canada publication not right. The effects of moose in the Acadian region are also clear. [Expert in Cape Breton Highlands] [Follow-up] Moose in Acadian forest region could migrate to cooler sites (boreal forests and taiga), and such moose should be assessed with just "SI" and "N". Consequently, all the subscores were collected here.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Populations have been fragmented and isolated, possibly due to in part establishing and decommissioning roads (including forestry harvesting roads) (Snaith and Beazley, 2004). Similarly, roads could be a partial reason for constrained distribution of moose in Cape Breton as well (Beazley et al., 2008). · Roads are probably not barriers for moose in Cape Breton Highlands, where land-use and forestry clearing are irrelevant. [Expert in Cape Breton Highlands] · The only effect of woodland roads on moose is that the road density adversely correlated with the density of moose. [Expert in Cape Breton Highlands]
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-**Dec** GI-Inc-SI-N-**SD**-**Dec**	According to dispersal records of this species in several regions, moose can migrate for more than 10 km (possibly up to 50 km) (Parker, 2003). Although this species in Nova Scotia may not seasonally migrate for long distances (Parker, 2003; Snaith and Beazley, 2004), these records show high disersal ability of this species. · Moose have dispersal capabilities that can respond to a changing climate. The biggest limitation is that the habitat is saturated with moose and we're an island. So I stick with 'decrease' for the indicator', or 'slight decrease'. [Expert in Cape Breton Highlands] · The range of a calf and its range when it's independent overlap something like 30% (don't go very far to new places). Just because they have legs doesn't mean they're going to go. [Expert in Cape Breton Highlands]

		· Moose were released here in 1948 in Cape Breton, and now they're all over the island. So, they do move. They would populate new areas if there were new areas. It can take advantage of new habitat, it's less vulnerable than other species. But we're an island without many spaces to move to. [Expert in Cape Breton Highlands]
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-**N**-SD GI-**Inc**-**SI**-N-SD	Renecker and Hudson (1986) reported that moose in Alberta, from where moose were introduced to Cape Breton, iniated thermal panting above 14°C and did open-mounthed panting at ≥20°C, concluding that upper thermal limits of this species is 14-20°C during summer season. Likewise, they proposed that upper thermal limits of this species is -5 to 0°C during winter season. Yet, some recent studies have shown that moose could be more tolerant to heat stress (McCann et al., 2013). McCann et al. (2013) reported heat-stress thresholds of 17°C under calm conditions and 24°C under windy ones, by observing moose at the Minnesota Zoological Garden. Mainland of Nova Scotia is close to the southern limit of this species' distribution, and it is likely to be affected by heat stress (Snaith and Beazley, 2004). Even in the southeastern side of Cape Breton, summer and abnormal hot weather could bring about heat stress on moose (Beazley et al., 2008).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	Riverine and marsh habitats are beneficial for this species by alleviating heat stress (Dou et al., 2013). Parker (2003) suggested that post-fire forest regeneration often produces many aspen trees and that such aspen trees could be beneficial for beavers. Beavers then create wetlands, and such wetlands are useful for moose during summer season (Parker, 2003). · Aspen is not important here. [Expert in Cape Breton Highlands] · Nevertheless, it's certainly true that moose will take advantage of any pond they come across. [Expert in Cape Breton Highlands] · That makes more sense for Kejimkujik for post-fire regeneration. [Expert in Cape Breton Highlands]
C2c (Disturbance)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	Early successional vegetation and/or burned areas are beneficial for this species, though severe and repeated burnings are harmful (Feldhamer, 2003; Snaith and Beazley, 2004; Fisher and Wikinson, 2005). Also, in Cape Breton, Balsam firs have been replaced by birches due to outbreaks of budworms, which was beneficial for moose (Bridgland et al., 2007). Yet, it is also true that moose themselves have hindered forest succession by browsing in this park (Parks Canada, 2010c).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Moose are morphologically capable to move through snow, and only much deep snow (> 70cm) could restrict their movements in Atlantic Canada (Kelsall, 1969). Smaller amount of snowfall will increase the exposure of this species to *Parelaphostrongylus tenuis*, leading to higher mortality of moose (Beazley et al., 2006). However, this parasite is not common in Cape Breton, because its carrier, white-tailed deer, is uncommon

		(Franklin, 2013). Much snow depth (deeper than 60 cm) could hinder movements of this species and/or require more energy (Beazley et al., 2008). Given a much snowy climate in this park, less snow accumulation will be both positive and negative on this species' survival. · Effect of snow varies so much from winter to winter (how much snow is on top of the plateau and its condition) even without climate change, and moose are just running around on top of the crust during years with lots of rain. In contrast, 3 or 4 feet of powder snow could also accumulate in some years, when moose can't move through. [Expert in Cape Breton Highlands] · Snow pack has increased in the last five years during warm winters, because more of Gulf of St. Lawrence is open. Thus, more moisture is coming while temperature is still below zero degree. [Expert in Cape Breton Highlands] · We still expect the same snowfalls at high elevations in the future that we see at low elevations today. Deer were probably seasonal and went up/down when they were around. [Expert in Cape Breton Highlands] · I think that this subscore should be neutral, because we know moose do well in deep snow. [Expert in Cape Breton Highlands]
C3 (Physical habitat)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	Highlands in granitic regions, where white-tail deer are infrequent, are suitable habitats for moose in Cape Breton (Beazley et al., 2008).
C4a (Other spp for habitat)	GI-Inc-**SI**-N SD GI-Inc-**SI**-N	Preferring early successional deciduous vegetation (Snaith and Beazley, 2004). Parks Canada (2010c) reported that this species favoured early successional stands of white birch in Cape Breton Highlands. Parker (2003) also suggested that post-fire forest regeneration often produces many aspen trees and that such aspen trees could be beneficial for beavers. Beavers then create wetlands, and such wetlands are useful for moose during summer season (Parker, 2003). Further, mature coniferous stands could be also useful for this species to adjust its body temperature during summer season (Parker, 2003). In support of this idea, Broders et al. (2012) observed moose in mostly softwood or mixed forests during summer season in mainland Nova Scotia. In the MVA, because beaver may be stable/adaptable to climate change under moderate climate change scenario (c.f.: the result of beaver in Fundy National Park), the subscores of N and SD were additionally chosen.
C4b (Diet)	Inc-**SI**-N-SD Inc-**SI**-N-SD	In Nova Scotia including Cape Breton, important foods for this species cover red, sugar, and mountain maples, white and yellow birches, hazelnuts, and balsam firs (Thompson and Basquill, 1997; Snaith and Beazley, 2004; Bridgland et al., 2007). In Cape Breton, it was documented that moose damaged drastically balsam firs by browsing (Pardy, 1997).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	White-tailed deer is currently uncommon in Cape Breton (Franklin, 2013), but northward expansion of deer's distribution could partly lead to decline of moose populations via interspecific competition of food/habitats and

		bringing a parasitic nematode, *P. tenuis* (Robinson et al., 2010). Such impacts of deer on moose may be pronounced with less snow accumulation in Cape Breton Highlands.
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	An intra-population genetic variation was larger for a population in Cape Breton than those in most surrounding areas (Broders et al., 1999; Beazley et al., 2006). Yet, this population was originated from an artificial reintroduction from populations in Alberta in 1940s (Parker, 2003; Bridgland et al., 2007). · This population in Cape Breton Highlands was founded by 18 individuals initially, and therefore I don't think their genetic variation should be greater than those of other populations even now. [Expert in Cape Breton Highlands] · Dr. Hugh Broders said that there was 'enough' genetic variation, I don't think our population would have greater genetic variation than the source population in Alberta. [Expert in Cape Breton Highlands]
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Northward expansion of deer's distribution has partly led to decline of moose populations in eastern Canada and the United States via interspecific competition of food/habitats and bringing a parasitic nematode, *P. tenuis* (Robinson et al., 2010). However, this trend is a macro-geographic pattern, but not a more local pattern focusing on Cape Breton or Nova Scotia. Further, moose in Cape Breton may be different from moose discussed by Robinson et al. (2010) at subspecies level.
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Climate change will increase thermal stress and mortality caused by transmission of *P. tenuis* for this species in Nova Scotia mainlands (Beazley et al., 2006). Similar change may be expected even in Cape Breton, but no documents have explicitly mentioned so. Also, it should be noted that moose in Cape Breton are different from those in the mainland in Nova Scotia at subspecies level.

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	4	38	37	22	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------		
Severe scenario		-------------------------------			
	Renecker and Hudson (1986) reported that moose in Alberta, from where moose were introduced to Cape Breton, iniated thermal panting above 14°C and did open-mouthed panting at ≥20°C, concluding that upper thermal limits of this species is 14-20°C during summer season. Likewise, they proposed that upper thermal limits of this species is -5 to 0°C during winter season. Yet, some recent studies have shown that moose could be more tolerant to heat stress (McCann et al., 2013). McCann et al. (2013) reported heat-stress thresholds of 17°C under calm conditions and 24°C under windy ones, by observing moose at the Minnesota Zoological Garden. Mainland of Nova Scotia is close to the southern limit of this species' distribution, and it is likely to be affected by heat stress (Snaith				

	and Beazley, 2004). Even in the southeastern side of Cape Breton, summer and abnormal hot weather could bring about heat stress on moose (Beazley et al., 2008). Preferring early successional deciduous vegetation (Snaith and Beazley, 2004). Parks Canada (2010c) reported that this species favoured early successional stands of white birch in Cape Breton Highlands. Parker (2003) also suggested that post-fire forest regeneration often produces many aspen trees and that such aspen trees could be beneficial for beavers. Beavers then create wetlands, and such wetlands are useful for moose during summer season (Parker, 2003). Further, mature coniferous stands could be also useful for this species to adjust its body temperature during summer season (Parker, 2003). In support of this idea, Broders et al. (2012) observed moose in mostly softwood or mixed forests during summer season in mainland Nova Scotia. White-tailed deer is currently uncommon in Cape Breton (Franklin, 2013), but northward expansion of deer's distribution could partly lead to decline of moose populations via interspecific competition of food/habitats and bringing a parasitic nematode, *P. tenuis* (Robinson et al., 2010). Such impacts of deer on moose may be pronounced with less snow accumulation in Cape Breton Highlands. In short, this species in Cape Breton Highlands National Park could be affected by temperature increase as well as further infections of *P. tenuis* negatively. However, considering recent insights about moose’s heat tolerance and the relatively cool climate in Cape Breton Highlands National Park, this species might not show noticeable declines under climate change. As well, Cape Breton is geographically isolated and thus less sensitive to invasion of more deer and more *P. tenuis*. Topographical complexity may also contribute to separation between moose and deer. Therefore, “HV” was not chosen here. Consequently, MV and PS were chosen under moderate scenario while just MV was chosen under severe scenario. However, experts suggested that the moose in Cape Breton Highlands under moderate climate change scenario is presumably stable. Therefore, the category of MV was removed, while just PS was left.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of coyote (*Canis latrans*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	A geographical barrier of Cape Breton Island isolated from the mainland exists, but this species has expanded into Cape Breton Highlands recently (around 1980) from the mainland (Porter, 2013). This species has also expanded its distribution to Newfoundland via ice bridges (Blake, 2006). Although this species could be distributed in a wide range of habitats, such as alpine tundra, boreal forests, aspen parklands and steppes with short-grass (Banfield, 1976), here it was assumed that coyotes mainly inhabit Acadian forests as well as boreal forests. This species could survive under warmer climates, and natural barriers, like those among cold refugia for brook trout, are not likely to affect it. Thus, the natural barriers may not be relevant to the species' vulnerability in the park.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Although some coyotes have used roads to travel, demarcate boundaries and possibly collect foods (garbage), this species generally seems to refrain from including roads in their home ranges (Gompper, 2002; Porter, 2013). However, the artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Cape Breton species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	In northeastern North America, this species can migrate for more than 100 km on average, and some individuals travel for more than 300 km (Gompper, 2002). This species has also expanded its distribution to Newfoundland via ice bridges (Blake, 2006).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	Basically, this species is highly adaptable, ranging from 10°N latitude (Costa Rica) to 70°N latitude (northern Alaska). In cold winter, this species can predate deer, particularly dead deer, because of high mortality of deer (Gese et al., 1996). However, winter temperature lower than -10°C is critical for coyotes from even Fairbanks in Alaska (Shield, 1972). The minimum monthly temperature in Cape Breton Highlands is -11.2°C in February, and therefore warmer climates might mitigate negative impacts of such harsh winter season on this species.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Generally, this species seems to be common in hilly country with poplar bluffs and stream banks with willows (Banfield, 1976). In some parts in northeastern North America, coyotes tend to gather in frozen lakes, ericaceous bogs and/or beaver meadows to get food during winter (Gompper, 2002).
C2c	Inc-SI-N-**SD**-Dec	This species tends to inhabit disturbed and open habitats, such as burned and logged stands (Fisher and

(Disturbance)	Inc-SI-N-**SD**-Dec	Wilkinson, 2005).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-N	In deep snow, this species can predate deer, particularly dead deer (Gese et al., 1996; Feldhamer et al., 2003; Patterson and Messier, 2003). In southwestern Yukon, coyotes prefer harder snow, which could fall under colder temperatures. However, snow also limits the movements of coyotes, lowering the probability of harvesting snowshoe hares (Murray and Boutin, 1991). Frozen lakes are preferred by coyotes as places where they can acquire foods, like deer, easily during winter (Gompper, 2002). Therefore, disappearances of ice and/or snow are likely to be negative for coyotes.
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	No preference for certain geological features. Furthermore, this species can migrate for more than 100 km on average (Gompper, 2002), suggesting its great ability to be compatible with various geological conditions.
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	It seems to be common in hilly country with poplar bluffs and stream banks with willows, though it could also be distributed alpine tundra, boreal forests, aspen parklands and steppes with short-grass (Banfield, 1976).
C4b (Diet)	Inc-**SI**-N-**SD** Inc-**SI**-N-**SD**	In northeastern North America, this species generally forages white-tailed deer, snowshoe hares and also sometimes fruits (Gompper, 2002). Both live prey and carrion are available for this species, and it is regarded as an opportunistic and generalist feeder (Feldhamer et al., 2003). In Cape Breton Highlands, moose carcasses are known to be a representative food for coyotes (Porter, 2013). Also, according to an observation in Cape Breton, deer are more likely to be predated than snowshoe hares, when deer are vulnerable due to severe winter (Patterson et al., 1998). In contrast, this species is generally known as an important disperser of some plant species (Cypher and Cypher, 1999).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	Although there hava been no genetic studies on coyotes in Nova Scotia, coyote populations in this province are recently established since the 1970s (Telefer, 2004). In line with this, according to a study analyzing mtDNA, there is a geographical decline in genetic diversity northeastwards in coyote populations around the Great Lakes including Ontario (Kays et al., 2009).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	13	87
Severe scenario	0	0	0	0	100
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	
Severe scenario			-------------------------------	-------------------------------	
	Basically, this species is highly adaptable, ranging from 10°N latitude (Costa Rica) to 70°N latitude (northern Alaska). In cold winter, this species can predate deer, particularly dead deer, because of high mortality of deer (Gese et al., 1996). However, winter temperature lower than -10°C is critical for coyotes from even Fairbanks in Alaska (Shield, 1972). The minimum monthly temperature in Cape Breton Highlands is -11.2°C in February, and therefore warmer climates might mitigate negative impacts of such harsh winter season on this species. This species tends to inhabit disturbed and open habitats, such as burned and logged stands (Fisher and Wilkinson, 2005). In northeastern North America, this species generally forages white-tailed deer, snowshoe hares and also sometimes fruits (Gompper, 2002). Both live prey and carrion are available for this species, and it is regarded as an opportunistic and generalist feeder (Feldhamer et al., 2003). In Cape Breton Highlands, moose carcasses are known to be a representative food for coyotes (Porter, 2013). Also, according to an observation in Cape Breton, deer are more likely to be predated than snowshoe hares, when deer are vulnerable due to severe winter (Patterson et al., 1998). In contrast, this species is generally known as an important disperser of some plant species (Cypher and Cypher, 1999). Therefore, coyote population will be presumably stable or moderately increase in response to temperature increase and possibly stronger disturbances under the climate change scenarios. Although the number of deer, the main food for coyote, may also increase under severe climate change scenario with less snow, degree of difficulty to predate deer might also increase due to less snow, canceling out the positive effect of deer increase. Given that coyote may not flourish “significantly” because of temperature increase and/or snow decline in direct ways, this species was judged to be PS/MA, but not HA, under severe scenario as well.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of snowshoe hare (*Lepus americanus*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. Snowshoe hares are found in boreal forests region in this island (Parks Canada, 2010a). According to Young et al. (2011), snowshoe hare in extensive mountainous wilderness area should be assessed with neutral score in B2a. Yet, Cape Breton Highlands National Park is a limited area, and therefore hare could migrate to just taiga region in the future even when it needs snowy habitats at high elevations. Thus, Inc and SI were selected for severe climate change scenario.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Once forests are clearly cut, at least 15-20 years would be needed to create suitable habitat for this species (Parker et al., 1983; Doyon et al., 2000). However, the artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Cape Breton species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species could disperse for distances of up to 20 km (Feldhamer et al., 2003).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	This species is distributed from Alaska to northern California and western Nevada (Feldhamer et al., 2003), though the subspecies of *L. a. struthopus* is restricted to the Maritime Provinces and Gaspe Peninsula of Quebec (Banfield, 1976). This species is quite tolerant to cold temperature (< -40°C) during winter (Doyon et al., 2000; Kielland et al., 2010). In contrast, according to a study in Alaska, population growth of this species seems to be at best when summer growing degree-days (GDD) during May and July are between 1,600 and 1,700 (Kielland et al., 2010). Given the GDD during the end of May and the beginning of September at the centroid in Cape Breton Highlands National Park is 1,389, the GDD during May and July may be around or smaller than 1,300. Thus, snowshoe hares there could get somewhat benefits from warmer temperatures in this park.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Leporidae is generally regarded as a dry-land animal, but snowshoe hares could swim in water (Johnson, 1925). This species is commonly seen in cedar bogs or coniferous forests in lowlands in the eastern side of this

hydrological niche)		species' distribution (Banfield, 1976). Wet conditions, like sub-continental Canada in La Nina years, may increase food resources for snowshoe hares, though there is no empirical evidences yet (Zhang et al., 2007). So, given all the information, somewhat moist conditions may be optimal for this species.
C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-**SD**-Dec	Sullivan (1994) stated that this species inhabits early to mid- successional forests (< 25 yrs). In this regard, creating forest succession caused by forest harvesting and/or forest fires is beneficial for snowshoe hares and Lynx (Parker et al., 1983; Paragi et al., 1997; Poole, 2003). Hoving et al. (2004) explained that Canadian lynx is likely to inhabit early successional forests in northern Maine, because its main feed, snowshoe hare, is distributed in such forests. Yet, hare was frequently found in open mature coniferous forests in summer, while it is likely to inhabit successional habitats of mixed forests (around 20 yrs after cutting) during winter in Cape Breton (Parker et al., 1983).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-**Inc**-SI-**N** SD	Snowshoe hares, which change their coat colors in winter, are less likely to be predated by coyotes in snow (Murray and Boutin, 1991). The southern limit of this species' distribution corresponds to areas with notable snow cover (Murray, 2000). In contrast, great amounts of snow (depth > 30cm) could be detrimental for this species as well, according to an observation in interior Alaska (Kielland et al., 2010). This is probably because hares may be much less mobile in relation to thier predators including coyotes in such snowy conditions (Kielland et al., 2010). Lynx is more likely to catch snowshoe hares in more hard-packed snow, which would be replaced by soft snow under warming climates (Stenseth et al., 2004). Such information suggests that moderate amounts of soft snow (depth = 15-30 cm) are optimal for this species' survival.
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	
C4a (Other spp for habitat)	GI-Inc-**SI**-N GI-Inc-**SI**-N	Generally, snowshoe hares are commonly seen in cedar bogs or coniferous forests in lowlands in the eastern side of this species' distribution (Banfield, 1976). Cheng et al. (2014) reported higher genetic diversity in populations in boreal forests than those in the other populations, indicating the importance of boreal habitats for this species. In Cape Breton, this species was frequently found in open mature coniferous forests in summer, while it is likely to inhabit successional habitats of mixed forests (around 20 yrs after cutting) during winter (Parker et al., 1983).
C4b (Diet)	Inc-**SI**-**N**-SD Inc-**SI**-**N**-SD	Snowshoe hares forage various foods of green grasses and forbs during summer, while they eat buds, twigs, bark and leaves of evergreen plants during winter (Banfield, 1976; Doyon et al., 2000). Particularly, willows, birches, hazelnuts, maples, trembling aspens, hawthorns and some conifers (e.g., tamaracks, white pines, hemlocks, balsam firs) are preferred during winter (Banfield, 1976). In Cape Breton, it was documented that snowshoe hares damaged drastically balsam firs (Pardy, 1997).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e	Inc-SI-**N**	Snowshoe hare is a main food for canadian lynxes and bobcats in Cape Breton (Parker and Smith, 1983; Parker

(Other spp interaction)	Inc-SI-N	et al., 1983).			
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD				
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N				
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD				
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	94	6
Severe scenario	0	3	33	64	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	
Severe scenario		-------------------------------	-------------------------------		
	This species is distributed from Alaska to northern California and western Nevada (Feldhamer et al., 2003), though the subspecies of *L. a. struthopus* is restricted to the Maritime Provinces and Gaspe Peninsula of Quebec (Banfield, 1976). This species is quite tolerant to cold temperature (< -40°C) during winter (Doyon et al., 2000; Kielland et al., 2010). In contrast, according to a study in Alaska, population growth of this species seems to be at best when summer growing degree-days (GDD) during May and July are between 1,600 and 1,700 (Kielland et al., 2010). Given the GDD during the end of May and the beginning of September at the centroid in Cape Breton Highlands National Park is 1,389, the GDD during May and July may be around or smaller than 1,300. Thus, snowshoe hares there could get somewhat benefits from warmer temperatures in this park. Snowshoe hares, which change their coat colors in winter, are less likely to be predated by coyotes in snow (Murray and Boutin, 1991). The southern limit of this species' distribution corresponds to areas with notable snow cover (Murray, 2000). In contrast, great amounts of snow (depth > 30cm) could be detrimental for this species as well, according to an observation in interior Alaska (Kielland et al., 2010). This is probably because hares may be much less mobile in relation to thier predators including coyotes in such snowy conditions (Kielland et al., 2010). Lynx is more likely to catch snowshoe hares in more hard-packed snow, which would be replaced by soft snow under warming climates (Stenseth et al., 2004). Such information suggests that moderate amounts of soft snow (depth = 15-30 cm) are optimal for this species' survival. Generally, snowshoe hares are commonly seen in cedar bogs or coniferous forests in lowlands in the eastern side of this species' distribution (Banfield, 1976). Cheng et al. (2014) reported higher genetic diversity in populations in boreal forests than those in the other populations, indicating the importance of boreal habitats for this species. In Cape Breton, this species was frequently found in open mature coniferous forests in summer, while it is likely to inhabit successional habitats of mixed forests (around 20 yrs after cutting) during winter (Parker et al., 1983). Overall, under moderate climate change scenario, summer temperature increase could be possibly positive and contribute to growth of the hare population. On the other hand, under severe climate change scenario, declines of				

	boreal coniferous forests and also declines of snow accumulation will be more influential than the slightly positive effect of summer temperature increase. Thus, MV and PS were chosen under severe scenario.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of Canada lynx (*Lynx canadensis*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. Lynx is found in boreal forest regions in Cape Breton, being isolated from populations of the same species in the mainland (Parker et al., 1983; Poole, 2003; Parks Canada, 2010a). This species refrains from using waterbodies (Poole, 2003), though it can swim and cross rivers (Banfield, 1976). Hoving (2001) and Parker (2001) stated that movements between Cape Breton and the peninsula of Nova Scotia was unlikely, warning that such a geographic isolation could be serious for this species' survival in changing climates. Within Cape Breton Highlands National Park, lynx could migrate to just taiga region in the future even when it needs snowy habitats at high elevations. Thus, Inc and SI were selected for severe climate change scenario.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is able to cross multilane highways, but lowlands and urban areas are generally obstacles for Lynx particularly in western mountainous and southern areas in this species' distribution (Poole, 2003). This species is also exposed to artificial disturbances (e.g., clear-cutting) just outsides of Cape Breton Highlands National Park (Parker et al., 1983). A study examining effects of road density on lynx reported a relatively small effect in Cape Breton, where relatively high road density was detected in comparison with other habitats of Lynx in eastern North America (Hoving et al., 2005).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	Dispersal for long distances (> 1,000 km) is known with this species (Poole, 2003). In line with this, this species can move for 9 km/day in summer and 8 km/day on average in Cape Breton (Parker et al., 1983).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	This species is distributed from Alaska to the northern United States, but the southern limit of the distribution has receded northwards in the Maritimes and southern Ontario (Banfield, 1976; Koen et al., 2014). Very severe winter (e.g., < -35°C) could be fatal for lynx (Poole, 2003). Yet, this species' distribution in eastern North America corresponds with snowy areas where mean annual snowfall is larger than 268 cm (Hoving, 2001). So, temperature may be relatively irrelevant to this species' vulnerability, but no studies are available to confirm this idea.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD**	Generally, this species refrains from using waterbodies (Poole, 2003), though it can swim and cross rivers (Banfield, 1976). As well, in terms of its distribution range, lynx seems to avoid wet coastal forests in the

hydrological niche)		western side of Canada (Poole, 2003).
C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-SD-**Dec**	Generally, this species prefers older regenerating stands (more than 20 yrs) than younger forests (Poole, 2003). In Cape Breton, this species tends to utilize advanced successional habitats of mixed forests (around 20 yrs after cutting) (Parker et al., 1983), and halted forest successions by moose are serious problems for lynxes (Bridgland et al., 2007; Parks Canada, 2010c). More quantitatively, Parker et al. (1983) suggested a combination of 50% mature coniferous forests, 30% mature mixed forests, 12% successional forests and 8% wet areas for lynx in Cape Breton. In this regard, restarting forest succession caused by forest harvesting and/or forest fires is beneficial for snowshoe hares and lynxes (Parker et al., 1983; Paragi et al., 1997; Poole, 2003). Particularly in the southern edges of this species' distribution, supressing fires could lead to decline of lynx number (Mowat and Slough, 2003). Moose is vulnerable to climate change, and therefore the negative impact of moose browsing will be reduced in changing climates.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-**Inc**-SI-N	This species' distribution in eastern North America corresponds with snowy areas where mean annual snowfall is larger than 268 cm (Hoving, 2001). According to an observation in Yukon, this species travels more snowy areas (snow depth ≈ 50-60 cm) than travel routes by coyotes (Murray et al., 1994). As well, deep snow might assist lynxes to predate deer (Fuller, 2004). Lynx is more likely to catch snowshoe hares in more hard-packed snow, which would be replaced by soft snow under warming climates (Stenseth et al., 2004).
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	No preference for certain geological features. Furthermore, this species can migrate for more than 100 km on average (Poole, 2003), suggesting its great ability to be compatible with various geological conditions.
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	Generally, this species inhabits old regenerating stands (more than 20 yrs), such as *Picea*, *Pinus* and *Abies balsamifera* (Poole, 2003). Hoving (2001) described deciduous vegetation as inappropriate habitats for this species in eastern North America. In Cape Breton, this species inhabits mature coniferous forests during summer but advanced successional habitats of mixed forests (around 20 yrs after cutting) during winter (Parker et al., 1983). More quantitatively, Parker et al. (1983) suggested a combination of 50% mature coniferous forests, 30% mature mixed forests, 12% successional forests and 8% wet areas for lynx in Cape Breton.
C4b (Diet)	**Inc**-**SI**-N-SD **Inc**-**SI**-N-SD	Snowshoe hare is a main food for lynx in Cape Breton, and rarely white-tailed deer and ruffed grouse are also predated by lynx (Parker et al., 1983; Murray et al., 1994; Fuller, 2004). It is noteworthy, however, lynx predates more diverse foods in summer than in winter (Parker et al., 1983). As well, in more southern side of this species' distribution, greater variety of preys for this species could be expected (e.g., red squirrel) (Roth et al., 2007).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	Even the lynx could be predated by coyotes (Poole, 2003). Also, bobcats might compete with Canada lynx in Cape Breton (Parker et al., 1983; Poole, 2003). Interspecific hybridization between lynx and bobcat has been also confirmed in not only Minnesota but also New Brunswick (Schwartz et al., 2004; Homyack et al., 2008;

<table>
<tr><td></td><td></td><td colspan="4">Murray et al., 2008). Such impacts of bobcat on lynx may be pronounced with less snow accumulation in Cape Breton Highlands (Parks Canada, 2010c).</td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4">Lynx populations in eastern Canada were highly differentiated from those in other regions at mtDNA (Rueness et al., 2003). In particular, although morphologically this species in Cape Breton is distinct from the same species in the mainland and Newfoundland, genetic differentiations were not empirically confirmed yet (Khidas et al., 2013).</td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-**SI**-**N**-SD-Dec
GI-Inc-**SI**-**N**-SD-Dec</td><td colspan="4">A warming regional climate in the last 20-30 years has decreased snow amounts, being negative for Canada lynx but positive for bobcat in eastern North America (Hoving, 2001). However, a map-based modelling of this species' distribution, based on data of snowfall and deciduous cover, suggested that Cape Breton Highlands is still the most likely area for occurrence of this speices (Hoving et al., 2005).</td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-**SI**-N-SD-Dec
GI-**Inc**-SI-N-SD-Dec</td><td colspan="4">This species in Cape Breton Highlands will be affected by disruptions of bobcats as well as coyotes, which would be able to invade into highlands under warming climates, but it is not clearly documented if such disruptions could lead to population declines of lynx or not (Parker, 2001). In contrast, the populations in this island are predicted to decline assuming smaller amounts of snowfall (Carroll, 2007).</td></tr>
<tr><td rowspan="3">The CCVI [%]
Moderate scenario
Severe scenario</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>0</td><td>0</td><td>45</td><td>50</td><td>6</td></tr>
<tr><td>0</td><td>6</td><td>94</td><td>0</td><td>0</td></tr>
<tr><td rowspan="4">The MVA**
Moderate scenario
Severe scenario</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">This species is distributed from Alaska to the northern United States, but the southern limit of the distribution has receded northwards in the Maritimes and southern Ontario (Banfield, 1976; Koen et al., 2014). Very severe winter (e.g., < -35°C) could be fatal for lynx (Poole, 2003). Yet, this species' distribution in eastern North America corresponds with snowy areas where mean annual snowfall is larger than 268 cm (Hoving, 2001). So, temperature may be relatively irrelevant to this species' vulnerability, but no studies are available to confirm this idea. Therefore, physiological thermal niche should be "unknown" in this assessment. Consequently, the MVA did not determine vulnerability/adaptability of the species.</td></tr>
</table>

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of bobcat (*Lynx rufus*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	A geographical barrier of Cape Breton Island isolated from the mainland exists. The bobcat has been found in Acadian forest regions in Cape Breton since around 1960 (Parks Canada, 2010a; Parker and Smith, 1983; Parker et al., 1983). This species has probably immigrated to Cape Breton via the causeway from the mainland (Parker and Smith, 1983). Given that this species can inhabit without snow or cool climate, steep slopes and limited area of highlands cannot be barriers for bobcat’s adaptation.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Bobcats seem to be tolerant of human presence and disturbance, but still they avoid habitats which are adjacent to human dwelling areas (Feldhamer et al., 2003). Banfield (1976) regarded this species more tolerant of artifical effects than Canada lynx.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	According to a study in northwest Montana, bobcats can move for less than 5 km/day on average during winter due to snow, though longer movements (>10 km) have been also documented by some previous studies (Newbury, 2013). In contrast, in other than winter, this species is more mobile (Newbury, 2013). This species' movement scale could be much different depending on not only snow conditions, but also sex, home range size and/or hare populations' demography (Feldhamer et al., 2003). The longest dispersal is more than 1,000 km (Feldhamer et al., 2003).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species is distributed in a wide range of elevation and latitude, including central British Columbia (55°N) to Oaxca, Mexico (17°N) (Feldhamer et al., 2003; Wigginton and Dobson, 2007). While bobcat may avoid extreme low temperatures, its southern limit is determined by not high temperature but interspecific competition with other felid species (Sánchez-Cordero et al., 2008). The subspecies of *L. r. gigas* is seen in Nova Scotia, New Brunswick and probably southern Quebec (Banfield, 1976).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2c (Disturbance)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C2d	GI-Inc-SI-**N**	Deep snow may hinder the invasion and colonization of bobcats in the highlands (plateau) in particularly the

(Ice/Snow)	GI-Inc-SI-**N** Dec	western side of Cape Breton (Parker and Smith, 1983; Parker et al., 1983). According to Porter (2013), bobcats were seen at elevations < around 280 m in Cape Breton.
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	According to Porter (2013), bobcats were seen at elevations < around 280m in Cape Breton, though this is probably because of snow effects.
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species inhabits various environments, covering boreal forests, arid deserts, and humid tropical regions, though it generally prefers rocky country with dense vegetation (Feldhamer et al., 2003). Therefore, this species habitats are much less restricted than those of Canada lynx (Feldhamer et al., 2003).
C4b (Diet)	Inc-**SI**-**N**-SD Inc-**SI**-**N**-SD	Snowshoe hare is a main food for bobcats in Cape Breton, and rarely white-tailed deer, some small mammals and birds are also predated by this species (Parker and Smith, 1983). However, when hare is less abundant, bobcats are more likely to feed on deer and small mammals (Matlack and Evans, 1992).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	Bobcat may compete with Canada lynx in Cape Breton in particularly little-snow winters (Parker et al., 1983; Poole, 2003; Parks Canada, 2010c). Interspecific hybridization between lynx and bobcat has been also confirmed in not only Minnesota but also New Brunswick (Schwartz et al., 2003; Homyack et al., 2008; Murray et al., 2008).
C5a (Genetic variation)	**Inc**-SI-N-SD **Inc**-SI-N-SD	Bobcat populations in eastern Canada, incuding a population of Nova Scotia, harbored smaller genetic variations at microsatellite loci than those in other regions, probably due to population isolation and genetic bottleneck in the past (Croteau et al., 2012).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-**N**-**SD**-Dec GI-Inc-SI-**N**-**SD**-Dec	A warming regional climate in the last 20-30 years has decreased snow amounts, being negative for Canada lynx but positive for bobcat in eastern North America (Hoving, 2001). Yet, according to a questionnaire survey by Roberts and Crimmins (2010), a status of bobcat populations in Nova scotia was fluctuating, but not increasing.
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Deer increase due to milder winter in the future will contribute to expanding the distributions of bobcats, resulting in more frequent exposures of Canada lynx to bobcat in northeastern Minnesota (Kapfer, 2012).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	0	0	100	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			------------------------------		

<table>
<tr><td rowspan="2">Severe scenario</td><td></td><td></td><td></td><td>--------------------------------</td><td></td></tr>
<tr><td colspan="5">This species is distributed in a wide range of elevation and latitude, including central British Columbia (55°N) to Oaxca, Mexico (17°N) (Feldhamer et al., 2003; Wigginton and Dobson, 2007). While bobcat may avoid extreme low temperatures, its southern limit is determined by not high temperature but interspecific competition with other felid species (Sánchez-Cordero et al., 2008). Deep snow may hinder the invasion and colonization of bobcats in the highlands (plateau) in particularly the western side of Cape Breton (Parker and Smith, 1983; Parker et al., 1983). According to Porter (2013), bobcats were seen at elevations < around 280 m in Cape Breton. Bobcat populations in eastern Canada, incuding a population of Nova Scotia, harbored smaller genetic variations at microsatellite loci than those in other regions, probably due to population isolation and genetic bottleneck in the past (Croteau et al., 2012). Therefore, temperature increase per se may not be influential on the species' vulnerability/adaptability, whereas decline of snow accumulation will contribute to spread of bobcat in Cape Breton. To reflect this possibility, under severe climate change scenario, the option of MA was chosen. Another option of HA was not adopted, because bobcat increase has never been observed in Cape Breton clearly and also because its genetic variation is limited.</td></tr>
</table>

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was not determined due to a lack of information about physiological thermal niche.

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[Assessment sheet] Climate change vulnerability assessments of American marten (*Martes americana*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists, and this species cannot cross over this barrier (i.e., the Strait of Canso) (Scott, 2001). In contrast, this species inhabits boreal land region in Cape Breton Highlands (Parks Canada, 2010a). Cape Breton Highlands National Park is a limited area, and therefore the marten could migrate to just taiga region in the future even when it needs snowy habitats at high elevations. Thus, Inc and SI were selected for severe climate change scenario.
B2b (Artificial barriers)	GI-Inc-**SI**-N GI-Inc-**SI**-N	Deforestation of mature coniferous forests and progressive development have extremely eliminated suitable habitats for this species in Cape Breton (Scott, 2001). Because this species requires extensive habitats with large area, the artificial effects outside the park were reflected here as "SI".
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-Dec GI-Inc-SI-N-**SD**-Dec	A parent–offspring distance σ of this species is 3.8-7.25 km (Broquet et al., 2006). Its maximam dispersal distance is 40 km (Carroll, 2007).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	This species' distribution traverses north-central North America (circumboreal forests), being in a more northern side than the distribution of fishers (Banfield, 1976; Feldhamer et al., 2003; Krohn, 2012). Therefore, high temperature might be a partial reason for this distribution, but also the marten's distribution might be restricted by just boreal forest distribution. There have been no relevant studies to this issue.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Occupying mesic, conifer-dominated forests (Banfield, 1976).
C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-SD-**Dec**	This species selects old-growth forests but not burned-over or logged areas, though it occasionally utilizes the latter as well (Banfield, 1976; Bowman and Robitaille, 1997; Fisher and Wilkinson, 2005). Forest fires could seriously damage marten populations (Banfield, 1976). Halted forest successions by moose are serious problems for marten in Cape Breton (Bridgland et al., 2007; Parks Canada, 2010c). Also, any stochastic events including forest fire and excessive snowfall could be fatal for small populations of this species in Cape Breton (Nova Scotia American Marten Recovery Team, 2006). However, moose is vulnerable to climate change, and therefore the negative impact of moose browsing will be reduced in changing climates. As well, fires are

		unlikely to occur easily in Cape Breton, and therefore fire effects should not be overestimated.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-**Inc**-SI-N	Requiring deep snowpacks (Carroll, 2007; Wasserman et al., 2012). Being able to move more freely in deep snow than predators and/or competitors (Godbout and Ouellet, 2010; Krohn, 2012).
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	No preference for certain geological features.
C4a (Other spp for habitat)	GI-Inc-**SI**-N GI-**Inc**-**SI**-N	Preferring mature coniferous forests (Banfield, 1976; Godbout and Ouellet, 2010), particularly balsam firs and black spruces in eastern Canada (Banfield, 1976). Because balsam fir as well as black spruce will be vulnerable to severe climate change scenario, not only “SI” but also “Inc” were chosen in this scenario.
C4b (Diet)	Inc-**SI**-N-**SD** Inc-**SI**-N-**SD**	This species is an opportunistic predator which feeds on rodents, lagomorphs, birds, and sometimes insects, fruits, as well as seeds (Feldhamer et al., 2003). However, in northern New Brunswick, 95% of total calories consumed by this species was consisted of snowshoe hares, grouses, and squirrels in early winter (Cumberland et al., 2001). In Cape Breton, red-backed vole (*Clethrionomys gapperi*) and deer mouse (*Peromyscus maniculatus*) could be main prey species for marten (Scott, 2001).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	Its closely related species, fishers, can compete with and predate martens, possibly limiting the distribution of martens in the future with less snow (Krohn, 2012).
C5a (Genetic variation)	**Inc**-SI-N-SD **Inc**-SI-N-SD	This species' populations in Cape Breton is genetically isolated from those in the mainland of Nova Scotia, due to a barrier of the Strait of Canso (Scott, 2001). As well, the population size in Cape Breton is likely to be very small (Scott, 2001). Considering all these demographic statuses, it is plausible that the populations in Cape Breton retain just small genetic variations. In line with this, Scott (2001) suggested a risk of inbreeding depression in these populations. Recently, these predictions (i.e., extremely small intra-population variation) were confirmed by actual genetic analyses at both nuclear and mitochndorial loci (Nova Scotia American Marten Recovery Team, 2006).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-**SI**-N-SD-Dec GI-**Inc**-SI-N-SD-Dec	Small peripheral populations including that in Nova Scotia will be unlikely to be sustained under climate change (Carroll, 2007). American marten will continue to retreat from its southern range (Krohn, 2012).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	11	89	0

Severe scenario	0	100	0	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario					
Severe scenario					
	This species' distribution traverses north-central North America (circumboreal forests), being in a more northern side than the distribution of fishers (Banfield, 1976; Feldhamer et al., 2003; Krohn, 2012). Therefore, high temperature might be a partial reason for this distribution, but also the marten's distribution might be restricted by just boreal forest distribution. There have been no relevant studies to this issue. Therefore, physiological thermal niche should be "unknown" in this assessment. Consequently, although marten is probably vulnerable to climate change, the MVA did not determine vulnerability/adaptability of the species.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was not determined due to a lack of information about physiological thermal niche.

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[Assessment sheet] Climate change vulnerability assessments of white-tailed deer (*Odocoileus virginianus*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	A geographical barrier of Cape Breton Island isolated from the mainland exists. This species inhabits Acadian land region in Cape Breton Highlands (Parks Canada, 2012). This species could survive under warmer climates, and natural barriers, like those among cold refugia for brook trout, are not likely to affect it. Thus, the natural barriers may not be relevant to the species' vulnerability in the park.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species prefers feeding in disturbed and early successional forests (Russell et al., 2001). However, some road-kills of deer were found in New Brunswick (Whitlaw et al., 1998). · This is Neutral not SI due to increased food availability from roadsides etc. [Expert in Kejimkujik]
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	In northern ranges, whitetails showed migration distances ranging from 6 to 23 km (Feldhamer et al., 2003). Female whitetails migrated for 18-168 km in northeastern Minnesota (Nelson and Mech, 1992). Some of male whitetails monitored to the end of their second fall moved for distances of around 19 km on average, but female whitails moved very little (Patterson et al., 1999). Thus, there are a great variation in whitetail's migration distances (Brinkman et al., 2005), but overall this species could move for over 10km.
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD**	This species seems to be comfort in an ambient summer temperature ranging between 17 and 18°C (Holter et al., 1975), which is higher than the summer average temperature in Cape Breton Highlands (15.0°C). In contrast, the most optimal winter temperature for this species is between 5 and 20 °C (Holter et al., 1975), whereas the winter average temperature in this park is -5.2°C. Moreover, cold temperatures may increase the likelihood of depredation by coyotes (Feldhamer et al., 2003). Records in Nova Scotia showed that individual number of this species increased after mild winter and decreased after severe winter (Patterson and Power, 2001). Highlands are colder for this species in Cape Breton during winter (Nova Scotia Department of Natural Resources, 2012). As well, it is known that deer avoid north-facing slopes (Nova Scotia Department of Natural Resources, 2012). · I don't believe that deer will be as stressed by summer warmth to the point where it will outweigh the benefits from an increased winter temperature. [Expert in Kejimkujik]
C2bi (Historical hydrological	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	

niche)		
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	No preference for certain hydrological features.
C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-**SD**-Dec	This species prefers feeding in disturbed and early successional forests (Russell et al., 2001), and artificial fire experiments confirmed the fact that fires could contribute to browsing by deer (Dills, 1970). However, during winter, a combination of forest cover and browse is important for deer, and they choose mature mixedwoods (e.g., white spruces, and balsam firs) rather than submature mixedwoods in New Brunswick (Boer, 1978; Morrison et al., 2002).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD Dec	Deep snow will increase the probability of depredation by coyotes (Feldhamer et al., 2003; Patterson and Messier, 2003) and occassionally Lynx (Fuller, 2004). Actually, whitetails tend to avoid snow depth larger than 35 cm by migration (Brinkman et al., 2005), and deer move down to lowlands in Cape Breton during winter (Kelsall, 1969; Parker et al., 1982; Beazley et al., 2008).
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	In highlands in granitic regions in Cape Breton, white-tail deer are infrequent (Kelsall, 1969; Beazley et al., 2008). Yet, a lack of deer in highlands during winter could be attributed to its body shape which is not adaptive to heavy snow (> 40 cm) (Kelsall, 1969).
C4a (Other spp for habitat)	GI-Inc-**SI**-N SD GI-Inc-**SI**-N SD	This species prefers feeding in disturbed and early successional forests (Russell et al., 2001). However, during winter, a combination of forest cover and browse is important for deer, and they choose mature mixedwoods (e.g., white spruces, and balsam firs) rather than submature mixedwoods in New Brunswick (Boer, 1978; Morrison et al., 2002). As well, softwoods were previously believed to be important for this species during particularly severe winters, but a study in southern New Brunswick suggested that mixedwood stands may be more suitable for deer during less severe winters (Sabine et al., 2001). Currently, Cape Breton Highlands harbor limited area of suitable habitat for deer, and therefore SI was chosen for the CCVI calculation. However, warmer climates will develop forests in Cape Breton Highlands in the future (from taiga or shrubby forests to upright forests), and in this sense climate change will contribute to growth and spread of deer in the park.
C4b (Diet)	Inc-**SI**-**N**-SD Inc-**SI**-**N**-SD	Foods eaten by white-tailed deer are varied depending on habitats and latitudes, and therefore whitetails are opportunistic, concentrate selectors (Feldhamer et al., 2003). Although acorns are important food for this species in oak forests in autumn, whitetails would be herbivorous generalists without such typical foods (Feldhamer et al., 2003). According to rumen analysis with deer in southern and central New Brunswick, they fed on herbs and woody browse in spring but fruit and mast in summer/autumn seasons (Skinner and Telfer, 1974). Furthermore, according to an observation in eastern Cape Breton, deer browsed hemlock and maple sapling heavily (Bouman et al., 2004). Under warmer climates, availability of such foods will be improved. · More food does not make deer more vulnerable to climate change. [Expert in Kejimkujik] [Follow-up] It is true that more food does not make deer more vulnerable to climate change, and therefore only

		Neutral score was chosen in the MVA. However, the CCVI assessment tries to determine subscores based on resource specificity of assessed species. Here, to follow Young et al.'s protocol, the subscores of SI as well as N may need to be retained. Moreover, to reflect the possibility of increasing food under changing climates, SD should be chosen.
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-N Inc-SI-N	
C4e (Other spp interaction)	Inc-SI-N Inc-SI-N	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	74	26
Severe scenario	0	0	0	25	75
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario				------------------------------	
Severe scenario				------------------------------	------------------------------
	This species seems to be comfort in an ambient summer temperature ranging between 17 and 18°C (Holter et al., 1975), which is higher than the summer average temperature in Cape Breton Highlands (15.0°C). In contrast, the most optimal winter temperature for this species is between 5 and 20 °C (Holter et al., 1975), whereas the winter average temperature in this park is -5.2°C. Moreover, cold temperatures may increase the likelihood of depredation by coyotes (Feldhamer et al., 2003). Records in Nova Scotia showed that individual number of this species increased after mild winter and decreased after severe winter (Patterson and Power, 2001). Highlands are colder for this species in Cape Breton during winter (Nova Scotia Department of Natural Resources, 2012). As well, it is known that deer avoid north-facing slopes (Nova Scotia Department of Natural Resources, 2012). Deep snow will increase the probability of depredation by coyotes (Feldhamer et al., 2003; Patterson and Messier, 2003) and occassionally Lynx (Fuller, 2004). Actually, whitetails tend to avoid snow depth larger than 35cm by migration (Brinkman et al., 2005), and deer move down to lowlands in Cape Breton during winter (Kelsall, 1969; Parker et al., 1982; Beazley et al., 2008). This species prefers feeding in disturbed and early				

	successional forests (Russell et al., 2001). However, during winter, a combination of forest cover and browse is important for deer, and they choose mature mixedwoods (e.g., white spruces, and balsam firs) rather than submature mixedwoods in New Brunswick (Boer, 1978; Morrison et al., 2002). As well, softwoods were previously believed to be important for this species during particularly severe winters, but a study in southern New Brunswick suggested that mixedwood stands may be more suitable for deer during less severe winters (Sabine et al., 2001). Warmer climates will develop forests in Cape Breton Highlands in the future, and in this sense climate change will contribute to growth and spread of deer in the park. In short, warmer winter and less snow will positively influence survivals of deer. Therefore, this species will flourish under climate change at least moderately. As well, under severe climate change scenario, high adaptation could be also possible, because severe winter in Cape Breton Highlands National Park will be milder with less snow accumulation. Such a possibility was also supported by records in Nova Scotia, which showed that the individual number of this species increased after mild winter and decreased after severe winter (Patterson and Power, 2001).

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of deer mouse (*Peromyscus maniculatus*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	A geographical barrier of Cape Breton Island isolated from the mainland exists. This species inhabits Acadian land region in Cape Breton Highlands (Parks Canada, 2012). This species could survive under warmer climates, and natural barriers, like those among cold refugia for brook trout, are not likely to affect it. Thus, the natural barriers may not be relevant to the species' vulnerability in the park.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Regarding influences of artificial disturbance on this species, there have been a few different results. Fuller et al. (2004) reported that partially harvested mixed stands harbored more densed populations of deer mice than mature mixed stands or regenerating clearcut sites. In contrast, higher density of deer mice were found in more matured coniferous forests in the same region by another research team (Homyack et al., 2005). However, the artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Cape Breton species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Average home ranges of this sedentary species were reported 2.31 acreas for males and 1.39 acres for females (Banfield, 1976). Anderson et al. (2000) found that these mice moved for around 50 m in low floodplains, on average, between two different trapping sessions. Also, according to a study in New Brunswick, population growth of deer mouse showed spatial autocorrelation at the distances less than 300 m (Bowman et al., 2001). Given these data, this species is likely to be able to move for more than 100 m.
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	This species is distributed from Yukon Territory to the southern United States and the Mexican plateau, but the subspecies of *P. m. abietorum* is found in just from the Maritime Provinces to the eastern side of the St Lawrence River (Banfield, 1976). Temperature impacts on the initiation of spring breeding of this species were also examined but not detected (Millar and Herdman, 2004). By investigating 11 years demographic data in Alberta, Kalcounis-Rueppell et al. (2002) also concluded that the species has a high capability to accommodate extreme weather conditions (temperature and precipitation). Meanwhile, according to experiments of *P. m. bairdii* from Erie Lake, deer mice selected around 24-25°C on average after different temperature exposures (14-15°C, 22°C, and 33°C) (Stinson and Fisher, 1953). Demas and Nelson (1998) reported that a combination between food restriction and low ambient temperature (8°C) led to reduction in reproductive and immune functions of deer mouse in East Lansing, Michigan.
C2bi	GI-Inc-SI-N-SD	

(Historical hydrological niche)	GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD**	This species is tolerant to different habitats, but deer mice commonly inhabit dry environments (Banfield, 1976).
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	This species is tolerant to different habitats (Banfield, 1976). Regarding influences of artificial disturbance on this species, there have been a few different results. Fuller et al. (2004) reported that partially harvested mixed stands harbored more densed populations of deer mouse than mature mixed stands or regenerating clearcut sites. In contrast, higher density of deer mouse were found in more matured coniferous forests in the same region by another research team (Homyack et al., 2005). Furthermore, this species is known as a flood-threatened animal species (Andersen et al., 2000; Golet et al., 2013). In North Carolina, there were no significant differences in individual number of this species between post-fire sites and control sites (Ford et al., 1999). Some effects of winds on this species (e.g., increasing thermoregulatory costs in cold conditions) were also detected, but generally deer mice stay in covers/layers of relatively still air close to ground (Chappell and Holsclaw, 1984).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is active even during snowy winter season (Banfield, 1976). Snow impacts on the initiation of spring breeding of this species were examined but not detected (Millar and Herdman, 2004).
C3 (Physical habitat)	Inc-SI-N-**SD**-**Dec** Inc-SI-N-**SD**-**Dec**	This species is tolerant to different habitats including arid short-grass steppes and deep dark coniferous forests (Banfield, 1976).
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** SD GI-Inc-**SI**-**N** SD	This species is tolerant to different habitats including arid short-grass steppes and deep dark coniferous forests (Banfield, 1976). However, according to an observation in northern Maine, deer mice were found in mature deciduous stands, but not mature coniferous stands (Fuller et al., 2004). Myers et al. (2005) also found a strong association between deer mice and northern hardwoods and hemlocks in northern Michigan. Such vegetation will moderately flourish under warmer climates in Cape Breton Highlands, and therefore "SD" was chosen by the MVA.
C4b (Diet)	Inc-SI-**N**-**SD** Inc-SI-**N**-**SD**	This species collects many seeds of ragweeds, apples, cherries, Douglas firs, oak acorns and so on and cache them during autumn season (Banfield, 1976). Also, it forages maple and elm samaras during spring (Banfield, 1976). However, other than such vegetable diets, deer mice also feed on insects, eggs, larvaes or spiders, and therefore this species is likely an omnivore (Banfield, 1976). Demas and Nelson (1998) reported that a combination between food restriction and low ambient temperature (8°C) led to reduction in reproductive and immune functions of deer mouse in East Lansing, Michigan.
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e	Inc-SI-**N**	Shorter winter (warmer temperature and less snow) will lead to replacement of deer mice by white-footed mice

(Other spp interaction)	Inc-SI-**N**	(*P. leucopus*) in northern Michigan (Myers et al., 2005).
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Shorter winter (warmer temperature and less snow) will lead to replacement of deer mice by white-footed mice (*P. leucopus*) in northern Michigan (Myers et al., 2005).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	1	18	75	7
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			------------------------------	------------------------------	
Severe scenario			------------------------------	------------------------------	
	This species is distributed from Yukon Territory to the southern United States and the Mexican plateau, but the subspecies of *P. m. abietorum* is found in just from the Maritime Provinces to the eastern side of the St Lawrence River (Banfield, 1976). Temperature impacts on the initiation of spring breeding of this species were also examined but not detected (Millar and Herdman, 2004). By investigating 11 years demographic data in Alberta, Kalcounis-Rueppell et al. (2002) also concluded that the species has a high capability to accommodate extreme weather conditions (temperature and precipitation). Meanwhile, according to experiments of *P. m. bairdii* from Erie Lake, deer mice selected around 24-25°C on average after different temperature exposures (14-15°C, 22°C, and 33°C) (Stinson and Fisher, 1953). Demas and Nelson (1998) reported that a combination between food restriction and low ambient temperature (8°C) led to reduction in reproductive and immune functions of deer mouse in East Lansing, Michigan. According to an observation in northern Maine, deer mice were found in mature deciduous stands, but not mature coniferous stands (Fuller et al., 2004). Myers et al. (2005) also found a strong association between deer mice and northern hardwoods and hemlocks in northern Michigan. Such vegetation will flourish under warmer climates in Cape Breton Highlands. However, shorter winter (warmer temperature and less snow) will lead to replacement of deer mice by white-footed mice (*P. leucopus*) in northern Michigan (Myers et al., 2005). Therefore, climate change will be beneficial for deer mouse in terms of thermal and habitat conditions, but competition with white-footed mouse will partly cancel out the positive effects of climate change. As well, temperature increase is unlikely to lead to drastic increase of deer mouse. Therefore, both of PS and MA, but not HA, were chosen.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of masked shrew (*Sorex cinereus*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	A geographical barrier of Cape Breton Island isolated from the mainland exists. This species inhabits Acadian land region in Cape Breton Highlands (Parks Canada, 2012). This species could survive under warmer climates, and natural barriers, like those among cold refugia for brook trout, are not likely to affect it. Thus, the natural barriers may not be relevant to the species’ vulnerability in the park.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Precommerical thinning could improve habitat quality for this species in northern Maine, leading to higher abundance of masked shrews (Homyack et al., 2005). Even according to meta-analysis, no significant responses of masked shrews to forest harvest were confirmed (Zwolak, 2009).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	This species is distributed from the southern Appalachians and central Rocky Mountains to Alaska, though it is confined to highlands in the southern limit of the species' distribution (around New York) (Banfield, 1976; Whitaker, 2004). Generally, warm and wet conditions (in April) are supposed to be beneficial for this species to reduce heat and water losses (Vickery and Bider, 1978), though it could also inhabit areas where minimum temperature is as low as -20°C (Yom-Tov & Yom-Tov, 2005). Yom-Tov & Yom-Tov (2005) reported that body size of the species was larger in warmer regions as well, but it is attributable to better dietary conditions (during winter). In contrast, the subspecies of *S. c. acadicus* is confined to the Maritimes (Banfield, 1976; Whitaker, 2004).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	Vickery and Bider (1978) reported that warm and wer weather is beneficial for this species (in April). The same authors also suggested that moderate levels of rainfall are the most optimal for the shrew while heavy rains might be negatively influential on the species' activities. A lack of humidity is an important limiting factor for this species, which retreats to moist shrubs and/or forests from dry open fields (Banfield, 1976; Brannon, 2002; Whitaker, 2004). Brannon (2002) reported that masked shrews were found in mostly north-facing slopes and streamsides in the southern Appalachian Mountains.
C2c	Inc-SI-**N**-**SD**-Dec	This species is tolerant to various habitats, including seashores to alpine areas or arctic tundra (Banfield, 1976;

(Disturbance)	Inc-SI-**N**-**SD**-Dec	Whitaker, 2004). However, according to an observation in Cape Breton, masked shrew was found more frequently in early regeneration sites than late regeneration sites (Parker et al., 1983). In line with this, precommerical thinning could improve habitat quality for this species in northern Maine, leading to higher abundance of masked shrews (Homyack et al., 2005). In North Carolina, there were no significant differences in individual number of this species between post-fire sites and control sites (Ford et al., 1999). Even according to a meta-analysis, no significant responses of masked shrews to forest harvest were confirmed (Zwolak, 2009).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-N-**SD**-**Dec** Inc-SI-N-**SD**-**Dec**	This species is tolerant to various habitats, including seashores to alpine areas or arctic tundra (Banfield, 1976; Whitaker, 2004). Brannon (2002) reported that masked shrews were found in mostly north-facing slopes and streamsides in the southern Appalachian Mountains. Yet, this habitat restriction may be attributed to hydrological niche of this species.
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	This species is tolerant to various habitats, including seashores to alpine areas or arctic tundra (Banfield, 1976; Whitaker, 2004). However, the subspecies of *S. c. acadicus* is known to be common in particularly coniferous forests in New Brunswick (Morris, 1948). According Kirkland (1990), plant communities are unlikely to influence shrews directly, but they could affect shrews indirectly by adjusting micrometeorological conditions and/or abundance of invertebrates.
C4b (Diet)	Inc-SI-**N**-SD Inc-SI-**N**-SD	Masked shrews, including the subspecies of *S. c. acadicus*, are known to be generalist insectivores feeding on mainly Coleoptera and insect larvaes (Morris, 1948; Whitaker, 2004). According to Yom-Tov & Yom-Tov (2005), these food resources (small invertebrates) may be more available under milder winter. Thus, in the MVA, this subfactor was regarded as contribution to the species' adaptability.
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	A population in Prince Edward Island harbored a comparable variation to other populations in the mainland (Stewart and Baker, 1992), but genetic variations of the same species in Cape Breton have never been investigated.
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	This species in Alaska has increased body size in the second half of the last century, probably due to improved food availability led by global warming (Yom-Tov and Yom-Tov, 2005).

D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	0	8	86	7
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			------------------------------	------------------------------	
Severe scenario			------------------------------	------------------------------	
	This species is distributed from the southern Appalachians and central Rocky Mountains to Alaska, though it is confined to highlands in the southern limit of the species' distribution (around New York) (Banfield, 1976; Whitaker, 2004). Generally, warm and wet conditions (in April) are supposed to be beneficial for this species to reduce heat and water losses (Vickery and Bider, 1978), though it could also inhabit areas where minimum temperature is as low as -20°C (Yom-Tov & Yom-Tov, 2005). Yom-Tov & Yom-Tov (2005) reported that body size of the species was larger in warmer regions as well, but it is attributable to better dietary conditions (during winter). In contrast, the subspecies of *S. c. acadicus* is confined to the Maritimes (Banfield, 1976; Whitaker, 2004). This subspecies is known to be common in particularly coniferous forests in New Brunswick (Morris, 1948). According Kirkland (1990), plant communities are unlikely to influence shrews directly, but they could affect shrews indirectly by adjusting micrometeorological conditions and/or abundance of invertebrates. In line with this, masked shrews, including the subspecies of *S. c. acadicus*, are known to be generalist insectivores feeding on mainly Coleoptera and insect larvaes (Morris, 1948; Whitaker, 2004). According to Yom-Tov & Yom-Tov (2005), these food resources (small invertebrates) may be more available under milder winter. Hence, although temperature increase will be somewhat beneficial for this species, declines of coniferous forests might cancel out the positive impacts of climate change in part. Thus, both of PS and MA were chosen for the species.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of red squirrel (*Tamiasciurus hudsonicus*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	A geographical barrier of Cape Breton Island isolated from the mainland exists. This species inhabits boreal forest region in Cape Breton (Parks Canada, 2012). This species could survive under warmer climates, and natural barriers, like those among cold refugia for brook trout, are not likely to affect it. Thus, the natural barriers may not be relevant to the species' vulnerability in the park.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Road kills of red squirrels were reported in Nova Scotia (Fudge et al., 2007). However, in the southern boreal mixedwood zone of north-central Saskatchewan, Bayne and Hobson (2000) found significantly more abundant red squirrels in fragmented forests than continuous forests. However, the artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Cape Breton species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	In Alberta, most adults out of their original territories were within their neighborhoods by intervals of up to 135 m (Larsen and Boutin, 1994). In contrast, the largest long-distance movement of this species was documented as around 1.61 km (Bowman et al., 2002). As well, Francl et al. (2010) stated 4 km/yr was the possibly largest migration distance of the same species.
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	This species is distributed from Alaska to southern Arizona and New Mexico, whereas the subspecies of *T. h. gymnicus* is in just the Maritimes and Quebec (south of the St Lawrence River) (Banfield, 1976; Feldhamer et al., 2003). According to Pauls (1978), red squirrels in Winipeg showed more locomotive activities outside their nests in warmer temperatures (tested temperatures: -30 to +30 °C). This result was inconsistent with another study conducted in a laboratory where red squirrels were more active in cooler conditions (tested temperatures: 10-35°C) (Clarkson and Ferguson, 1972). Increase of spring temperature was positive on breeding success of the same species, at least in the range between 4 to 7°C in Yukon (Descamps et al., 2008).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	

C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	This species is associated with climax coniferous forests (Banfield, 1976; Vernes, 2004). In contrast, according to a study of *T. h. grahamensis* in southeastern Arizona, most red squirrels survived forest ground fires (Koprowski et al., 2006). In contrast, crown fires seem to be more influential on squirrels as well as their arboreal nests (Koprowski et al., 2006).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	White spruce buds are predated by red squirrels during deep-snow periods, when other food is not available, though the same species in interior Alaska could access to cone supplies via open tunnel systems (Smith, 1968). Therefore, snow sometimes hinder access to foods for red squirrels.
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	
C4a (Other spp for habitat)	GI-Inc-**SI**-N GI-**Inc**-**SI**-N	This species could inhabit both boreal coniferous forests as well as hardwood deciduous forests, though it prefers mixed forests including white pines and hemlocks on north-facing slopes (Banfield, 1976). Vernes (2004) suggested that this species was associated with mature coniferous forests as well. · Red squirrels tie to spruce. [Expert in Cape Breton Highlands] [Follow-up] Because spruce species were judged as mostly HV under severe climate change scenario, both Inc and SI were chosen here under the same scenario.
C4b (Diet)	Inc-SI-**N**-**SD** Inc-SI-**N**-**SD**	This species could forage a wide variety of foods, including conifer cones (e.g., pines and spruces), hardwood nuts, buds, flowers, fleshy fruits, barks, mashrooms and tree sap (Banfield, 1976; Feldhamer et al., 2003). Furthermore, larvaes of spruce bark beetle are utilized by red squirrels, providing around 20% of total energy requirements in Yukon Territory (Pretzlaw et al., 2006). Such a dietary change is likely to have been led by climate change (Pretzlaw et al., 2006).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	This species could compete with northern flying squirrels (*Glaucomys sabrinus*) (Pyare et al., 2010).
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	According to a meta-analysis in the southwestern part of North Ameirca, intra-population genetic variations of red squirrels were reduced in limited areas and/or isolated locations (Ditto and Frey, 2007). Therefore, the isolated and limited area in Cape Breton is also likely to have led to a reduced genetic variation of a squirrel population there. However, there is no evidence to suppor t this possibility yet.
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	This species in Yukon showed advanced timing of breeding by 18 days over the last decade, when spring temperature has increased, due to plastic and genetic changes (directional selection) (Reale et al., 2003).

		However, the genetic change was not based on molecular evidences and may have been overestimated (Postma, 2006).			
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	This species was forecasted to disappear in mid latitudinal areas of the United States, such as Great Smoky Mountains, Shenandoah, and Zion National Parks, due to climate change (Burns et al., 2003). As well, global warming was supposed to lower habitat quality of coniferous forests for red squirrels, and such a change in combination with reduced genetic variations could threat the persistence of squirrel populations (Ditto and Frey, 2007).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	0	27	73	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario					
Severe scenario					
	This species is distributed from Alaska to southern Arizona and New Mexico, whereas the subspecies of *T. h. gymnicus* is in just the Maritimes and Quebec (south of the St Lawrence River) (Banfield, 1976; Feldhamer et al., 2003). According to Pauls (1978), red squirrels in Winipeg showed more locomotive activities outside their nests in warmer temperatures (tested temperatures: -30 to +30 °C). This result was inconsistent with another study conducted in a laboratory where red squirrels were more active in cooler conditions (tested temperatures: 10-35°C) (Clarkson and Ferguson, 1972). Increase of spring temperature was positive on breeding success of the same species, at least in the range between 4 to 7°C in Yukon (Descamps et al., 2008). Therefore, physiological thermal niche should be "unknown" in this assessment. Consequently, the MVA did not determine vulnerability/adaptability of the species.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of black bear (*Ursus americanus*) inCape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	A geographical barrier of Cape Breton Island isolated from the mainland exists. This species inhabits taiga land region in Cape Breton Highlands according to Parks Canada (2012), but it has been observed in lower lands as well in Cape Breton except its southeastern region (Macmichael, 2007). This species could survive under warmer climates, and natural barriers, like those among cold refugia for brook trout, are not likely to affect it. Thus, the natural barriers may not be relevant to the species' vulnerability in the park.
B2b (Artificial barriers)	GI-Inc-**SI**-N GI-Inc-**SI**-N	Bears are not affected by not busy roads, but they still refrain from crossing main roads where more than 10,000 vehicles run per day (Macmichael, 2007; Robinson et al., 2010). As well, Landry et al. (2001) indicated that wilderness areas around national parks in Atlantic Canada are crucial for maintaining bear populations due to this species' wide minimum critical area.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-**Dec** GI-Inc-SI-N-**SD**-**Dec**	According to a genetic study, a male bear killed in Texas is likely to have migrated across 300 km from New Mexico (Onorato et al., 2004). Such high mobility of males was confirmed by other studies as well (e.g. 15-68 km in Costello (2010)), but females are less mobile, settling within 0-7 km from their home ranges (Costello, 2010).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species is found in forested regions in 39 states of the United States, 11 Canadian provinces and territories, and some parts of Mexico (Feldhamer et al., 2003). Even in Nova Scotia, it is distributed everywhere at high densities except the southeastern Cape Breton (Macmichael, 2007; Nova Scotia Government, 2013), and therefore there seems no thermal preference in its habitats.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	No preference for certain hydrological features. Accordingly, in Nova Scotia, it is distributed everywhere at high densities except the southeastern Cape Breton (Macmichael, 2007; Nova Scotia Government, 2013).
C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-**SD**-Dec	This species' preference to early/late successional habitats could be altered depending on seasons and/or places. For instance, early-successional habitats created by logging or fire are preferred during summer, whereas mature forests are selected during autumn and winter (USDA, n.d.). Also, black bears in post-fire places could consume more vegetation and/or moose calves, leading to better growth and reproduction (Schwartz and Frantzmann, 1991; USDA, n.d.).

C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-**N**	According to a study in west-central Idaho, due to insulative effect of snow cover and/or moist soils sustained by snow cover, American bear tends to select north-facing slopes to overwinter (in dens) (Beecham et al., 1983). However, Hayes and Pelton (1994) pointed out that slope aspect that bears chose was different among previous case studies, possibly depending on availability of dens. Therefore, the positive effect of snow cover for the American bear is not clear.
C3 (Physical habitat)	Inc-SI-N-**SD**-**Dec** Inc-SI-N-**SD**-**Dec**	No preference for certain geological features. Furthermore, according to a genetic study, a male bear killed in Texas is likely to have migrated across 300 km from New Mexico (Onorato et al., 2004). Such high mobility of males was confirmed by other studies as well (e.g. 15-68 km in Costello (2010)), suggesting its great ability to be compatible with various geological conditions.
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	This species' preference to early/late successional habitats could be altered depending on seasons and/or places. For instance, early-successional habitats created by logging or fire are preferred during summer, whereas mature forests are selected during autumn and winter (USDA, n.d.).
C4b (Diet)	Inc-**SI**-N-**SD** Inc-**SI**-N-**SD**	This species is an omnivorous and opportunistic predator of ungulate (Banfield, 1974; Zagar and Beecham, 2006). More specifically, fruits and seeds are main resources (Beeman & Pelton, 1980). Availability of nuts, produced by oaks and beeches, during autumn season is crucial for black bear populations (Beeman & Pelton, 1980; Elowe & Dodge, 1989). In Cape Breton Highlands, it was documented that black bears also strip bark of balsam fir trees (Pardy, 1997) and moose (Franklin, 2013). To show such specific dietary preference, not only SD but also SI were chosen for the CCVI calculation. However, under warming climates, most of the foods will flourish but not decline (c.f., assessment result of oak, beech, and deer). Thus, in the MVA, only SD was chosen.
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	1	33	32	34	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	
Severe scenario			-------------------------------	-------------------------------	
	This species is an omnivorous and opportunistic predator of ungulate (Banfield, 1974; Zagar and Beecham, 2006). More specifically, fruits and seeds are main resources (Beeman & Pelton, 1980). Availability of nuts, produced by oaks and beeches, during autumn season is crucial for black bear populations (Beeman & Pelton, 1980; Elowe & Dodge, 1989). In Cape Breton Highlands, it was documented that black bears also strip bark of balsam fir trees (Pardy, 1997) and moose (Franklin, 2013). In other words, given that red oak will flourish under warmer climates, such vegetational change will possibly lead to richer food resources for bear in Cape Breton Highlands National Park. However, there will be no directly positive effect of climate change on bear in terms of its thermal niche. High adaptation, like instant increase of deer after mild winter, has not been reported or considered with American bear. Therefore, both of PS and MA, but not HA, were given for bear under the both climate change scenarios.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of red fox (*Vulpes vulpes*) in Cape Breton Highalnds National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	A geographical barrier of Cape Breton Island isolated from the mainland exists. This species inhabits Acadian land region in Cape Breton Highlands (Parks Canada, 2012). This species could survive under warmer climates, and natural barriers, like those among cold refugia for brook trout, are not likely to affect it. Thus, the natural barriers may not be relevant to the species' vulnerability in the park.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Red foxes could use artificially modified areas, such as agricultural fields and urban areas (Feldhamer et al., 2003; Silva et al., 2009). Only four killed red foxes were found in the highway No.101 in Nova Scotia during 20 months (Fudge et al., 2007).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	Although this species' daily movements are at around 10 km-scales (Feldhamer et al., 2003), male red foxes move for 69 km on average and possibly up to 267 km in the autumn (Banfield, 1976).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species is distributed in a very wide range including Europe, North America, Asia and North Africa, whereas the subspecies of *V. v. rubicosa* inhabits the Maritime provinces and southeastern Quebec (Banfield, 1976). The northern limit of this species' distribution has expanded northwards at macrogeographic scale likely due to improved food availability (Hersteinsson and Macdonald, 1992). This food availability was then ultimately attributed to warming climates (Hersteinsson and Macdonald, 1992).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	Red foxes are distributed in various different types of habitats, including arctic tundra, boreal forests, deciduous forests and urban environments (Feldhamer et al., 2003). This species prefers semi-open country (e.g., lakeshores, riversides, deforested areas) and can hardly be seen in dense forests (Banfield, 1976; Feldhamer et al., 2003).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	Snow accumulations lead red foxes to avoid forested areas during winter (Feldhamer et al., 2003). According to Halpin and Bissonette (1988), deep snow restricted hunting activities by red foxes which were targetting small mammals in Maine.
C3	Inc-SI-**N**-SD-Dec	This species digs dens in usually sandy soils (Feldhamer et al., 2003). Red foxes were observed in lowlands in

(Physical habitat)	Inc-SI-**N**-SD-Dec	the eastern side of Cape Breton Highlands but not the western side or highlands (Porter, 2013).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Red foxes are distributed in various different types of habitats, including arctic tundra, boreal forests, deciduous forests and urban environments (Feldhamer et al., 2003). However, there were several studies reporting more specific preferences of red foxes somewhere. For instance, when much snow fell, this species tended to avoid softwood forests in Maine (Halpin and Bissonette, 1988). Also, forest habitats were perferred rather than lowlands and mesic grasslands by foxes in Yellow Stone National Park, which might be attributable to subspecies (*V. v. macroura*)-specific feature (Van Etten et al., 2007).
C4b (Diet)	Inc-SI-N-**SD** Inc-SI-N-**SD**	This species is an omnivore, eating meats (e.g., moles, snowshoe hares) in winter but invertebrates (e.g., crayfish, beetles) as well as vegetable matters (e.g., acorns, berries) in summer (Banfield, 1976). Feldhamer et al. (2003) documented this species as a frugivorous species, though admitting the fact that it also feeds on birds, reptiles, amphibians, fish and insects. The northern limit of this species' distribution has expanded northwards at macrogeographic scale likely due to improved food availability (Hersteinsson and Macdonald, 1992). This food availability was then ultimately attributed to warming climates (Hersteinsson and Macdonald, 1992).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	This species could be predated by or compete with coyotes and bobcats (Banfield, 1976; Feldhamer et al., 2003). Activity level of red foxes was positively correlated with that of moose and negatively correlated with that of coyotes in Cape Breton Highlands (Porter, 2013).
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	0	100
Severe scenario	0	0	0	0	100
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	
Severe scenario				-------------------------------	

	This species is distributed in a very wide range including Europe, North America, Asia and North Africa, whereas the subspecies of *V. v. rubicosa* inhabits the Maritime provinces and southeastern Quebec (Banfield, 1976). The northern limit of this species' distribution has expanded northwards at macrogeographic scale likely due to improved food availability (Hersteinsson and Macdonald, 1992). This food availability was then ultimately attributed to warming climates (Hersteinsson and Macdonald, 1992). Red foxes are distributed in various different types of habitats, including arctic tundra, boreal forests, deciduous forests and urban environments (Feldhamer et al., 2003). This species prefers semi-open country (e.g., lakeshores, riversides, deforested areas) and can hardly be seen in dense forests (Banfield, 1976; Feldhamer et al., 2003). Snow accumulations lead red foxes to avoid forested areas during winter (Feldhamer et al., 2003). According to Halpin and Bissonette (1988), deep snow restricted hunting activities by red foxes which were targetting small mammals in Maine. Therefore, although temperature increase per se may not be relevant to vulnerability/adaptability of red fox, disturbances and decline of snow accumulation may be beneficial for the same species. Because these positive effects are not clear, PS/MV and MV were chosen under moderate and severe climate change scenarios respectively.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of balsam fir (*Abies balsamea*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. Balsam firs are found in Acadian forests and boreal forests regions in Cape Breton (Parks Canada 2012). Steep slopes in the park may hinder upward migration of the species, and therefore Inc and SI were chosen for the CCVI. Yet, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered. · We may see fewer balsam fir in the lower elevations of the park but there would be adequate habitat for it in the higher elevations. [Expert in Cape Breton Highlands]
B2b (Artificial barriers)	GI-Inc-**SI**-N GI-Inc-**SI**-N	· Is a grass area occurred by moose browsing an artificial barrier? Because there should have been more balsam firs, without browsing by moose that were brought into here artificially. [Expert in Cape Breton Highlands] · Artificial barrier should be physical barriers, but not grasslands. [Expert in Cape Breton Highlands] · The grasslands created by moose are physical barriers, interrupting seed dispersal of balsam fir in particular. When we hear barrier, we think of mountain or island and at that scale it's easier to digest, but smaller scales within kilometers can still be barriers. [Expert in Cape Breton Highlands]
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Maximum seed dispersal distance of this species is around 160 m, according to Scheller and Mladenoff (2005). · Seeds are shed during winter and may be affected in how far they go by the snow cover, particularly later in the winter when there's a bit of a crust on the snow pack. If the winters are going to change substantially, and the snow pack is going to vary, then we might find a much lower distribution than we have at the moment. [Expert in Cape Breton Highlands]
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-**N**-SD GI-**Inc**-**SI**-N-SD	The annual mean temperature of the entire species' range, 2.9°C (range: -5.3 to 11.9°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.7°C. In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently in the middle of the species' distribution, but it will be hotter than the warmer limit of the distribution under severe climate change scenario (c.f., Appendix). This species grows best under the average summer temperature of around 21°C or below (Fowells, 1965), while the summer temperature in Cape Breton Highlands National Park is 15.0°C.
C2bi (Historical hydrological	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	

niche)		
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	This species generally grows in moist conditions, and particularly seed germination and seedling growth are sensitive to dry summer weather (Fowells, 1965). Pardy (1997) reported that balsam firs could be observed in both drier and wetter sites in Cape Breton. In contrast, in Quebec, black spruce is likely to replace balsam fir in extreme conditions, such as dry and coarse deposits or humid organic deposits (Messaoud et al., 2007). Parks Canada (2010c) reported that this species is on mesic sites in Cape Breton Highlands at late stages in forest succession.
C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec **Inc**-**SI**-N-SD-**Dec**	This species is shade tolerant but much susceptible to windfall and fire (Fowells, 1965; Achim et al., 2005; Scheller and Mladenoff, 2005). Yet, Telfer (2004) recorded remarkable regeneration of this species in forest gaps which were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. In Quebec, this species was confined to riversides or lakesides, which could buffer influences of fires (Messaoud et al., 2007). However, fires are unlikely to occur easily in Cape Breton, and therefore fire effects should not be overestimated. In Cape Breton, it was documented that moose browsing has supressed regeneration of balsam firs (Bridgland et al., 2007; Smith et al., 2010), though mortality of this species due to browsing was smaller than that of white birches. Moose is vulnerable to climate change, and therefore the negative impact of moose browsing will be reduced in changing climates. As well, spruce budworm outbreaks could reduce growth of this species and finally kill it at high mortality (e.g., 70-100% for mature fir forests) in Cape Breton during latter 1970s (Ostaff and MacLean, 1989), but this species is able to regenerate after such defoliation (MacLean, 1984; Pardy, 1997). In support of this, balsam fir is also often seen in regenerating stands, and a forest transition model revealed increasing balsam firs in the high altitude areas in Cape Breton for the next 100 years (Gullison, 2002). Parks Canada (2010c) reported that this species is on mesic sites in Cape Breton Highlands at late stages in forest succession. ·One of the reasons balsam fir is at risk for being less abundant is the warming temperature and insect epidemics. Given that budworm is more a boreal phenomenon, budworm outbreak would be less serious, but balsam fir adelgid would have more of an impact on balsam fir under climate change. [Expert in Cape Breton Highlands] · Fire intensity and frequency is expected to increase, which might increase vulnerability of balsam fir. One half of the park has a larger fire history. [Expert in Cape Breton Highlands]
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	Generally, balsam fir grows on Podzol, Podzolic, Gray Wooded or gley, covering silt loams and stony loams (Fowells, 1965). This species is likely to be distributed at pH ranging between 4.0 and 6.0 (Fowells, 1965). This species is distributed widely, covering the plateau to canyon slopes and valley bottoms in Cape Breton (Gullison, 2002). Due to its tolerance of nutrient stress, this species seems to grow better in upper-slope areas in this island (Smith, 1998). In line with this, the same species tends to be more common in upper positions in

		steeper slopes in Quebec (Messaoud et al., 2007). Organic matters could lead dominance of black spruces rather than balsam firs (Messaoud et al., 2007).			
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is shade tolerant (Fowells, 1965; Achim et al., 2005; Scheller and Mladenoff, 2005).			
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD				
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated.			
C4d (Other spp for disp)	Inc-**SI**-**N** Inc-**SI**-**N**	This is a wind-dispersed species, but rodents spread its seeds as well (Fowells, 1965).			
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**				
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD				
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N				
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD				
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-Inc-**SI**-N-SD-Dec **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	65	35	0
Severe scenario	0	100	0	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario		-------------------------------	-------------------------------		
Severe scenario	-------------------------------	-------------------------------			
	The annual mean temperature of the entire species' range, 2.9°C (range: -5.3 to 11.9°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.7°C. In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently in the middle of the species' distribution, but it will be hotter than the warmer limit of the distribution under severe climate change scenario (c.f., Appendix). This species grows best under the average summer temperature of around 21°C or below (Fowells, 1965), while the summer temperature in Cape Breton Highlands National Park is 15.0°C. In Cape Breton, it was documented that moose browsing has supressed regeneration of balsam firs (Bridgland et al., 2007; Smith et al., 2010), though mortality of this species due to browsing was smaller than that of white birches. Moose is vulnerable to climate change, and therefore the negative impact of moose browsing will be reduced in changing climates. As well, spruce budworm outbreaks could reduce growth of this species and				

	finally kill it at high mortality (e.g., 70-100% for mature fir forests) in Cape Breton during latter 1970s (Ostaff and MacLean, 1989), but this species is able to regenerate after such defoliation (MacLean, 1984; Pardy, 1997). Therefore, fir is vulnerable to climate change due to temperature increase, whereas browsing by moose will be suppressed partly. In other words, negative impacts of climate change on fir may be partly canceled by weakened effect of moose browsing. So, MV/PS and HV/MV were given for the balsam fir under moderate and severe climate change scenarios. In expert consultation, several experts suggested that the result of HV under severe scenario is probably fine for lowland areas, but not for whole the park. In this regard, giving the two categories of HV and MV here may be plausible. Thus, these categories were unchanged even after the consultation.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of striped maple (*Acer pensylvanicum*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. Striped maples are found in Acadian forests region in Cape Breton (Parks Canada, 2012). Steep slopes in the park may hinder upward migration of the species, and therefore Inc and SI were chosen for the CCVI. Yet, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	This species disseminates 13.75 seeds per m^2 at 10m and 1.25 seeds per m^2 at 60 m from each mother tree respectively, though some seeds on crusted snow cover could be moved for longer distances of up to 4 km (Gabriel and Walters, 1990).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-**SI**-**N**-SD	This species prefers cool places in Nova Scotia (Saunders, 1996). The annual mean temperature of the entire species' range, 6.2°C (range: 1.3 - 18.4°C) (Natural Resources Canada, 2014), is higher than the mean temperature of the park, 4.7°C. This species' seeds collected from south-central New Brunswick exhibited much higher germination rate in a condition of "16 h dark at 5 °C: 8 h light at 15 °C" than another condition of "16 h dark at 20 °C : 8 h light at 30 °C" during April and May (Bourgoin and Simpson, 2004).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	This species grows best on well-drained, moderately moist soils (Gabriel and Walters, 1990; Farrar, 1995), though its shallow root system makes it competitive for soil moisture (Gabriel and Walters, 1990).
C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	This species is shade-tolerant (Farrar, 1995), and it grows well under small forest gaps (Burns and Honkala, 1990). It prefers shaded places in Nova Scotia (Saunders, 1996). Striped maple is not strong for wind damages due to shallow roots, but generally it is protected by other dominant trees from winds (Gabriel and Walters, 1990). As well, Nyland et al. (2006) postulated that prescribed burnings would not be useful to control striped maples. However, accroding to an empirical study in Pennsylvania, it is sensitive to fires, so prescribed fires could be useful to control unwanted striped maples in silviculture (Brose et al., 2007).

C2d (Ice/Snow)	GI-Inc-SI-N GI-Inc-SI-N	Some seeds of this species on crusted snow cover could be moved for long distances (Gabriel and Walters, 1990).
C3 (Physical habitat)	Inc-SI-N-SD-Dec Inc-SI-N-SD-Dec	Generally, this species grows best on northern slopes in deep valleys with brown or gray-brown podzolic soils (Gabriel and Walters, 1990; Farrar, 1995). Its shallow root system makes it competitive for soil moisture as well as nutrients (Gabriel and Walters, 1990). This species prefers shaded and rich slopes in Nova Scotia (Saunders, 1996). In Cape Breton, it is absent from the plateau (Roland, 1945).
C4a (Other spp for habitat)	GI-Inc-SI-N GI-Inc-SI-N	
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-N Inc-SI-N	
C4e (Other spp interaction)	Inc-SI-N Inc-SI-N	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	0	100
Severe scenario	0	0	34	66	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	
Severe scenario		-------------------------------	-------------------------------		
	This species prefers cool places in Nova Scotia (Saunders, 1996). The annual mean temperature of the entire species' range, 6.2°C (range: 1.3 - 18.4°C) (Natural Resources Canada, 2014), is higher than the mean temperature of the park, 4.7°C. This species' seeds collected from south-central New Brunswick exhibited much higher germination rate in a condition of "16 h dark at 5 °C : 8 h light at 15 °C" than another condition of "16 h dark at 20 °C : 8 h light at 30 °C" during April and May (Bourgoin and Simpson, 2004). This				

	species is shade-tolerant (Farrar, 1995), and it grows well under small forest gaps (Burns and Honkala, 1990). It prefers shaded places in Nova Scotia (Saunders, 1996). Striped maple is not strong for wind damages due to shallow roots, but generally it is protected by other dominant trees from winds (Gabriel and Walters, 1990). Hence, although striped maple may flourish under moderate climate change scenario due to better thermal condition, too high temperature as well as disturbances (winds) may be adverse for the same species under severe climate change scenario.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

References cited in just this sheet (references that were already cited in the main text as common documents for many species are not shown here.)

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[Assessment sheet] Climate change vulnerability assessments of red maple (*Acer rubrum*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. Red maples are found in Acadian forests region in Cape Breton (Smith, 1998). Steep slopes in the park may hinder upward migration of the species, and therefore Inc and SI were chosen for the CCVI. Yet, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species can regenerate by sprouting after cutting and is often observed in post-harvest sites in New Brunswick (Franklin et al., 2000; Veinotte et al., 2003).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Sugar maple seeds can be dispersed for around 100 m but rarely beyond 5 km (He and Mlandeoff, 1999; Clark et al., 2003). This species may have spread at the pace of 80-90 m/yr (McLachlan et al., 2005).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD** Dec	In Nova Scotia, it is the most common hardwood (Roland, 1980; Saunders, 1996). The annual mean temperature of the entire species' range, 10.8°C (range: -0.3 to 23.9°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.7°C. In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently close to cooler limit of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Although this species is often observed in extreme soil-moisture conditions, either very wet or very dry (Fowells, 1965), multiple studies suggested that it somewhat prefers swamps, riversides and moist soils (Fowells, 1965; Farrar, 1995; Boland, 2012). Saeki et al. (2011) documented that swamps and wet/mesic upland forests were primary habitats for this species before European settlement in North America but that even dry upland forests are also included in current (i.e., post- European settlement) habitats. In Nova Scotia, it is the most common hardwood (Roland, 1980; Saunders, 1996).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species was regarded as being weak for fire damage (Fowells, 1965). Nevertheless, disturbances (e.g., fire, hurricanes) have contributed to an increasing number of red maple trees (Walter & Yawney, 1990; Saunders, 1996), probably because red maple is an early-successional colonist with wind-dispersed samaras (McLachlan et al., 2005). In support of this, Telfer (2004) recorded regeneration of this species in forest gaps which were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in

<table>
<tr><td></td><td></td><td colspan="5">1954.</td></tr>
<tr><td>C2d
(Ice/Snow)</td><td>GI-Inc-SI-N
GI-Inc-SI-N SD</td><td colspan="5">This species is not resilient to damages of ice and snow (Fowells, 1965).</td></tr>
<tr><td>C3
(Physical habitat)</td><td>Inc-SI-N-SD-Dec
Inc-SI-N-SD-Dec</td><td colspan="5">Saeki et al. (2011) documented that swamps and wet/mesic upland forests were primary habitats for this species before European settlement in North America but that even dry upland forests are also included in current (i.e., post-settlement) habitats. In other words, such a habitat generalist trait has led to a wide spread distribution of this species (Saeki et al., 2011). In Nova Scotia, it is the most common hardwood (Roland, 1980; Saunders, 1996), likely because this species can grow on a wide range of soil formations (Fowells, 1965).</td></tr>
<tr><td>C4a
(Other spp for habitat)</td><td>GI-Inc-SI-N
GI-Inc-SI-N</td><td colspan="5">This species can tolerate moderately to shade environments (Farrar, 1995) and can grow in combination with more than 70 commercial tree species (Fowells, 1965).</td></tr>
<tr><td>C4b
(Diet)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5"></td></tr>
<tr><td>C4c
(Pollination)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5">This species was supposed to be just wind-pollinated, but insects could help its pollination (USDA, 2011).</td></tr>
<tr><td>C4d
(Other spp for disp)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5">Wind-dispersed species (Fowells, 1965).</td></tr>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5"></td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5">A habitat generalist trait of this species has led to a wide spread distribution in the past, being reflected in high diversity of chloroplast haplotypes throughout this species' range (Saeki et al., 2011). However, there is insufficient information about genetic variations within maple populations in Nova Scotia yet.</td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="5"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="5">These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).</td></tr>
<tr><td rowspan="3">The CCVI [%]
Moderate scenario
Severe scenario</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>100</td><td>0</td></tr>
<tr><td rowspan="4">The MVA**
Moderate scenario
Severe scenario</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td></td><td></td><td></td><td>-------------------------------</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>-------------------------------</td></tr>
<tr><td colspan="5">In Nova Scotia, it is the most common hardwood (Roland, 1980; Saunders, 1996). The annual mean temperature of the entire species'</td></tr>
</table>

	range, 10.8°C (range: -0.3 to 23.9°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.7°C. In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently close to cooler limit of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). This species was regarded as being weak for fire damage (Fowells, 1965). Nevertheless, disturbances (e.g., fire, hurricanes) have contributed to an increasing number of red maple trees (Walter & Yawney, 1990; Saunders, 1996), probably because red maple is an early-successional colonist with wind-dispersed samaras (McLachlan et al., 2005). In support of this, Telfer (2004) recorded regeneration of this species in forest gaps which were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. Hence, although future climates may be still cooler than the average climate of the species' distribution, red maple will flourish under climate change due to temperature increase, disturbances, and less snow accumulation. To reflect such adaptability, MA and HA were given for the species under moderate and severe climate change scenarios respectively.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of sugar maple (*Acer saccharum*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. Pure sugar maple stands are found in Acadian land region in Cape Breton (Parks Canada, 2010a), and the upper limit of this species' distribution ranges between 800 and 1,250 feets in northern half of this island, as of around 1960 (Greenidge, 1961). Steep slopes in the park may hinder upward migration of the species, and therefore Inc and SI were chosen for the CCVI. Yet, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Sugar maple seeds can be dispersed for around or more than 100 m (Johnson, 1988; He and Mlandeoff, 1999). Maximum seed dispersal distance of this species is around 200 m, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** Dec GI-Inc-SI-N-**SD** Dec	The annual mean temperature of the entire species' range, 7.5°C (range: -0.4 to 19.5°C) (Natural Resources Canada, 2014), is higher than the mean temperature of the park, 4.7°C. In line with this, sugar maple pure forests are found in the Acadian forest regions, where growing season is longer than that in the plateau, in Cape Breton Highlands (Smith, 1998; Parks Canada, 2010a). In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently close to the cooler limit of the species' distribution, and it will be in the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	Generally, preferring moist and well-drained soils (Fowells, 1965; Farrar, 1995). River floodplains and stream banks are primary habitats for this species (Saeki et al., 2011). In Cape Breton Highlands, sugar maple is likely to be distributed in slopes along valley (Livingstone and Estes, 1966; Smith, 1998; Gullison and Bourque, 2001).
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	This species was previously regarded as just a late-successional species, and number of its seedlings has decreased after some burnings (Swan, 1970). Some shade is needed for this species, and its seedlings may dry out without any shade (Betts and Forbes, 2005). However, the latest studies observed that it is able to regenerate competitively after disturbances like hurricanes, forest fires and clear-cuttings, indicating this

		species as a trans-successional species (Nolet et al., 2008; Vargas-Rodriguez and Platt, 2012).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-**Inc**-**SI**-N	Snow could significantly assist this species to avoid fires and also enjoy moist conditions (Henne et al., 2007). Snow removal could be harmful for sugar maples, urging replacement of this species by other tree species (Comerford et al., 2012). Also, Phillips (2009) proposed that less snow around the Bay of Fundy would lead to more frequent thaw/freeze damage for this species.
C3 (Physical habitat)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	This species can thrive on all soil types in either of acid or alkaline, if these soils are rich, moist and well drained (Fowells, 1965). In other words, this speices is intolerant of nutrient stress (Smith, 1998). River floodplains and stream banks are primary habitats for this species (Saeki et al., 2011). In Cape Breton Highlands, sugar maple is likely to be distributed in lower slopes along valleys (Livingstone and Estes, 1966; Smith, 1998; Gullison and Bourque, 2001; Frechette and Vernal, 2012), though this is probably because growing season is limited in the plateau (Smith, 1998). In contrast, unstable rocky soils on upper slopes were judged as inappropriate sites for this species (Smith, 1998).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is exceeding in shade-tolerance among hardwoods (except American beech) (Godman et al., 1990; Smith, 1998; Nolet et al., 2008).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-**SI**-**N** Inc-**SI**-**N**	This species was supposed to be bee-pollinated, but recently this species is likely to pollinate without the helps of insects (Godman et al., 1990).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Wind-dispersed species (Fowells, 1965). Although its postdispersed seeds are predated by small mammals like eastern chipmunks, seed dispersal by these animals has not been confirmed (Hsia and Francl, 2009).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	**Inc**-SI-N-SD **Inc**-SI-N-SD	The population in Cape Breton Highlands showed smaller heterozygosity and polymorphism than most other populations, and this heterozygosity was significantly smaller in relation to some other populations (Young et al., 1993). These results implied genetic drift and/or natural selection at the eastern edge of this species' distribution (Young et al., 1993). Also, Saeki et al. (2011) stated that limited diversity of this species' chloroplast haplotypes throughout the species' range could be attributed to its restricted geographic range during Last Glacial Maximum without vast coastal plains (i.e., a strong bottleneck effect).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	50	50
Severe scenario	0	0	67	33	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario				-------------------------------	
Severe scenario			-------------------------------	-------------------------------	
	The annual mean temperature of the entire species' range, 7.5°C (range: -0.4 to 19.5°C) (Natural Resources Canada, 2014), is higher than the mean temperature of the park, 4.7°C. In line with this, sugar maple pure forests are found in the Acadian forest regions, where growing season is longer than that in the plateau, in Cape Breton Highlands (Smith, 1998; Parks Canada, 2010a). In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently close to the cooler limit of the species' distribution, and it will be in the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). Snow could significantly assist this species to avoid fires and also enjoy moist conditions (Henne et al., 2007). Snow removal could be harmful for sugar maples, urging replacement of this species by other tree species (Comerford et al., 2012). Also, Phillips (2009) proposed that less snow around the Bay of Fundy would lead to more frequent thaw/freeze damage for this species. The population in Cape Breton Highlands showed smaller heterozygosity and polymorphism than most other populations, and this heterozygosity was significantly smaller in relation to some other populations (Young et al., 1993). These results implied genetic drift and/or natural selection at the eastern edge of this species' distribution (Young et al., 1993). Also, Saeki et al. (2011) stated that limited diversity of this species' chloroplast haplotypes throughout the species' range could be attributed to its restricted geographic range during Last Glacial Maximum without vast coastal plains (i.e., a strong bottleneck effect). Therefore, although temperature increase may be beneficial for this species' survival, limited genetic variation may interrupt adaptation of sugar maple under climate change. As well, less snow cover will be damaging to the same species species in this park. Therefore, assuming that high adaptation is unlikely to occur with the species, MA and PS/MA were chosen for sugar maple under moderate and severe climate change scenarios.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of yellow birch (*Betula alleghaniensis*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. Yellow birches are found in Acadian forests region in Cape Breton (Parks Canada, 2012). Steep slopes in the park may hinder upward migration of the species, and therefore Inc and SI were chosen for the CCVI. Yet, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD -Dec	Maximum seed dispersal distance of this species is around 400 m, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-N-**SD** GI-Inc-**SI**-N-**SD**	The annual mean temperature of the entire species' range, 5.0°C (range: -0.7 to 17.9°C) (Natural Resources Canada, 2014), is close to the mean temperature of the park, 4.7°C. In Nova Scotia, the yellow birch grows well on northern or eastern slopes, where temperature is cooler (Fowells, 1965; Saunders, 1996). Even in Cape Breton, shaddy valley bottoms are suitable for this species because of cooler microclimates (Smith, 1998). In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently in the cooler side of the species' distribution, and it will be in the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species is distributed on moist soils (Farrar, 1995). In less moist sites, yellow birch is likely to be replaced by other tolerant species gradually (Fowells, 1965). Also, droughts can be critical for germination and seedling development of this species (Jackson and Booth, 2002).
C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-**SD**-Dec	This species could occur at any point of forest successions, but it is regarded as a climax species (Fowells, 1965). However, disturbances to some degrees (including fire and windthrow) in forest floor are beneficial for germination of this species (Fowells, 1965; Betts and Forbes, 2005). Windthrow is important to maintain this species' occurrence (Schulte and Mladenoff, 2005). Small forest gaps are also helpful for development of this species' seedlings (Fowells, 1965). In contrast, because its thin bark can be easily burned, this species may be

		injured in forest fire (Fowells, 1965). Rootlet mortality could be drastically increased by higher soil temperature in summer (Fowells, 1965).
C2d (Ice/Snow)	GI-Inc-SI-N GI-Inc-SI-N	Secondary seed dispersal of this species on snow allows it to move for hundreds of feet from mother trees (Fowells, 1965: Saunders, 1996). As well, early spring thaw-freeze events have led to dieback of yellow birches in the Maritime Regions during 1930s-1950s, and little snow cover pronounces the negative effects of such events (Bourque et al., 2005). Climate change, especially temperature variability, will prolong length of such thaw events (Zhu et al., 2002).
C3 (Physical habitat)	Inc-SI-N-SD-Dec Inc-SI-N-SD-Dec	This species occurs on podzolic soils, and its best habitat is moderately well-drained sandy loams (Fowells, 1965). In Cape Breton, this species is distributed up to the altitude of around 335 m (Roland, 1945), and upper-slopes are better for dominance of yellow birches than lower slopes in a long-term (Smith, 1998; Bouman et al., 2004). Simultaneously, shaddy valley bottoms are suitable for this species because of cooler microclimates (Smith, 1998).
C4a (Other spp for habitat)	GI-Inc-SI-N GI-Inc-SI-N	This species could occur at any point of forest successions, but it is regarded as a climax species (Fowells, 1965). It is tolerant of most other birch species but not much competitive with other tree species (Fowells, 1965).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-N Inc-SI-N	Wind-pollinated (Fowells, 1965).
C4d (Other spp for disp)	Inc-SI-N Inc-SI-N	
C4e (Other spp interaction)	Inc-SI-N Inc-SI-N	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	33	67	0
Severe scenario	0	81	19	0	0

The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------	-------------------------------	
Severe scenario		-------------------------------	-------------------------------		
	The annual mean temperature of the entire species' range, 5.0°C (range: -0.7 to 17.9°C) (Natural Resources Canada, 2014), is close to the mean temperature of the park, 4.7°C. In Nova Scotia, yellow birch grows well on northern or eastern slopes, where temperature is cooler (Fowells, 1965; Saunders, 1996). Even in Cape Breton, shaddy valley bottoms are suitable for this species because of cooler microclimates (Smith, 1998). In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently in the cooler side of the species' distribution, and it will be in the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). Secondary seed dispersal of this species on snow allows it to move for hundreds of feet from mother trees (Fowells, 1965: Saunders, 1996). As well, early spring thaw-freeze events have led to dieback of yellow birches in the Maritime Regions during 1930s-1950s, and little snow cover pronounces the negative effects of such events (Bourque et al., 2005). Climate change, especially temperature variability, will prolong length of such thaw events (Zhu et al., 2002). Hence, under moderate climate change scenario, yellow birch will be stable or slightly flourishing due to a thermally milder condition. Even under severe climate change scenario, temperature increase per se will not be so harmful, but less snow accumulation will afftect this species negatively, and hence it was judged presumably stable or moderately vulnerable.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of white birch (*Betula papyrifera*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. White birches are found in boreal forests region in Cape Breton (Parks Canada, 2012). Steep slopes in the park may hinder upward migration of the species, and therefore Inc and SI were chosen for the CCVI. Yet, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species can regenerate by sprouting after cutting and often observed in post-harvest sites in New Brunswick (Fowells, 1965; Franklin et al., 2000).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-**SD**-Dec GI-Inc-SI-**N**-**SD**-Dec	This species disperses seeds for considerable distances thanks to its light seed weight, but most seeds may fall in just neighborhoods of their mother trees (Fowells, 1965). A maximum seed dispersal distance of this species is around 5 km, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-**N**-SD GI-**Inc**-SI-N-SD	This species is distributed in Alaska and most of Canada, reaching northward nearly to the tree growth limit (Fowells, 1965). It is unlikely that white birch grows at an average July temperature higher than 21°C (Fowells, 1965). The annual mean temperature of the entire species' range, 3.9°C (range: -4.8 to 12.5°C) (Natural Resources Canada, 2014), is slightly lower than the mean temperature of the park, 4.7°C. This species showed declined growth and diebacks likely due to its sensitivity to temperature and moisture in warmer and less moist years than normal ones in northern Michigan (Jones, 1993). In terms of Growing-Degree Days (GDD5), Cape Breton Highalnds National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, the same park will be hotter than the warmer limit.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-**SD** GI-Inc-**SI**-N-**SD**	This species could be distributed on soils in a wide range of moisture conditions, though it tends to be more common in somewhat drier sites (Fowells, 1965). Wang et al. (1998) reported that this species is tolerant of drought. Because white birch is physiologically tolerant of extreme site conditions, it is distributed in upper ridges of the plateau in Cape Breton as well (Bourque et al., 2000). Pardy (1997) reported that balsam fir often coexists with white birch on drier sites in this island. In contrast, this species showed declined growth and diebacks likely due to its sensitivity to temperature and moisture in warmer and less moist years than normal

		ones in northern Michigan (Jones, 1993).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-SD-**Dec**	This species is not shade-tolerant, being often found in forest edges, lakeshores, and roadsides (Farrar, 1995; Scheller and Mladenoff, 2005). This species can regenerate by sprouting after fire and cutting (Fowells, 1965; Franklin et al., 2000). Fire could contribute to establishments of this species' stands, but moderate fires could be also harmful for already established stands by burning trees (Fowells, 1965; Couillard et al., 2012). Wang et al. (1998) reported that this species is tolerant of drought. On the other hand, rootlet mortality and birch dieback-like symptom are expected with increased soil temperatures (Fowells, 1965). In Cape Breton, it was documented that moose browsing has supressed regeneration of white birches resulting in high mortality (Bridgland et al., 2007; Smith et al., 2010), whereas the same species could expand its distribution after spruce budworm outbreaks (Pardy, 1997; Smith, 1998). Moose is vulnerable to climate change, and therefore the negative impact of moose browsing will be reduced in changing climates.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-**Inc**-**SI**-N	White birch decline in northeastern North America may be ascribed to early spring thaw-freeze events, which were reported with yellow birches, due to thier shallow roots (Mohan et al., 2009; Auclair et al., 2010). Little snow cover pronounces the negative effects of such events (Bourque et al., 2005). Climate change, especially temperature variability, will prolong length of such thaw events (Zhu et al., 2002).
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	This species grows on podzol soils, but sometimes it could grow on brown podzolic soils as well (Fowells, 1965). Shallow and stony soils, bog together with peat soils are available for white birch (Fowells, 1965). In Cape Breton, it was documented that birch is generally intolerant of nutrient stress (Smith, 1998). However, because white birch is physiologically tolerant of extreme site conditions, it is distributed widely, covering even in upper ridges of the plateau in Cape Breton (Bourque et al., 2000; Gullison, 2002).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is more intolerant than most other tree species in the northeastern United States, except aspens, pin cherries and gray birches (Fowells, 1965).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated.
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Wind-dispersed species (Fowells, 1965).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	

<table>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-**N**-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4">These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).</td></tr>
<tr><td rowspan="3">The CCVI [%]
Moderate scenario
Severe scenario</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>100</td><td>0</td></tr>
<tr><td>0</td><td>50</td><td>50</td><td>0</td><td>0</td></tr>
<tr><td rowspan="4">The MVA**
Moderate scenario
Severe scenario</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td></td><td>------------------------------</td><td></td><td></td><td></td></tr>
<tr><td>------------------------------</td><td>------------------------------</td><td></td><td></td><td></td></tr>
<tr><td colspan="5">This species is distributed in Alaska and most of Canada, reaching northward nearly to the tree growth limit (Fowells, 1965). It is unlikely that white birch grows at an average July temperature higher than 21°C (Fowells, 1965). The annual mean temperature of the entire species' range, 3.9°C (range: -4.8 to 12.5°C) (Natural Resources Canada, 2014), is slightly lower than the mean temperature of the park, 4.7°C. This species showed declined growth and diebacks likely due to its sensitivity to temperature and moisture in warmer and less moist years than normal ones in northern Michigan (Jones, 1993). In terms of Growing-Degree Days (GDD5), Cape Breton Highalnds National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, the same park will be hotter than the warmer limit. This species is not shade-tolerant, being often found in forest edges, lakeshores, and roadsides (Farrar, 1995; Scheller and Mladenoff, 2005). This species can regenerate by sprouting after fire and cutting (Fowells, 1965; Franklin et al., 2000). Fire could contribute to establishments of this species' stands, but moderate fires could be also harmful for already established stands by burning trees (Fowells, 1965; Couillard et al., 2012). Wang et al. (1998) reported that this species is tolerant of drought. On the other hand, rootlet mortality and birch dieback-like symptom are expected with increased soil temperatures (Fowells, 1965). In Cape Breton, it was documented that moose browsing has supressed regeneration of white birches resulting in high mortality (Bridgland et al., 2007; Smith et al., 2010), whereas the same species could expand its distribution after spruce budworm outbreaks (Pardy, 1997; Smith, 1998). Moose is vulnerable to climate change, and therefore the negative impact of moose browsing will be reduced in changing climates. White birch decline in northeastern North America may be ascribed to early spring thaw-freeze events, which were reported with yellow birches, due to thier shallow roots (Mohan et al., 2009; Auclair et al., 2010). Little snow cover pronounces the negative effects of such events (Bourque et al., 2005). Climate change, especially temperature variability, will prolong length of such thaw events (Zhu et al., 2002).Therefore, although some disturbances may be positive for white birch, temperature increase makes it vulnerable to both of moderate and severe climate change scenarios. Furthermore, less snow accumulation will contribute to the vulnerability, but browsing by moose will be also suppressed under severe climate change scenario. Therefore, MV was given under moderate scenario, while HV and MV were given under severe scenario.</td></tr>
</table>

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of American beech (*Fagus grandifolia/Fagus americana*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. American beeches are found in Acadian land region in Cape Breton (Parks Canada, 2012). Steep slopes in the park may hinder upward migration of the species, and therefore Inc and SI were chosen for the CCVI. Yet, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-Dec GI-Inc-SI-N-**SD**-Dec	A past migration speed of this species was estimated as roughly 80-90 m/yr (sustained 4 km per reproduction) mainly by long-distance dispersals (Cogbill, 2005; McLachlan et al., 2005).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD** Dec	In North America, *F. grandifolia* is distributed in and around the temperate zone (Fang and Lechowicz, 2006). The annual mean temperature of the entire species' range, 9.8°C (range: 0.7 - 21.0°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.7°C. In agreement with this, extremely cold damages to this species has been known in northern Cape Breton (Saunders, 1996). In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently close to the cooler limit of the species' distribution, and it will be closer to the middle of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be just in the middle of the distribution. Sufficient growing season warmth was crucial for this species' northwards migration, and a lack of growing season warmth has prevented its migration to the Atlantic Islands (Fang and Lechowicz, 2006).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	Moist soils with low base saturation allow beeches to occupy and dominate in late-successionlal forests (Kitamura and Kawano, 2001; Canham, 2005). This species tends to prefer moist conditions more strongly at its northern limit than its southern limit (Fang and Lechowicz, 2006).
C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	This species is very vulnerable to fire injury due to its thin barks and large surface roots (Fowells, 1965). In line with this, its abundance was lowered after wildfire, being replaced by species like sugar maple, red maple, hemlock and red spruce (Telfer, 2004). However, such fires are unlikely to occur easily in Cape Breton, and

		therefore fire effects should not be overestimated. Also, in forest gaps, sugar maple is more likely to grow well than beech (Beaudet et al., 2007), whereas American beech is more shade-tolerant than sugar maple (Smith, 1998). In cold regions within this species' range (e.g., highlands in west-central New Brunswick), cold winter temperature may have controlled the spread of beech bark disease, which is very common and serious in Acadian forests (Houston and Houston, 2000; Simpson, 2008). Given the fact that Cape Breton Highlands is situated in the northern limit of the distribution, warming is likely to contribute to expand the disease infection further, even though this disease has been already seen in Cape Breton. Nevertheless, positive effects of warming on growth of this species may outweigh the negative effects of this disease in warm climates (Witter et al., 2004).			
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-N	Snow could somewhat assist this species to avoid fires and also enjoy moist conditions (Henne et al., 2007).			
C3 (Physical habitat)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	This species is usually observed in the Gray-Brown Podzolic and the Laterite, but not limestone walleys, and timber forests including many beech trees are found in acidic conditions of pH ranging between 4.1 and 6.0 (Fowells, 1965). This speices is intolerant of nutrient stress, which might control the growth and distribution of this species in Cape Breton (Smith, 1998).			
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is very tolerant and competitive (Fowells, 1965; Kitamura and Kawano, 2001; Canham, 2005).			
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD				
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Koch et al., 2010).			
C4d (Other spp for disp)	Inc-**SI**-N Inc-**SI**-N	This species' seeds are secondarily dispersed by pigeons, blue jays and rodents (Kitamura and Kawano, 2001; Cogbill, 2005).			
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**				
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD				
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N				
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD				
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	According to pollen fossil analysis in Cape Breton, *Fagus* has decreased in the last 1,000 years due to climate cooling (Miller and Livingstone, 1993).			
D2 (Modeled change)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely

Moderate scenario	0	0	0	0	100
Severe scenario	0	0	0	100	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario				-------------------------------	
Severe scenario				-------------------------------	
	In North America, *F. grandifolia* is distributed in and around the temperate zone (Fang and Lechowicz, 2006). The annual mean temperature of the entire species' range, 9.8°C (range: 0.7 - 21.0°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.7°C. In agreement with this, extremely cold damages to this species has been known in northern Cape Breton (Saunders, 1996). In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently close to the cooler limit of the species' distribution, and it will be closer to the middle of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be just in the middle of the distribution. Sufficient growing season warmth was crucial for this species' northwards migration, and a lack of growing season warmth has prevented its migration to the Atlantic Islands (Fang and Lechowicz, 2006). According to a simulation study targetting Cape Breton, a beech component in stands was predicted to increase drastically under warming climate, because this species needs warmer climate than sugar maple, yellow birch and red maple (Smith, 1998). This species is very vulnerable to fire injury due to its thin barks and large surface roots (Fowells, 1965). In line with this, its abundance was lowered after wildfire, being replaced by species like sugar maple, red maple, hemlock and red spruce (Telfer, 2004). However, such fires are unlikely to occur easily in Cape Breton, and therefore fire effects should not be overestimated. Also, in forest gaps, sugar maple is more likely to grow well than beech (Beaudet et al., 2007), whereas the American beech is more shade-tolerant than sugar maple (Smith, 1998). In cold regions within this species' range (e.g., highlands in west-central New Brunswick), cold winter temperature may have controlled the spread of beech bark disease, which is very common and serious in Acadian forests (Witter et al., 2004; Simpson, 2008). Given the fact that Cape Breton Highlands is situated in the northern limit of the distribution, warming is likely to contribute to expand the disease infection further, even though this disease has been already seen in Cape Breton. Nevertheless, positive effects of warming on growth of this species may outweigh the negative effects of this disease in warm climates (Witter et al., 2004). Snow could somewhat assist this species to avoid fires and also enjoy moist conditions (Henne et al., 2007). Overall, beech will flourish drastically due to temperature increase in Fundy National Park. In this sense, MA and HA should be appropriate to show the adaptability under moderate and severe climate change scenarios respectively. Yet, moderately negative influences of less snow accumulation, hydrological change and/or beech bark disease might cancel such a positive effect of thermal change in part. Therefore, just MA was chosen for beech here.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of Eastern larch/American larch/Tamarack (*Larix laricina*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	**GI**-**Inc**-**SI**-N **GI**-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. Larches are found in taiga region in Cape Breton (Smith, 1998; Gullison and Bourque, 2001). Bouman et al. (2004) noted that this species is also a main component species of boreal forests in Cape Breton Island. Within Cape Breton Highlands National Park, larch could migrate to nowhere in the future surrounded by lowlands, and migration will be completely/remarkably hindered. Thus, GI, Inc, and SI were selected.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Artificial disturbances, such as logging and farming, in the last 200 years have favoured such a pioneer species, allowing it to expand its distribution to neighboring uplands in southern New Brunswick (Ying and Morgenstern, 1991).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-**SI**-N-SD-Dec GI-Inc-**SI**-N-SD-Dec	Only 2% of larch seeds were disseminnated for 60 m or more in an observation in Minnesota (Duncan, 1954). The numbers of filled seeds dispersed for 9 m and 18 m were around 11% and 6% of that dispersed just under mother trees respectively in Alaska, indicating limited seed dispersal ability of this species in comparison with other coniferous species (Fowells, 1965; Brown et al., 1988).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-**N**-SD GI-**Inc**-**SI**-N-SD	This species is distributed from Alaska south to Maryland and West Virginia, suggesting the widest distribution of American coniferous tree species (Fowells, 1965; Park and Fowler, 1982). However, according to a study in Ontario, this species is likely to be highly differentiated in terms of cold hardiness, specializing to each microclimate (Joyce, 1988). The annual mean temperature of the entire species' range, 2.3°C (range: -7.3 to 10.3°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.7°C. This species dominates wet acid peat softwoods in cool/cold areas in the Acadian Forest Region (Loos and Ives, 2003). The highest temperature in this species' distribution is between 29 and 43°C (Fowells, 1965). In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species is associated with bogs and swamps especially in the southern part of the species' distribution, while it could be distributed in a wide range of sites in more northern parts (Fowells, 1965; Park and Fowler,

hydrological niche)		1982). In Cape Breton Highlands National Park, larch is distributed in moist areas (Franklin, 2013). High watertables in floodplain wetlands also could contribute to protecting this species from fire-related damages (Brown et al., 1988). However, prolonged water periods, like flooding, may decrease germination rate of this species (Duncan, 1954; Fowells, 1965).
C2c (Disturbance)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	Generally, the eastern larch is a pioneer and intolerant species, beginning forest successions in bog lands (Fowells, 1965; Duncan, 1954; Smith, 1998). This species dominates wet acid peatsoftwoods in the Acadian Forest Region, and there are stand-replacing fires and small patch blowdowns (Loos and Ives, 2003). However, strong fires and winds could be negative for this species because of its shallow roots (Fowells, 1965). Artificial disturbances, such as logging and farming, in the last 200 years have favoured such a pioneer species, allowing this species to expand its distribution to neighboring uplands in southern New Brunswick (Ying and Morgenstern, 1991). Larch sawfly and larch beetle have also influenced the forests by defoliation and/or damaging seeds (Fowells, 1965; Loos and Ives, 2003). As well, larch seeds are often damaged by chalcids, which are likely to be killed by low temperature (e.g., mortality rate is 100% in -20°C for 12 weeks) according to a study in Ontario (Prevost, 2002). In contrast, disturbances by browsing mammals are not influential on this species (Duncan, 1954).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Snowfall amount greatly varies within this species' distribution between 76 and 406 cm (Fowells, 1965).
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species dominates wet acid peat softwoods with poor organic soils in the Acadian Forest Region (Fowells, 1965; Hinds, 2000; Loos and Ives, 2003). Duncan (1954) suggested that this species could grow in uplands even in the southern side of this species' distribution, given favourable moisture conditions without harsh interspecific competition. The same author also proposed that pH (at least in the range between 4.5 and 7.5) has little influences on germination of this species.
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species dominates wet acid peat softwoods with black spruce in the Acadian Forest Region (Fowells, 1965; Loos and Ives, 2003). Eastern larch is a very fast growing species, though the growth is negatively correlated with latitude of seedlings' origins (Park and Fowler, 1982)
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Ying and Morgenstern, 1990).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b	Inc-SI-N	

(Genetic bottleneck)	Inc-SI-N				
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD				
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-Inc-**SI**-N-SD-Dec **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	7	94	0
Severe scenario	0	75	25	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario		-------------------------------	-------------------------------		
Severe scenario		-------------------------------			
	This species is distributed from Alaska south to Maryland and West Virginia, suggesting the widest distribution of American coniferous tree species (Fowells, 1965; Park and Fowler, 1982). However, according to a study in Ontario, this species is likely to be highly differentiated in terms of cold hardiness, specializing to each microclimate (Joyce, 1988). The annual mean temperature of the entire species' range, 2.3°C (range: -7.3 to 10.3°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.7°C. This species dominates wet acid peat softwoods in cool/cold areas in the Acadian Forest Region (Loos and Ives, 2003). The highest temperature in this species' distribution is between 29 and 43°C (Fowells, 1965). In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate and severe climate change scenarios (c.f., Appendix). Generally, eastern larch is a pioneer and intolerant species, beginning forest successions in bog lands (Fowells, 1965; Duncan, 1954; Smith, 1998). Therefore, thermal change will be harmful on larch, though the same species will still persist under severe climate change scenario, being partly assisted by disturbance regimes. Thus, not HV, but MV was given for larch under severe scenario.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of white spruce (*Picea glauca*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. White spruces are found in boreal forests region in Cape Breton (Parks Canada, 2012). Steep slopes in the park may hinder upward migration of the species, and therefore Inc and SI were chosen for the CCVI. Yet, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	White spruces could disseminate its seeds for 100 m on average but sometimes over than 300 m (Fowells, 1965). According to a modelling study, seed rain of this species halves at a distance of 30 m, but around 3% of dispersed seeds could move for more than 800 m (Wirth et al., 2008). Maximum seed dispersal distance of this species is around 200 m, according to Scheller and Mladenoff (2005). Moreover, a cpDNA phylogeographical study suggested that postglacial migration rates of 1,500-2,000 m/yr, presumed by a fossil pollen analysis, was an overestimation (Anderson et al., 2006).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-**N**-SD GI-**Inc**-**SI**-N-SD	The annual mean temperature of the entire species' range, 1.2°C (range: -11.9 to 10.6°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.7°C. However, some of this species' range has experienced considerably hot temperature (e.g., 43°C in southwestern Manitoba) (Fowells, 1965), indicating a high climatic flexibility of this species (Farrar, 1995). Yet, even this species showed inhibited photosynthesis with heat treatment at 42°C or higher (Bigras, 2000). In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be hotter than the warmer limit of the distribution.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD**	This species inhabits wet insular Nova Scotia but also semi-arid continental areas in southwestern Manitoba (Fowells, 1965). White spruce occurs more frequently on drier uplands in Alaska (Wirth et al., 2008), but in Nova Scotia it develops best along streams, lakes or coast (Saunders, 1996). Lack of moisture could be a main reason for controlling this species' southern limits (Barber et al., 2004). However, Pardy (1997) reported that

		balsam fir often coexists with white spruce on relatively drier sites in Cape Breton. Therefore, even considering that Cape Breton is generally in moist conditions, a little drier environment should be suitable for this species in Cape Breton Highlands.
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	This species is intermediately shade-tolerant and classified as a climax species, but still it is unlikely to compete well with hardwoods (Fowells, 1965; Scheller and Mladenoff, 2005). In other words, some gaps are needed for regeneration of this species (e.g., abandoned agricultural fields in Cape Breton) (Smith, 1998; Bouman et al., 2004). It is susceptible to windthrow but more tolerant of winds than black spruce and balsam fir on uplands (Fowells, 1965). Fires could allow white spruce to replace black spruce, if there is no effect of permafrost, in Alaska (Wirth et al., 2008). However, white spruce is generally regarded as a fire-intolerant species, and its populations in central Quebec may have been declining due to fire disturbances as well as postfire growth of black spruce stands (Lafontaine et al., 2010). In Cape Breton during latter 1970s, spruce budworm outbreaks killed it at relatively moderate mortality (i.e., 27% (Ostaff and MacLean, 1989) or 50% (Smith, 1998)), whilst spruce beetles have simltaneously killed another spruces which corresponded around 39% of total volume (Ostaff and MacLean, 1989).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-**N** SD	Most parts of this species' distribution are in the permafrost zone in northern Canada (Fowells, 1965), though it was documented, for instance, that white spruce was distributed without permafrost in some parts in Alaska (Wirth et al., 2008). Wamer climates may generally lead to earlier snowmelting, enabling this species to grow better (Wilmking et al., 2004), while snow-free conditions could bring about winter desiccation and cold-induced photoinhibition at alpine-treeline in Yukon (Danby and Hik, 2007). Secondary seed dispersal of this species on snow may be relevant to this species' colonization as well (Wirth et al., 2008).
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	This species could occur on a wide range of pH and various types of soils which are characterized with glacial, lacustrine, marine, or alluvial origins, whereas it grows best on podozolized gamma gley loams or clays (Fowells, 1965). As well, white spruce requires much more nutrient than other associated tree species, being able to respond well to fertilizer treatments (Fowells, 1965).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is intermediately shade-tolerant and classified as a climax species, but still it is unlikely to compete well with hardwoods (Fowells, 1965; Scheller and Mladenoff, 2005). Also, this species is likely to be dispalced by balsam fir in Cape Breton by succession (Gullison, 2002).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Andalo et al., 2005).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Many birds attempt to obtain seeds of white spruce (Fowells, 1965). Also, it was documented that white spruce was preferred in comparison with black spruce by red squirrels, though spruce seeds dispered by squirrels were unlikely to germinate successfully (Brink and Dean, 1966). Secondary seed dispersal of this species on snow may be relevant to this species' colonization as well (Wirth et al., 2008).
C4e	Inc-SI-**N**	

(Other spp interaction)	Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-**N**-SD Inc-SI-**N**-SD	Although there has been no study quantifying genetic variations of this species in Cape Breton, haplotypic diversity in cpDNA regions was moderate or high in New Brunswick population in comparison with those in other parts of the species' range (Lafontaine et al., 2010).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-**SI**-N-SD-Dec **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	50	50	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario		-------------------------------	-------------------------------		
Severe scenario	-------------------------------	-------------------------------			
	The annual mean temperature of the entire species' range, 1.2°C (range: -11.9 to 10.6°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.7°C. However, some of this species' range has experienced considerably hot temperature (e.g., 43°C in southwestern Manitoba) (Fowells, 1965), indicating a high climatic flexibility of this species (Farrar, 1995). Yet, even this species showed inhibited photosynthesis with heat treatment at 42°C or higher (Bigras, 2000). In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be hotter than the warmer limit of the distribution. Therefore, although white spruce is a little tolerant to thermal change, it is still vulnerable to climate change. Under severe climate change scenario, in particular, white spruce could be extirpated because of too high temperature and possibly budworm/beetle outbreaks. In this respect, HV and MV were chosen for white spruce under severe scenario. However, be aware that, the determined vulnerability under moderate climate change scenario is slightly less serious than that of black spruce. White spruce is likely to replace black spruce under warming climates in Alaska, likely because the former species is slightly more fitting to a warm climate than the latter one (Wirth et al., 2008).				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of black spruce (*Picea mariana*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. Black spruces are found in boreal forests region in Cape Breton (Parks Canada, 2012), whereas Gullison (2002) reported that this species was found mainly at altitudes higher than 350 m. Steep slopes in the park may hinder upward migration of the species, and therefore Inc and SI were chosen for the CCVI. Yet, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-**SI**-**N**-SD-Dec GI-Inc-**SI**-**N**-SD-Dec	Seeds of this species can be dispersed for just short distances of up to 79 m (USDA, n.d.). However, indirect evidences of long-distance seed dispersal (tens of metres or more) of black spruces have been also reported (e.g., Payette and Delwaide, 1994).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-**N**-SD GI-**Inc**-**SI**-N-SD	The annual mean temperature of the entire species' range, 0.9°C (range: -9.0 to 9.9°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.7°C. In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be almost the warmer limit of the distribution. However, this species' range is latitudinally wide from 41°N to 68°N, indicating a high thermal flexibility of this species (Fowells, 1965). USDA (n.d.) also suggested elevation is less important for determining this species' distribution than local topography and drainage. Further, reproduction of this species (e.g, cone crop, number of seeds) was scarcely affected by climate, according to a study covering a wide latitudinal range in the boreal zone in Quebec (Messaoud et al., 2007b). In Quebec, balsam fir stands have been gradually replaced by black spruce stands under colder and drier climate together with more frequent fires since the last 2,500 years (Messaoud et al., 2007a).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	In Nova Scotia, this species is common in swamps, bogs or poorly drained areas (Roland, 1945). Pardy (1997) reported that balsam fir often coexists with black spruce on relatively wetter sites in Cape Breton. As well,

hydrological niche)		Parks Canada (2010c) reported that this species is on hydric sites in Cape Breton Highlands at late stages in forest succession.
C2c (Disturbance)	Inc-SI-N-SD-Dec Inc-SI-N-SD-Dec	Black spruce is intermediately tolerant of shade (Smith, 1998). It grows at slower pace than balsam fir and white birch, and therefore regeneration would take much time after budworm outbreaks (Pardy, 1997; Smith, 1998). In contrast, this species is more competitive than balsam fir (Messaoud et al., 2007a). Crown and surface fires kill this species, but it could regenerate soon after light fires (Fowells, 1965; Rajora and Pluhar, 2003; USDA, n.d.). Its seeds adapt to fire and can be opened by heat (Fowells, 1965). However, fires could allow other species (e.g., white spruce) to replace black spruce, if there is no effect of permafrost, in Alaska (Wirth et al., 2008). Black spruce is also susceptible to wind because of its shallow root system (Fowells, 1965; USDA, n.d.). In Cape Breton during latter 1970s, spruce budworm outbreaks killed black spruce at relatively moderate mortality (i.e., 50%) (Smith, 1998). Parks Canada (2010c) reported that this species is on hydric sites in Cape Breton Highlands at late stages in forest succession.
C2d (Ice/Snow)	GI-Inc-SI-N GI-Inc-SI-N	In most areas of this species' distribution, there are snow depths of around 50-75 cm in the end of February (Fowells, 1965). However, in southern or western peripheries of the distribution, snow depths could be less than 38 cm (Fowells, 1965). In areas where the total annual precipitation is less than 635 mm, spring snowmelt could compensate for water shortage for black spruces (Fowells, 1965). Given much more precipitation in Cape Breton Highlands (1,486 mm/yr), this effect may be irrelevant.
C3 (Physical habitat)	Inc-SI-N-SD-Dec Inc-SI-N-SD-Dec	This species can be found on organic as well as mineral soils (Fowells, 1965). Loams, sandy loams and rocky soils are available for black spruces as well (Fowells, 1965). In Atlantic Canada, this species is distributed on sandy and gravelly outwash plains, river terraces, eskers, and similar landforms with acidic and podzolized soils (Fowells, 1965). Gullison (2002) reported that this species was found mainly at altitudes higher than 350 m in northern Cape Breton.
C4a (Other spp for habitat)	GI-Inc-SI-N GI-Inc-SI-N	Black spruce is intermediately tolerant of shade (Smith, 1998). It grows at slower pace than balsam fir and white birch (Pardy, 1997; Smith, 1998).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-N Inc-SI-N	Wind-pollinated.
C4d (Other spp for disp)	Inc-SI-N Inc-SI-N	Its cones are often moved by red squirrels (Fowells, 1965). However, a later study reported that black spruce was not preferred in comparison with white spruce by red squirrels, and even spruce seeds dispered by squirrels were unlikely to germinate successfully (Brink and Dean, 1966).
C4e (Other spp interaction)	Inc-SI-N Inc-SI-N	White spruce is likely to replace black spruce under warming climates in Alaska (Wirth et al., 2008), likely because the former species is slightly more fitting to warm climates than the latter one. However, under severe climate change, even white spruces will no longer flourish.
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	A lineage originated from New England and the central Appalachians might have migrated northeastwards to Newfoundland and Labrador, according to a wide-scale analysis of mtDNA of this species (Jaramillo-Correa et

		al., 2004). However, levels of genetic variations in Cape Breton or Nova Scotia have not been clarified yet.			
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N				
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD				
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-Inc-**SI**-N-SD-Dec **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	69	31	0
Severe scenario	0	100	0	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario		-------------------------------			
Severe scenario	-------------------------------	-------------------------------			
	The annual mean temperature of the entire species' range, 0.9°C (range: -9.0 to 9.9°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.7°C. In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be almost the warmer limit of the distribution. However, this species' range is latitudinally wide from 41°N to 68°N, indicating a high thermal flexibility of this species (Fowells, 1965). USDA (n.d.) also suggested elevation is less important for determining this species' distribution than local topography and drainage. Further, reproduction of this species (e.g, cone crop, number of seeds) was scarcely affected by climate, according to a study covering a wide latitudinal range in the boreal zone in Quebec (Messaoud et al., 2007b). In Quebec, balsam fir stands have been gradually replaced by black spruce stands under colder and drier climate together with more frequent fires since the last 2,500 years (Messaoud et al., 2007a). Black spruce is intermediately tolerant of shade (Smith, 1998). It grows at slower pace than balsam fir and white birch, and therefore regeneration would take much time after budworm outbreaks (Pardy, 1997; Smith, 1998). In contrast, this species is more competitive than balsam fir (Messaoud et al., 2007a). Crown and surface fires kill this species, but it could regenerate soon after light fires (Fowells, 1965; Rajora and Pluhar, 2003; USDA, n.d.). Its seeds adapt to fire and can be opened by heat (Fowells, 1965). However, fires could allow other species (e.g., white spruce) to replace black spruce, if there is no effect of permafrost, in Alaska (Wirth et al., 2008). Black spruce is also susceptible to wind because of its shallow root system (Fowells, 1965; USDA, n.d.). In Cape Breton during latter 1970s, spruce budworm outbreaks killed black spruce at relatively moderate mortality (i.e., 50%) (Smith, 1998). White spruce is likely to replace black spruce under warming climates in Alaska (Wirth et al., 2008), likely because the former species is slightly more fitting to warm climates than the latter one. However, under severe climate change, even white spruces will no longer flourish. In short, under moderate climate change scenario, not only temperature increase but also competition with white spruce will be negative for black spruce, resulting in moderate vulnerability. Under severe climate change scenario, like balsam fir and white spruce, black spruce could be highly vulnerable (HV) (almost extirpated locally). At the same time, however, considering that the				

	temperature is still within the current temperature range of the species' distribution and that it has a high thermal flexibility, the class of MV was also chosen.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of red spruce (*Picea rubens*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. Red spruces are found in Acadian forests region in Nova Scotia (Wein and Moore, 1979). Steep slopes in the park may hinder upward migration of the species, and therefore Inc and SI were chosen for the CCVI. Yet, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	The mean dispersal distance of this species was reported as around 61 m (Govindaraju, 1988). However, its congeneric species, black spruce, disseminates its seeds for a mean distance of 31 m, while 15.2% and 2.9% of the seeds were predicted by a modelling study to be dispersed for longer distances of 300 m and 800 m respectively (Wirth et al., 2008).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-**SI**-**N**-SD	This species is extensively distributed and rather common in Nova Scotia, but not the Cape Breton uplands (Roland, 1980; Saunders, 1996). The annual mean temperature of the entire species' range, 4.4°C (range:-0.5 to 13.9°C) (Natural Resources Canada, 2014), is close to the mean temperature of the park, 4.7°C. In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently in the cooler side of the species' distribution, and it will be close to the middle of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be in the warmer side of the distribution.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Extensively being distributed and rather common in Nova Scotia, but not the Cape Breton uplands (Roland, 1980; Saunders, 1996). This species can grow best on well-drained soils (Saunders, 1996). This is one of typical species in mature forests on moist upland sites, being often observed in moist sites like north-facing slopes and lakesides in Ontario and Quebec (Farrar, 1995). · The fungi associated with spruce could be affected, if soils are affected by increased precipitation. Thus, this subfactor should not be neutral on the vulnerability of red spruce. [Expert in Fundy]

		· It is neutral, because I can’t see climate change affecting this subfactor to any great degree. [Additional expert] [Follow-up after consultation in Fundy NP] Negative effects of reduced precipitation on red spruce has been studied (Koo et al., 2014), and also heavy rainfall in August is beneficial for reproduction of ectomycorrhizal-basidiomycete communities in red spruce stands (Bills et al., 1986). In contrast, effects of increase in precipitation on fungi in red spruce stands have not been clarified yet. However, mean annual precipitation of the entire distribution of red spruce is 1,134 mm [5-95%: 979-1,350 mm] (Natural Resources Canada, 2014), while the current annual precipitation in Cape Breton Highlands National Park is 1,454 mm. Therefore, more increase in precipitation in this park will make this site less suitable for the species in terms of precipitation. In this respect, the subscore of C2bii was determined as SI and N.
C2c (Disturbance)	Inc-SI-N-SD-Dec Inc-SI-N-SD-Dec	This is one of typical species in mature forests on moist upland sites (Farrar, 1995), and spruce communities have been reduced and/or damaged sometimes by exntensive fire or intensified winds (Harrington, 1985; Adams and Stephenson, 1989). However, red spruce can be tolerant to moderate disturbances and forest canopy openings (White et al., 1985). In support of this, Telfer (2004) recorded regeneration of this species in forest gaps which were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. Furthermore, warm climates allow spruce bark beetle to complete one generation cycle in a single year but also survive winter easily (Bentz et al., 2010). Hence, global warming could contribute to population growth of spruce beetle (Bentz et al., 2010). As well, increase in growing degree days (GDD) will lead to greater fitness of this species (Phillips, 2013). In contrast, low spring temperature retards water uptake by spruce trees, and particularly spruces on north-facing slopes have been stressed (Berg et al., 2006). Therefore, warm spring temperature could lesson such seasonal stresses on spruces, possibly reducing probability of beetle infestations (Berg et al., 2006). Overall, benefits of warmer climates may outweigh demerits of climate change for spruce beetle. Thus, such beetle outbreaks could devastate red spruce populations. In Cape Breton Island, actually substantial damages by budworms as well as bark beeltes were reported between 1974 and 1981 (Ostaff and MacLean, 1989). · Eastern dwarf mistletoe may become a problem in climate change. It affects growth, though seed can still be produced. We are likely to get more disturbances, not less, and red spruce won’t like that. This will change the fire regime. Red spruce still needs a period of tranquility so gap disturbance may not benefit it. [Expert in Kejimkujik]
C2d (Ice/Snow)	GI-Inc-SI-N GI-Inc-SI-N	
C3 (Physical habitat)	Inc-SI-N-SD-Dec Inc-SI-N-SD-Dec	Extensively being distributed and rather common in Nova Scotia, but not the Cape Breton uplands (Roland, 1980; Saunders, 1996). Yet, this species prefers the podzolic soils with low pH ranging between 4.0 and 5.5 (Fowells, 1965).

C4a (Other spp for habitat)	GI-Inc-SI-N GI-Inc-SI-N	Being tolerant to interspecific competitions particularly in Canada (Fowells, 1965; White et al., 1985).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-N Inc-SI-N	All spruce species are wind-pollinated (Haselhorst and Buerkle, 2013).
C4d (Other spp for disp)	Inc-SI-N Inc-SI-N	This species' seeds are mainly disseminated by wind (Govindaraju, 1988), but they could be scatterhoarded by some animals like red squirrels (Dempsey and Keppie, 1993). · The bulk of dispersal is not dependent on other species. Squirrels don’t go long distances, they hoard seeds in their own territory. [Expert in Fundy]
C4e (Other spp interaction)	Inc-SI-N Inc-SI-N	· The fungi associated with spruce could be affected, if soils are affected by increased precipitation. Thus, this subfactor should not be neutral on the vulnerability of red spruce. [Expert in Fundy] · This is neutral, simply because assessing such interspecific competitive interactions is purely speculative. [Additional expert]
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	6	94	0
Severe scenario	0	86	15	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario			-------------------------------		
Severe scenario		-------------------------------			

This species is extensively distributed and rather common in Nova Scotia, but not the Cape Breton uplands (Roland, 1980; Saunders, 1996). The annual mean temperature of the entire species' range, 4.4°C (range:-0.5 to 13.9°C) (Natural Resources Canada, 2014), is close to the mean temperature of the park, 4.7°C. In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently in the cooler side of the species' distribution, and it will be close to the middle of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be in the warmer side of the distribution.

	This is one of typical species in mature forests on moist upland sites (Farrar, 1995), and spruce communities have been reduced and/or damaged sometimes by exntensive fire or intensified winds (Harrington, 1985; Adams and Stephenson, 1989). However, red spruce can be tolerant to moderate disturbances and forest canopy openings (White et al., 1985). In support of this, Telfer (2004) recorded regeneration of this species in forest gaps which were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. Furthermore, warm climates allow spruce bark beetle to complete one generation cycle in a single year but also survive winter easily (Bentz et al., 2010). In Cape Breton Island, actually substantial damages by budworms as well as bark beeltes were reported between 1974 and 1981 (Ostaff and MacLean, 1989). In short, in terms of thermal niche, red spruce could enjoy moderate climate change scenario but not severe scenario. In contrast, beetle outbreaks could be detrimental for the same species. Therefore, PS and MV were chosen for red spruce under moderate and severe scenarios respectively.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of red pine (*Pinus resinosa*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. Red pines are found in boreal forests region in New Brunswick, while the same species is not common in Cape Breton Highlands (Mosseler et al., 2003). However, we herewith regard this species as a boreal tree species in consideration of the upper limit of the Growing-Degree Days (GDD5) of this species. Steep slopes in the park may hinder upward migration of the species, and therefore Inc and SI were chosen for the CCVI. Yet, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-**SI**-N-SD-Dec GI-Inc-**SI**-N-SD-Dec	Its effective seeding distance is 12 m, though seeds can be disseminated up to 900 feet (Fowells, 1965; He and Mlandeoff, 1999).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-**SI**-**N**-SD	This species grows well under cool-to-warm summers and cold winters (Fowells, 1965). The annual mean temperature of the entire species' range, 4.8°C (range:-0.4 to 13.5°C) (Natural Resources Canada, 2014), is close to the mean temperature of the park, 4.7°C. In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently close to the cooler limit of the species' distribution, and it will be in the middle of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be close to the warmer limit of the distribution.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	The lightest soils (sandy soils) with low to moderate precipitaion are considerably preferred by this species, though it could be observed on swamp borders and lakesides as well (Roland, 1980; Fowells, 1965). Mean annual precipitation of the entire distribution of red pine is 909 mm [5-95%: 670-1,277 mm] (Natural Resources Canada, 2014), while the current annual precipitation in Cape Breton Highlands National Park is 1,454 mm. Therefore, more increase in precipitation in this park will make this site less suitable for the species in terms of precipitation.
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species can regenerate well after certain fires, windthrows and on bedrock slabs (Fowells 1965; Engstrom and Mann, 1993; Malliak and Roberts, 1994). Particularly, moderate fires are optimal disturbances for this

		species, removing inter-specific competitions with other tree species (Flanningan and Bergeron, 1998; Sutton et al., 2002).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	This species is distributed in the Podzol region with pH ranging between 4.5 and 6.0 (Fowells, 1965), and its seedlings prefers mineral soil exposure to grow (Flanningan and Bergeron, 1998).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Although red pine is not competitive (Fowells, 1965; Flanningan and Bergeron, 1998), it could be associated with various tree and shrub species (Fowells, 1965).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	This species is self-pollinated without insects/animals (Fowler, 1964).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Wind-dispersed species (Greene and Johnson, 1993).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-**Dec** **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	0	100
Severe scenario	0	0	100	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario				-------------------------------	
Severe scenario		-------------------------------	-------------------------------		
	This species grows well under cool-to-warm summers and cold winters (Fowells, 1965). The annual mean temperature of the entire species' range, 4.8°C (range:-0.4 to 13.5°C) (Natural Resources Canada, 2014), is close to the mean temperature of the park, 4.7°C. In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently close to the cooler limit of the species' distribution, and it will be in the middle of the distribution under moderate climate change scenario (c.f., Appendix). Further, under				

	severe climate change scenario, this park will be close to the warmer limit of the distribution. Therefore, more increase in precipitation in this park will make this site less suitable for the species in terms of precipitation. This species can regenerate well after certain fires, windthrows and on bedrock slabs (Fowells 1965; Engstrom and Mann, 1993; Malliak and Roberts, 1994). Particularly, moderate fires are optimal disturbances for this species, removing inter-specific competitions with other tree species (Flanningan and Bergeron, 1998; Sutton et al., 2002). However, it should be noted that fires will not be common under the moist Cape Breton climate. In other words, under moderate climate change scenario, red pine will flourish because of an improved thermal condition and intensified disturbances. In contrast, under severe climate change scenario, although increase of disturbance intensity may be a little beneficial for this species, temperature increase together with precipitation increase will be excessive and negative for red pine.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of white pine (*Pinus strobus*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. White pines are found in Acadian forests region in Cape Breton (the eastern coast of Cape Breton Highlands National Park) (Smith, 1998). Steep slopes in the park may hinder upward migration of the species, and therefore Inc and SI were chosen for the CCVI. Yet, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Its effective seed dispersal is around 100 m (Johnson, 1988; He and Mlandeoff, 1999). Some of the seeds can be gathered and cached by animals (Vander Wall, 2003).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** Dec GI-Inc-SI-**N**-**SD** Dec	This species is commonly found in Nova Scotia, but not Cape Breton (Roland, 1980; Boland, 2012). The annual mean temperature of the entire species' range, 5.8°C (range: -1.1 to 17.2°C) (Natural Resources Canada, 2014), is slightly higher than the mean temperature of the park, 4.7°C. In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently in the cooler side of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species can grow on a wide range of soils, though it grows best on moist, well drained sandy loam (Farrar, 1995; Joyce and Rehfeldt, 2013).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	It can tolerate of several disturbance types and survive in open canopies (Farrar, 1995; Weyenberg et al., 2004). Actually, there are multiple post-fire places where this species has grown (Saunder, 1996; Weyenberg et al., 2004). Although such fires may be rare to occur in Cape Breton Highlands, Telfer (2004) recorded regeneration of this species in forest gaps that were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. Therefore, such disturbances (e.g., winds and storms) may contribute to the species' adaptability.

C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	Commonly found in Nova Scotia, but not Cape Breton (Roland, 1980; Boland, 2012). This species prefers certain soil bases, such as granites (Fowells, 1965).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	It is a moderately shade-tolerant species, usually being mixed with other species like red oak (Fowells, 1965; Farrar, 1995).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Walter and Epperson, 2004).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Wind-dispersed species (Walter and Epperson, 2004).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-**SD**-Dec GI-Inc-SI-N-**SD**-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	100	0
Severe scenario	0	0	14	86	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario				-------------------------------	
Severe scenario				-------------------------------	
	This species is commonly found in Nova Scotia, but not Cape Breton (Roland, 1980; Boland, 2012). The annual mean temperature of the entire species' range, 5.8°C (range: -1.1 to 17.2°C) (Natural Resources Canada, 2014), is slightly higher than the mean temperature of the park, 4.7°C. In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently in the cooler side of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). It can tolerate of several disturbance types and survive in open canopies (Farrar, 1995; Weyenberg et al., 2004). Actually, there are multiple post-fire places where this species has grown (Saunder, 1996; Weyenberg et al., 2004). Although such fires may be				

	rare to occur in Cape Breton Highlands, Telfer (2004) recorded regeneration of this species in forest gaps that were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. Therefore, such disturbances (e.g., winds and storms) may contribute to the species' adaptability. Hence, thermal change will be beneficial for white pine under both of the climate change scenarios in terms of GDD5, while more frequent and/or intensified disturbances would be also positive for the same species. Degrees of such positive impacts of climate change on white pine are hard to specify precisely, but future mean temperature under severe climate change scenario will be higher than the mean temperature of the species' range, indicating a possibility of too warm condition. In this regard, the degree of adaptability may be smaller than those of a few other species that have thermally higher niche (e.g., red oak). So, MA was given for white pine under both of moderate and severe climate change scenarios.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of red oak (*Quercus rubra*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. Red oaks are found in Acadian forests region in Cape Breton (mid- to lower- slopes in Cape Breton Highlands National Park) (Smith, 1998). Steep slopes in the park may hinder upward migration of the species, and therefore Inc and SI were chosen for the CCVI. Yet, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-**SD**-Dec GI-Inc-SI-**N**-**SD**-Dec	Its effective seeding distance is 30 m but possibly reach 3,000 m (He and Mladenoff, 1999). Jays collect and disperse viable nuts of this species for 4-5 km (Crow, 1988; USDA, n.d.). Maximum seed dispersal distance of this species is around 1 km, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** Dec GI-Inc-SI-N-**SD** Dec	The annual mean temperature of the entire species' range, 9.8°C (range: 1.3 - 19.7°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.7°C. In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently colder than the cooler side of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species is commonly seen on light or well-drained soils (Roland, 1945; Saunders, 1996; Boland, 2012). It can regenerate better on mesic soils than exposed soils, being relatively sensitive to droughts among oak species (Crow, 1988).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species is tolerant to fires (Crow, 1988; Saunders, 1996; Abrams, 2003). Its seedlings require lights to grow (Farrar, 1995).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	It is found on a wide range of soils, from sands and stone-free deep soils to shallow and rocky soils (Fowells, 1965; Saunder, 1996). However, slope direction and/or topography (e.g., flat or steep slope) could affect this

		species' growth (Fowells, 1965). In New Brunswick, sandy/gravelly acid woodland and shores are utilized as habitats for this species (Hinds, 2000).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is intolerant to competition (Fowells, 1965; Farrar 1995), but still it is not associated with specific co-existing species.
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Grob, 2008).
C4d (Other spp for disp)	Inc-**SI**-**N** Inc-**SI**-**N**	Jays collect and disperse viable nuts of this species for 4-5 km, although even other birds and mammals eat the nuts (Crow, 1988; USDA, n.d.).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	0	100
Severe scenario	0	0	0	6	94
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario				------------------------------	------------------------------
Severe scenario					------------------------------
	The annual mean temperature of the entire species' range, 9.8°C (range: 1.3 - 19.7°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.7°C. In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently colder than the cooler side of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). This species is tolerant to fires (Crow, 1988; Saunders, 1996; Abrams, 2003). Its seedlings require lights to grow (Farrar, 1995). Overall, this oak species could flourish due to temperature increase as well as more frequent and/or intensified disturbances than now, and therefore red oak will be adaptable. Under severe climate change scenario in particular, the temperature will be almost the most optimal temperature for oak, and in this regard HV was chosen for this species.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are

the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of eastern hemlock (*Tsuga canadensis*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. Eastern hemlocks are found in Acadian land region in Cape Breton (Parks Canada, 2012). Steep slopes in the park may hinder upward migration of the species, and therefore Inc and SI were chosen for the CCVI. Yet, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	An effective seeding distance of this species is supposed to be around 30 m (He and Mladenoff, 1999), whereas occassionally it can disperse seeds over many tens of km (Davis, 1989). · The C1 subfactor should have same score as all pine family trees. Regardless of literature, it should be uniform within pine family. [Expert in Cape Breton Highlands]
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** Dec GI-Inc-SI-**N**-**SD** Dec	The annual mean temperature of the entire species' range, 6.3°C (range: -1.0 to 18.3°C) (Natural Resources Canada, 2014), is higher than the mean temperature of the park, 4.7°C. Accordingly, eastern hemlock is likely to be distributed in valley slopes, but not valley bottoms, because of warmer microclimates (Smith, 1998). In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently close to the cooler side of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). · In Kejimkujik National Park, it is found over much wider distribution than in Cape Breton Highlands National Park, where hemlock is only in ravines and on slopes (south-facing). [Expert in Cape Breton Highlands]
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	Preferring moist sites with good drainage (Roland, 1945; Farrar, 1995; Saunders, 1996; Haas and McAndrews, 2000). According to a pollen fossil analysis in Cape Breton, *Tsuga* has decreased before due to drier climates (Miller and Livingstone, 1993).

		· It’s one of the rainiest areas in North America. I don’t think that desert-like conditions are going to move in. It’s likely to stay the same more than get drier. Thus, N is better than SI. [Expert in Cape Breton Highlands] · Moisture change would be a positive influence, because it would dry things out, where hemlock is currently climate-limited. [Expert in Cape Breton Highlands] [Follow-up] According to Richards and Daigle (2011), for instance, precipitation in Cheticamp was projected to increase from 1,389 mm to 1,481 mm between 1980s and 2080s, though decrease in water surplus as well as increase in water deficit were predicted for the same site. Thus, although precipitation will increase, water balance will be directed toward a slightly drier condition than now.
C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	It is shade-tolerant (Farrar, 1995) and therefore not strongly depend on forest gaps. This species is highly vulnerable to fire, and it may have been distributed more abundantly before fire disturbances (Fowells, 1965; Roland, 1980; Foster and Zebryk, 1993). In contrast, fires have contributed to colonizations of some hemlock populations in southwestern Nova Scotia, and therefore fires may be both negative and positive for this species depending on some other factors (Mosseler et al., 2003). However, such fire effects may not be relevant in Cape Breton Highlands, where forest fires are unlikely to occur. Winds could also harm larger-size hemlocks (Fowells, 1965). According to Mosseler et al. (2003), intense deer browsing may be the most serious pressure on this species' regeneration currently across its distribution. Yet, such deer impact is limited in Cape Breton Highlands. · Moose are impacting hemlock right now. [Expert in Cape Breton Highlands] · Hemlock is more palatable to deer than moose, the browse might be higher under deer than moose. Deer can browse lower and more intensely in spots where hemlock are. [Expert in Cape Breton Highlands] · I have never seen hemlock browsing by deer population on mainland of Nova Scotia, even with large deer populations. Therefore, I don’t agree with Mosseler et al. (2003). [Expert in Cape Breton Highlands] · I would support the SI call with hemlock woolly adelgid is in southern Maine, being monitored by Canada Food Inspection Agency, would devastate Kejimkujik National Park. They have closed trails in Kejimkujik due to previous insect threats. Hemlock woolly adelgid is the biggest thing coming out of the States right now. [Expert in Cape Breton Highlands] [Follow-up] Mosseler et al. (2003) mentioned that adelgids have been devastating on hemlock in the southern side of its range.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	This species particularly perfers acidic, sandy, rocky, or glacial till soils (Roland, 1945; Natural Resources Canada, 2014). In Cape Breton Highlands, eastern hemlock is likely to be distributed in valley slopes, but not

		valley bottoms (Smith, 1998; Gullison, 2002), though this is probably because of warmer microclimates (Smith, 1998).
C4a (Other spp for habitat)	GI-Inc-SI-N GI-Inc-SI-N	This species was considered to lose in competitions with very shade-tolerant trees (e.g., sugar maple, beech, and red spruce) (Rogers, 1978). However, this species is also shade-tolerant (Farrar, 1995) and actually is codistributed with white pine, red spruce, yellow birch, and sugar maple (Saunders, 1996).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-N Inc-SI-N	Wind-pollinated (Potter et al., 2012).
C4d (Other spp for disp)	Inc-SI-N Inc-SI-N	Wind-dispersed species (Davis et al., 1991).
C4e (Other spp interaction)	Inc-SI-N Inc-SI-N	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	No significantly less variation was detected in Nova Scotia in comparion with those of other hemlock populations in this species' distributions (Potter et al., 2012). The cited authors then found indirect evidence of a relatively recent population expansion, but not bottleneck. Lemieux et al. (2011) also reported comparable or slightly smaller genetic variation in a population in Cape Breton with other populations by using polymorphic chloroplast DNA markers.
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	According to a pollen fossil analysis in Cape Breton, Tsuga has decreased in the last 1,000 years due to climate cooling (Miller and Livingstone, 1993).
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	0	100
Severe scenario	0	0	0	88	12
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario				------------------------------	
Severe scenario				------------------------------	
	The annual mean temperature of the entire species' range, 6.3°C (range: -1.0 to 18.3°C) (Natural Resources Canada, 2014), is higher than the mean temperature of the park, 4.7°C. Accordingly, eastern hemlock is likely to be distributed in valley slopes, but not valley bottoms, because of warmer microclimates (Smith, 1998). In terms of Growing-Degree Days (GDD5), Cape Breton Highlands National Park is currently close to the cooler side of the species' distribution, and it will be closer to the middle of the distribution				

	under moderate and severe climate change scenarios (c.f., Appendix). According to a pollen fossil analysis in Cape Breton, *Tsuga* has decreased before due to drier climates (Miller and Livingstone, 1993). Winds could harm larger-size hemlocks (Fowells, 1965). According to Mosseler et al. (2003), intense deer browsing may be the most serious pressure on this species' regeneration currently across its distribution. Yet, such deer impact is limited in Cape Breton Highlands. In conclusion, temperature increase will be beneficial for hemlock, even though disturbances (winds and/or deer browsing) will be a little harmful to this species. As well, although Cape Breton is in generally moist conditions, hemlock population might decline due to hydrological changes (drier conditions). Therefore, the class of HA was refrained from to use, and MA was given for hemlock under the both of climate change scenarios.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of American/white elm (*Ulmus americana*) in Cape Breton Highlands National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	A geographical barrier of Cape Breton Island isolated from the mainland exists. American elms are found in Acadian forests region in Cape Breton (Parks Canada, 2012). Steep slopes in the park may hinder upward migration of the species, and therefore Inc and SI were chosen for the CCVI. Yet, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered.
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	This species falls its seeds mostly within 90 m from each mother tree but sometimes for longer distances like 400 m (Fowells, 1965; Saunders, 1996).
C2ai (Historical thermal niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** Dec GI-Inc-SI-N-**SD** Dec	The annual mean temperature of the entire species' range, 10.1°C (range: 0.0 - 20.7°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.7°C. In Acadian forests, American elms dominate bottomlands, which are characterized by warm conditions (Loo and Ives, 2003).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species commonly occurs on wet lands, and its seedlings could develop on moist litters (Fowells, 1965; Farrar, 1995). As well, spring floods are charactristics of this species' habitats (Saunders, 1996; Smith, 1998), but the effect of floods was evaluated in the subfactor of C2c.
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-**SI**-N-**SD**-Dec	This species generally grows well in full sunlight, except its first-year seedlings (Fowells, 1965; Farrar, 1995). American elm is considerably tolerant of winds and fires, though fires could kill seedlings and saplings (Fowells, 1965). According to postglacial vegetation study by pollen analysis, American elm colonized and competed with other species well in post-fire sites during warm periods in Nova Scotia (Green, 1987). However, this species is extremely intolerant of snow storms (Rogers, 1923). Spring floods are charactristics of this species' habitats (Saunders, 1996; Smith, 1998). Such floods will be less frequent and/or weaker under severe climate change scenario, which assumes declines of snow accumulation. In Acadian forests including Cape Breton, this species and its distribution have been much influenced and supressed after around 1960 by Dutch Elm Disease (Gullison, 2002; Loo and Ives, 2003). Defoliation by this disease becomes wrose at

		temperatures exceeding 17°C with moderate sunshine length (5-7h) (Sutherland et al., 1997), but daytime is much longer than 5-7h in Cape Breton during such warm periods. Therefore, in this assessment, the effect of this disease is regarded to be stable under climate change.
C2d (Ice/Snow)	GI-Inc-SI-N GI-Inc-SI-N	Annual snowfall amount ranges from none in Florida to 380 cm in upper New York within this species' distribution (Fowells, 1965). This species is extremely intolerant of snow storms (Rogers, 1923), but it is hard to predict if and how frequency/intensity of snow storms changes under future climates (it could be increased and also possibly decreased). So, here, the subscore of C2d was not determined.
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	American elm grows best on rich well-drained loams, but it could occur on a wide range of soils including coarse sand and clays (Fowells, 1965). American elm is distributed on soils whose pH ranges between 5.5 and 8.0 (Fowells, 1965). Topographically, this species is often seen on, but not limited to, flats and bottom lands (Fowells, 1965). In Cape Breton, it is observed in sheltered pockets (Saunders, 1996).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Seeds of this species could be dispersed by winds and occassionally waterborne (Fowells, 1965).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Fowells, 1965).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate scenario	0	0	0	0	100
Severe scenario	0	0	0	50	50
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate scenario				-------------------------------	-------------------------------

Severe scenario				-------------------------------	-------------------------------
	The annual mean temperature of the entire species' range, 10.1°C (range: 0.0 - 20.7°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.7°C. In Acadian forests, American elms dominate bottomlands, which are characterized by warm conditions (Loo and Ives, 2003). This species generally grows well in full sunlight, except its first-year seedlings (Fowells, 1965; Farrar, 1995). American elm is considerably tolerant of winds and fires, though fires could kill seedlings and saplings (Fowells, 1965). According to postglacial vegetation study by pollen analysis, American elm colonized and competed with other species well in post-fire sites during warm periods in Nova Scotia (Green, 1987). However, this species is extremely intolerant of snow storms (Rogers, 1923). Spring floods are charactristics of this species' habitats (Saunders, 1996; Smith, 1998). Such floods will be less frequent and/or weaker under severe climate change scenario, which assumes declines of snow accumulation. Therefore, under moderate climate change scenario, American elm will just flourish due to a thermally better condition (MA/HA). Under severe climate change scenario, on the other hand, the positive effect of spring floods will be weakened, while temperature increase will be still beneficial. So, under the latter scenario, high adaptation might be compromised due to the weakened spring flood effect. In this regard, not only HA but also MA were chosen again.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of great blue heron (*Ardea herodias*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	In the Maritimes, this species nests in coastal areas, because limited number of fish are available in often acidic waters in inland areas (Erskine, 1992). Estuaries at low tides are also utilized for foraging in Boot Island, Nova Scotia (Quinney, 1982).
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	According to a literature review by Carney and Sydeman (1999), this species' behaviors (e.g., nesting) have been affected by logging-related disturbances. In contrast, artificial land-use has not been a serious factor for declines of heron populations in the Maritimes (Erskine, 1992). Nisbet (2000) also supported the idea that artificial disturbances are scarcely influential on this species. However, the artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Fundy species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species often fly for 20-30 km to find foods (Erskine, 1992).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species is distributed from Mexico to southeastern Alaska during breeding seasons, while it is from South America to southern Canada during winter (Godfrey, 1986). Therefore, Fundy is climatically situated in a middle part of the species' breeding range.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species feeds in and around waterbodies, such as shallow pools, riversides, and marshes (Godfrey, 1986). Abundance of this species increased linearly or quadratically with water depth according to an observation for two years in Florida (Bancroft et al., 2002).
C2c (Disturbance)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	Erskine (1992) and Nisbet (2000) proposed that artificial disturbances are scarcely influential on this species. Open water and open timber are utilized for foraging and nesting by this species respectively in Ontario (Steen et al., 2006). Strong winds and rains may be detrimental for foraging of this species (Quinney, 1982), but such effects may be just temporary.
C2d	GI-Inc-SI-**N**	Snowfall may restrict food availability for this species, like spruce grouse in Cape Breton Highlands.

(Ice/Snow)	GI-Inc-SI-**N** SD	
C3 (Physical habitat)	Inc-SI-**N**-SD-**Dec** Inc-SI-**N**-SD-**Dec**	At continental scale, this species inhabits inland areas as well (Belant and Tyson, 1997). However, in the Maritimes, this species nests in coastal areas, because limited number of fish are available in often acidic waters in inland areas (Erskine, 1992).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species nests in deciduous, coniferous, or mixed forests (Godfrey, 1986). Steen et al. (2006) reported that this species nests at high positions (30 m or higher from the ground) in forests and feeds in a wide variety of habitats in the eastern Great Lakes region.
C4b (Diet)	Inc-SI-**N**-SD Inc-SI-**N**-SD	Fish, frogs, insects, and small mammals are preys for this species (Godfrey, 1986). In the lower Rahway River, New Jersey, this species is a top carnivore species in the ecosystem, eating blue crabs and striped bass etc. (Maccarone and Brzorad, 2005). However, like the case of hermit thrush in its wintering sites, some of the food may be unavailable during cold winter.
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	100	0
Severe scenario	0	0	0	50	50
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario			------------------------------		
Severe scenario			------------------------------		
	This species is distributed from Mexico to southeastern Alaska during breeding seasons, while it is from South America to southern Canada during winter (Godfrey, 1986). Therefore, Fundy is climatically situated in a middle part of the species' breeding range. There were no specific subfactors that were relevant to the species' vulnerability/adaptability to climate change, and hence it was judged to be				

	presumably stable under the climate change scenarios.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of ruffed grouse (*Bonasa umbellus*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Exploitation by humans in forests in the Maritimes may not have led to serious declines of this species' populations (Erskine, 1992). Urbanization and also forest succession could bring about reduction of this species' habitats in the United States, and rather even-age silvicultural systems including clearcut could create habitats (Dessecker and McAuley, 2001). Kurzejeski and Root (1989) reported that this species could move across non-forested areas without difficulty.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-**Dec** GI-Inc-SI-N-**SD**-**Dec**	This species stays throughout a year in the Maritimes without migrations (Godfrey, 1986; Erskine, 1992). Yet, according to a releasing experiment in northern Missouri (Kurzejeski and Root, 1989), geometric centers of released grouses have shifted by around 1 km (males) or 2 km (females) from February to April. Further, a long-distance movement for 14.5 km was also found in the same study, whereas several previous studies reported much shorter dispersal distances (235-340 m) (Kurzejeski and Root, 1989). Small and Rusch (1989) reported long dispersal distances of 9.6 km during 17 days (females) and 6.4 km during 21 days (males) in autumn in Wisconsin.
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species is distributed from mid latitudinal parts of the United States to central Alaska permanently (Godfrey, 1986), and therefore Fundy is climatically situated in a middle part of the species' range.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Stream edges and ravines with alders/willows are utilized as habitats by this species (Godfrey, 1986). Succulent herbaceous vegetation, which is an important food for this species in the Appalachians, is distributed often in comparatively mesic sites (Dessecker and McAuley, 2001). Yet, Bendell and Bendell-Young (2002) reported that this species' eggs lost water less quickly than spruce grouse's eggs, suggesting that such a moisture tolerance of eggs could be a partial reason this species inhabits dry and warm deciduous forests.
C2c	Inc-SI-N-SD-Dec	Second-growth decidous and mixed forests are often utilized as main habitats, while mature forests are less

(Disturbance)	Inc-SI-N-SD-Dec	commonly used by this species (Godfrey, 1986; Dessecker and McAuley, 2001). Also, forest edges and openings are available for this species (Godfrey, 1986; Dessecker and McAuley, 2001). Such habitats have been maintained by periodic disturbances, such as fires and winds in the eastern United States (Dessecker and McAuley, 2001). Without periodic forest disturbances, ruffed grouse populations will decline, according to a modelling study in Rhode Island, USA (Blomberg et al., 2012).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-**Inc**-**SI**-N	Snow is beneficial for this species during winter, and snow decline could be a serious threat (Notaro et al., 2011). More specifically, snow allows this species to burrow and roost without much heat loss and much risk of depradation (Whitaker, 2003). High quality snow of at least 20 cm in depth is needed to do snow burrowing for this species (Blanchette et al., 2007).
C3 (Physical habitat)	Inc-SI-N-**SD**-**Dec** Inc-SI-N-**SD**-**Dec**	
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** SD GI-Inc-**SI**-**N** SD	Second-growth decidous and mixed forests (particularly aspens) are often utilized as main habitats, but also coniferous trees are used for shelters by this species (Godfrey, 1986; Dessecker and McAuley, 2001; Whitaker, 2003). In contrast, where coniferous trees are dominant, this species may be replaced by other grouses, such as spruce grouses and blue grouses (Erskine, 1992). According to Dessecker and McAuley (2001), not only young deciduous forests but also shrub-dominated habitats protect this species from predators. Because suitable habitats of aspens (*Populus grandidentata* and *P. tremuloides*) will be moved to more north than Fundy National Park under severe climate change scenario (c.f., Natural Resources Canada, 2014), only "SI" was chosen in the MVA.
C4b (Diet)	Inc-**SI**-N-**SD** Inc-**SI**-N-**SD**	Various plant materials, such as aspens, birches, and cherries, are available for this species in mesophytic forests in the core areas of the species' distribution, while only a few foods are available, like hard mast crops and succulent herbaceous vegetation, in the southern side of the distribution like the Appalachians in winter (Dessecker and McAuley, 2001; Whitaker et al., 2007). Future decline of paper birches in the eastern United States could bring about population decline and distribution shrinkage of ruffed grouse, because buds of this birch species are important food for grouse (Matthews et al., 2004). In contrast, although animals were not important components of this species' diet, 111 plant foods as well as 33 animal foods were identified from droppings of ruffed grouse still in Missouri (Korschgen, 1966). Like the case of hermit thrush in its wintering sites, some of the food may be unavailable during cold winter.
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	Depredation is a major cause for mortality of this species in the southern portion of its distribution (Dobony et al., 2001). For instance, American marten and grey fox, which may have invaded from the south due to a recent warming climate, were recorded as predators of this grouse in New Brunswick (Cumberland et al., 2001; McAlpine et al., 2008). Also, some other mammals could predate this species: raccoon, black bear, and bobcat

		(Dobony et al., 2001).			
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD				
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N				
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD				
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Future decline of paper birches in the eastern United States could bring about population decline and distribution shrinkage of ruffed grouse, because buds of this birch species are important food for grouse (Matthews et al., 2004).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	100	0
Severe scenario	0	1	20	78	1
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario			------------------------------	------------------------------	
Severe scenario		------------------------------	------------------------------		
	Second-growth decidous and mixed forests (particularly aspens) are often utilized as main habitats, while mature forests are less commonly used by this species (Godfrey, 1986; Dessecker and McAuley, 2001). Also, forest edges and openings are available for this species (Godfrey, 1986; Dessecker and McAuley, 2001). Such habitats have been maintained by periodic disturbances, such as fires and winds in the eastern United States (Dessecker and McAuley, 2001). Without periodic forest disturbances, ruffed grouse populations will decline, according to a modelling study in Rhode Island, USA (Blomberg et al., 2012). Where coniferous trees are dominant, this species may be replaced by other grouses, such as spruce grouses and blue grouses (Erskine, 1992). Therefore, climate change, which leads to more frequent and intensified disturbances and dominance of temperate hardwoods, may be positive for this species. In this sense, this species was judged as presumably stable or moderately adaptable under moderate climate change scenario. However, snow is beneficial for this species during winter, and snow decline could be a serious threat (Notaro et al., 2011). More specifically, snow allows this species to burrow and roost without much heat loss and much risk of depradation (Whitaker, 2003). High quality snow of at least 20 cm in depth is needed to do snow burrowing for this species (Blanchette et al., 2007). As well, suitable habitats of aspens (*Populus grandidentata* and *P. tremuloides*) will be moved to more north than Fundy National Park under severe climate change scenario (c.f., Natural Resources Canada, 2014), Therefore, under thisscenario, such negative impacts of climate change may be influential, possibly making this species moderately vulnerable. Thus, PS and MV were given for the species in the second scenario.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of hermit thrush (*Catharus guttatus*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Open woodlands including cut-over areas are possibly used by this species (Godfrey, 1986; Erskine, 1992). This species was highly abundant in burned sites, but not clearcuts, in Quebec (Imbeau et al., 1999). In contrast, according to a study in northern New Hampshire, this species was distributed in mature forests and shelterwoods, but not clearcuts (King and DeGraaf, 2000). In the central Appalachians, this species inhabited mature mixed forests disturbed by road building (Dellinger et al., 2007). In eastern Ontario and southern Quebec, this species reacted to forest cover negatively and fragmentation positively (Trzcinski et al., 1999). However, the artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Fundy species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species is a migratory bird, which stays in Baja California, Guatemala, and southern Florida during winter (Godfrey, 1986). However, this species is regarded as a short-distance migrant (MacMynowski and Root, 2007).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species' breeding area ranges from central Alaska to southern California or western Maryland (Godfrey, 1986), and therefore Fundy is climatically situated in a middle part of the species' range. In high boreal ecoclimatic region in central Labrador, this species' abundance was positively correlated with temperature during June and July in 2000, but not in 2001 or 2002 (Simon, 2005).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	This species could inhabit a wide range of hydrological niches, from bogs/swamps to dry sandy sites (Godfrey, 1986). In contrast, according to a study in central Labrador, this species was associated with lakes (Simon, 2005).
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	Open woodlands including cut-over areas are possibly used by this species (Godfrey, 1986; Erskine, 1992). However, in the southwestern United States, this species was more abundant before fires than thereafter (Bock

		and Block, 2005). According to a study in northern New Hampshire, this species was distributed in mature forests and shelterwoods, but not clearcuts (King and DeGraaf, 2000). In the central Appalachians, this species inhabited mature mixed forests disturbed by road building (Dellinger et al., 2007). In contrast, this species was highly abundant in burned sites, but not clearcuts, in Quebec (Imbeau et al., 1999). Therefore, the species' response to disturbances might be varied depending on regions, but disturbances could possibly affect the species negatively.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species might dislike snow (Stouffer and Dwyer, 2003). Available food could be restricted due to snow cover for particularly ground foraging bird species (Diggs, 2008), though it does not stay in New Brunswick during winter.
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	This species inhabits mixed forests as well as coniferous forests (Godfrey, 1986). There was no significant deviations among responses of this species to coniferous, deciduous, and mixedwood stands in Quebec (Girard et al., 2004). In contrast, this species was strongly associated with hemlock in central Conneticut (Tingley et al., 2002). According to a study in central Labrador, this species was most abundant in lichen woodlands (Simon, 2005). In the central Appalachians, this species inhabited mature mixed forests, but not mature deciduous forests (Dellinger et al., 2007).
C4b (Diet)	Inc-SI-N-**SD** Inc-SI-N-**SD**	This species feeds seeds as well as invertebrates (arthropods) (Long and Stouffer, 2003; MacMynowski and Root, 2007). The preferred food, arthropods, could be unavailable during cold winter (Diggs, 2008). In other words, such food is probably available even during winter season, if temperature is warm enough (e.g., 11.7°C in January 2000 in Louisiana) (Brown and Long, 2006).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	A mean arrival date of this species at summer sites in New York has been significantly earlier for 1951-1993 than 1903-1950 by around one month, but a similar significant change was not detected in Massachusetts (Butler, 2003). Spring migration time (mean arrival date) of hermit thrush significantly changed with spring temperature increase (MacMynowski and Root, 2007; Miller-Rushing et al., 2008).
D1	GI-Inc-SI-N-SD-Dec	

(Documented response)	GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	As long as coniferous forests are manintained for the purpose of fibre production, this species is likely to be persistent in the Maritimes (Erskine, 1992). However, global warming will be negative for such coniferous forests there (Erskine, 1992).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	26	74
Severe scenario	0	0	0	0	100
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario			-------------------------------		
Severe scenario		-------------------------------	-------------------------------		
	The species' response to disturbances might be varied depending on regions, but disturbances could possibly affect the species negatively. Furthermore, this species inhabits mixed forests as well as coniferous forests (Godfrey, 1986). There was no significant deviations among responses of this species to coniferous, deciduous, and mixedwood stands in Quebec (Girard et al., 2004). In contrast, this species was strongly associated with hemlock in central Conneticut (Tingley et al., 2002). According to a study in central Labrador, this species was most abundant in lichen woodlands (Simon, 2005). In the central Appalachians, this species inhabited mature mixed forests, but not mature deciduous forests (Dellinger et al., 2007). Hence, this species will be generally stable under climate change, but remarkable temperature increase might affect the same species negagtively via increases of disturbance pressures and/or temperate deciduous forests. In this regard, the classes of MV and PS were given for the species under severe climate change scenario.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of semi-palmated plover (*Charadrius semipalmatus*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	This species utilizes gravel beaches (Godfrey, 1986; Erskine, 1992). Reproductive success was better at coastal nests of this species than inland nests in Manitoba, probably because inland conditions often allow predators (e.g., foxes) to hide and den (Armstrong and Nol, 1993). However, this species forages in terrestrial habitats, which were apart from tide edges by more than 1m, according to an observation in California (Colwell and Landrum, 1993).
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species migrates southwards to from South America to the southern United States to overwinter (Godfrey, 1986; Erskine, 1992).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	This species breeds in the low arctic and subarctic regions in North America, and the Maritimes is the southernmost position in this species' breeding range (Godfrey, 1986; Erskine, 1992). Therefore, although this species goes southwards to (from South America to the southern United States) to overwinter, Fundy is in a relatively warm condition as a breeding site for this species. At a temperature above than 0°C, males of this species are active (Lishman et al., 2010). In Manitoba, a cold summer in 1992 has led to significant decrease in clutch size of this species, probably because of reduced brood size (Nol et al., 1997). In contrast, little is known about influences of high temperature on this species and about why this species is confined to high latitudinal areas during breeding seasons. Therefore, physiological thermal niche should be "unknown" in this assessment.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	This species' habitats are associated with fresh and salt water (e.g., lakesides, riversides, and beaches) (Godfrey, 1986). However, this species forages in terrestrial habitats, which were apart from tide edges by more than 1m, according to an observation in California (Colwell and Landrum, 1993).
C2c (Disturbance)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	This species' habitats are associated with open conditions with little vegetation (Godfrey, 1986). Reproductive success was better at coastal nests of this species than inland nests in Manitoba, probably because inland conditions often allow predators (e.g., foxes) to hide and den (Armstrong and Nol, 1993).

C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**				
C3 (Physical habitat)	Inc-SI-**N**-SD-**Dec** Inc-SI-**N**-SD-**Dec**	Reproductive success was better at coastal nests of this species than inland nests in Manitoba, probably because inland conditions often allow predators (e.g., foxes) to hide and den (Armstrong and Nol, 1993). This species utilizes gravel beaches (Godfrey, 1986; Erskine, 1992). This species utilized sands more frequently rather than cobbles in California (Colwell and Landrum, 1993).			
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**				
C4b (Diet)	Inc-SI-**N**-SD Inc-SI-**N**-SD	Various invertebrates are predated by semi-palmated plovers (Smith and Nol, 2000; Maillet and Weber, 2006).			
C4c (Pollination)	Inc-SI-N Inc-SI-N				
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**				
C4e (Other spp interaction)	Inc-**SI**-**N** Inc-**SI**-**N**	In Nunavut, this species is strongly associated with Arctic Terns, which help it to protect its nests against predators by their aggressive behaviors (Nguyen et al., 2003: 2006). Terns are also distributed in and around Fundy, but little is known about such an interspecific association in Fundy.			
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD				
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N				
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD				
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Without substantial evidence for this idea, Erskine (1992) speculated that the Little Ice Age (1300-1800s) may have been more suitable for this species than the current climate in the Maritimes. According to an observation between 1974 and 2006 in the Atlantic Maritimes Ecozone, this species has been exceptionally more abundant than before (Gratto-Trevor et al., 2012), but the reason for this exceptional change was not clarified.			
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	100	0
Severe scenario	0	0	0	50	50
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario					
Severe scenario					
	This species breeds in the low arctic and subarctic regions in North America, and the Maritimes is the southernmost position in this				

	species’ breeding range (Godfrey, 1986; Erskine, 1992). Therefore, although this species goes southwards to (from South America to the southern United States) to overwinter, Fundy is in a relatively warm condition as a breeding site for this species. At a temperature above than 0°C, males of this species are active (Lishman et al., 2010). In Manitoba, a cold summer in 1992 has led to significant decrease in clutch size of this species, probably because of reduced brood size (Nol et al., 1997). In contrast, little is known about influences of high temperature on this species and about why this species is confined to high latitudinal areas during breeding seasons. Therefore, physiological thermal niche should be "unknown" in this assessment. Consequently, the MVA did not determine vulnerability/adaptability of the species.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of pileated wood-pecker (*Dryocopus pileatus*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-**SI**-N GI-Inc-**SI**-N	This species has declined due to cutting of old-growth forests in the Maritimes (Erskine, 1992). In New Brunswick, this species was not found in plantations at all, suggesting that this species may need large protected areas with intact forests (Woodley et al., 2006). Flemming et al. (1999) found the fact that deciduous trees were more often utilized by this species in fragmented forests around Fundy, probably due to limited availability of coniferous trees in the fragments.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-**Dec** GI-Inc-SI-N-**SD**-**Dec**	This species generally settles in its breeding range even during winters (Godfrey, 1986). Yet, there is no available documents about specific dispersal distances of this species.
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species is distributed from the southern United States to forested parts in Canada including southern Northwest Territories (Godfrey, 1986), and therefore Fundy is climatically situated in a middle part of the species' range.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Areas close by water, such as bottomolands and valleys, are sometimes selected by this spcies for nesting (Hartwig et al., 2004).
C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	This species has declined due to cutting of old-growth forests in the Maritimes (Erskine, 1992). Robinson et al. (2010) also suggested that this species inhabits exclusively shaded interiors of forests. An observation in Fundy by Flemming et al. (1999) supported this idea. In central Vermont, detected individual number of this species was not changed significantly between before- and post- ice storms, suggesting no effects of ice storms on this species (Faccio, 2003).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	In central Vermont, detected individual number of this species was not changed significantly between before- and post- ice storms, suggesting no effects of ice storms on this species (Faccio, 2003).
C3	Inc-SI-N-**SD**-**Dec**	This species has also no specific geological preference, though it is a sedentary bird species.

(Physical habitat)	Inc-SI-N-**SD**-**Dec**	
C4a (Other spp for habitat)	GI-Inc-**SI**-N GI-Inc-**SI**-N	Mature forests including various tree species and standing dead trees are habitats for this species (Godfrey, 1986). Drapeau et al. (2009) documented that living trees are used for nesting while degraded trees are used for foraging by this species (Drapeau et al., 2009). Both deciduous and coniferous forests are available for nesting of this species (Godfrey, 1986). Erskine (2008) reported that this species utilized selectively Norway maples, but not other tree species like elms, in Sackville in New Brunswick. This might be due to a temporal outbreak of insect species which were peculiar to such maple trees (Erskine, 2008). In northern New Brunswick, American beeches were more often used by this species than other tree species including sugar maples (Lemaître and Villard, 2005). However, in Fundy National Park, this species utilized mainly red spruces and balsam firs but also some deciduous tree species (e.g., sugar maples, and yellow birches) (Flemming et al., 1999). Frakes (2013) found that sugar maples were selectively used for nesting by this species in northern mixed conifer-hardwood forests in Michigan as well.
C4b (Diet)	Inc-**SI**-**N**-SD Inc-**SI**-**N**-SD	Larvaes of sawflies were eaten by this species in Sackville, New Brunswick, though this might be due to a temporal outbreak of this insect species (Erskine, 2008). The cited author then proposed that ants, beetles, in combination with larval insects may be representative preys for the Pileated wood-pecker. According to Lemaître and Villard (2005), carpenter ants are main preys for this species, and therefore trees with large-diameters were preferred (DBH > 30-35 cm) by Pileated wood-pecker in northern New Brunswick. Like the case of hermit thrush in its wintering sites, some of the food may be unavailable during cold winter.
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Matthews et al. (2004) predicted decline of this species in the northwestern part of the United States in the future due to losses of eastern white pines. However, their projection target did not include New Brunswick.

The CCVI [%] Moderate Scenario	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
	0	0	0	100	0

Severe scenario	0	7	64	30	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario			-------------------------------		
Severe scenario		-------------------------------	-------------------------------		
	This species has declined due to cutting of old-growth forests in the Maritimes (Erskine, 1992). Robinson et al. (2010) also suggested that this species inhabits exclusively shaded interiors of forests. An observation in Fundy by Flemming et al. (1999) supported this idea. In central Vermont, detected individual number of this species was not changed significantly between before- and post- ice storms, suggesting no effects of ice storms on this species (Faccio, 2003). Mature forests including various tree species and standing dead trees are habitats for this species (Godfrey, 1986). Drapeau et al. (2009) documented that living trees are used for nesting while degraded trees are used for foraging by this species (Drapeau et al., 2009). Both deciduous and coniferous forests are available for nesting of this species (Godfrey, 1986). Erskine (2008) reported that this species utilized selectively Norway maples, but not other tree species like elms, in Sackville in New Brunswick. This might be due to a temporal outbreak of insect species which were peculiar to such maple trees (Erskine, 2008). In northern New Brunswick, American beeches were more often used by this species than other tree species including sugar maples (Lemaître and Villard, 2005). However, in Fundy National Park, this species utilized mainly red spruces and balsam firs but also some deciduous tree species (e.g., sugar maples, and yellow birches) (Flemming et al., 1999). Frakes (2013) found that sugar maples were selectively used for nesting by this species in northern mixed conifer-hardwood forests in Michigan as well. In summary, although this species will be presumably stable under climate change, more frequent and/or intensified disturbances, which could be brought about by severe climate change, may be negative for wood-pecker. Declines of spruce and fir stands might also affect this species negatively, whereas some adataptable deciduous tree species will partly compensate for the damage. In this regard, this species was considered moderately vulnerable or presumably stable under severe climate change scenario.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of peregrine falcon (*Falco peregrinus*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Occasionally, cities are utilized as habitats by this species (Godfrey, 1986; Chace and Walsh, 2006). However, replacement of native grasslands by crop fields may have partly led to declines of falcon populations (Kirk and Hyslop, 1998).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species is a long-distance migratory bird species (Worcester and Ydenberg, 2008).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species could breed everywhere, other than extremely hot/cold deserts as well as rain-forests in tropics (Erskine, 1992). More specifically, it can breeds from southern South America to Alaska (and other continents) (Godfrey, 1986). Franke et al. (2011) also found the fact that the North Atlantic Oscillation index, but not summer temperature, affected significantly survival rate of this species in Nunavut. Therefore, physiological thermal niche is so wide that climate change in Fundy may not seriously affect vulnerability of this species.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-**SD** GI-Inc-**SI**-N-**SD**	Reproductive failure observed in the Bay of Fundy during 2005 was attributed to a wet condition (e.g., 80% more rainfall than normal in May) (Holroyd and Banasch, 2012). Wet conditions deprive insulation ability of this species' feathers, resulting in rapid heat loss and nestling failures (Ancil et al., 2014). Climate change may induce drier conditions by higher evapotranspiration but also more frequent heavy rains, and therefore both negative and positive effects of climate change on this species should be considered here. Franke et al. (2011) also found the fact that the North Atlantic Oscillation index, but not summer precipitation, affected significantly survival rate of this species in Nunavut.
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	Open circumstances are preferred like shores and marshes (Godfrey, 1986). This is probably because open environments make it easier to predate preys for falcons (Beauchamp, 2013). However, wet conditions deprive insulation ability of this species' feathers, resulting in rapid heat loss and nestling failures (Ancil et al., 2014). This influence is reflected in the subcategory of C2bii, but also storms (combinations between strong rains and

		stron winds) should be regarded negative events for this species, reducing chick survival rates (Bradley et al., 1997).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	Heavy snowfall causes egg mortality and small clutch size of this species in the Northwest Territories (Bradley et al., 1997).
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C4b (Diet)	Inc-**SI**-**N**-SD Inc-**SI**-**N**-SD	This species predates small/meidum-sized bird species, such as flickers, blue jays, and robins (Godfrey, 1986; Erskine, 1992). Beauchamp (2008) and Dekker et al. (2011) observed many attacked semipalmated sandpipers by Peregrine falcons in the Bay of Fundy.
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	The population in Fundy was artificially reintroduced (Erskine, 1992; Parks Canada, 2010d).
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	77	23
Severe scenario	0	0	0	0	100
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario			-------------------------------		
Severe scenario			-------------------------------		
	This species could breed everywhere, other than extremely hot/cold deserts as well as rain-forests in tropics (Erskine, 1992). More specifically, it can breeds from southern South America to Alaska (and other continents) (Godfrey, 1986). Franke et al. (2011) also found the fact that the North Atlantic Oscillation index, but not summer temperature, affected significantly survival rate of this species				

	in Nunavut. Therefore, physiological thermal niche is so wide that climate change in Fundy may not seriously affect vulnerability of this species. Strong storms and rains could influence the same species negatively, but falcon is originally an inhabitant of open areas. In this sense, here, a little increase in frequency/intensity of storms/rains were considered not much relevant to the species' vulnerability/adaptability. Hence, it was judged to be presumably stable under the climate change scenarios.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of dark-eyed junco (*Junco hyemalis*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Tree-cutting may have contributed to creations of forest edges and also increase of juncos in the Maritimes (Erskine, 1992). In support of this, Blanc et al. (2010) observed more juncos in clearcut sites or irregular shelterwood cutting sites than selection cutting sites or uncut stands.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species is a migratory bird, which stays from southern Canada (including New Brunswick) to northern Mexico during winter (Godfrey, 1986). Females are more likely to overwinter in more southern regions than males (Ketterson and Nolan, 1976). For instance, in the zone between 43-45°N, female ratio is only 0.2 in winter (Ketterson and Nolan, 1976). Yet, in terms of capability of long-distance dispersal, this species could move for sufficient distances (> 10 km).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	This species is distributed from the southern United States to northwestern Alaska including tree-line fronts during its breeding season (Godfrey, 1986; Erskine, 1992), and therefore Fundy is climatically situated in a middle part of the species' range. During winter, low temperatures could be adverse for particularly smaller individuals of this species, which are often females (Ketterson and Nolan, 1976).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species is associated with forest openings and edges (Godfrey, 1986; Erskine, 1992). In support of this, Blanc et al. (2010) observed more juncos in clearcut sites or irregular shelterwood cutting sites than selection cutting sites or uncut stands. However, according to Simon et al. (2002), this species did not show strong associations with specific disturbance types or the time since disturbance.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	Snow cover interrupts frequently feeding of this species, probably being one of reasons for lower female ratio in higher latitudes in winter (Ketterson and Nolan, 1976).

C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is associated with forest (usually coniferous trees) openings and edges (Godfrey, 1986; Erskine, 1992). However, nests are often made on or near the ground, and therefore understory vegetation is utilized for protecting the nests (Godfrey, 1986; Erskine, 1992).
C4b (Diet)	Inc-SI-N-**SD** Inc-SI-N-**SD**	Seeds, fruits, and invertebrates are preys for this species (McGlothlin et al., 2007; MacMynowski and Root, 2007). However, like the case of hermit thrush in its wintering sites, some of the food may be unavailable during cold winter.
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	Genetic diversity of mtDNA at subspecies level (*J. h. hyemalis*) was examined, but detailed information about intra-population variations in Fundy/New Brunswick was not given (Mila et al., 2007).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Matthews et al. (2004) predicted substantial decline of this species in the United States in the future due to losses of striped maples. However, their projection target did not include New Brunswick.

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	0	100
Severe scenario	0	0	0	0	100
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario			-------------------------------	-------------------------------	
Severe scenario				-------------------------------	
	This species is distributed from the southern United States to northwestern Alaska including tree-line fronts during its breeding season (Godfrey, 1986; Erskine, 1992), and therefore Fundy is climatically situated in a middle part of the species' range. During winter, low temperatures could be adverse for particularly smaller individuals of this species, which are often females (Ketterson and Nolan, 1976). This species is associated with forest openings and edges (Godfrey, 1986; Erskine, 1992). In support of this, Blanc et al. (2010) observed more juncos in clearcut sites or irregular shelterwood cutting sites than selection cutting sites or uncut stands. However, according to Simon et al. (2002), this species did not show strong associations with specific disturbance types or the time since				

	disturbance. This species is associated with forest (usually coniferous trees) openings and edges (Godfrey, 1986; Erskine, 1992). However, nests are often made on or near the ground, and therefore understory vegetation is utilized for protecting the nests (Godfrey, 1986; Erskine, 1992). Hence, this species is likely to be stable under climate change, while temperature increase (in winter) and intensified disturbances could be positive for the same species. So, both classes of PS and MA were chosen under moderate climate change scenario. Under severe climate change scenario, such positive effects could be more clearly expected than moderate scenario. Yet, the positive effects were not regarded as “high”, because they are not decisive factors limiting the species’ distribution or population size (there are no evidence or report supporting such a possibility). In this regard, just the class of MA was given under severe scenario.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of white-winged crossbill (*Loxia leucoptera*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Modern forestry practices seem to be not harmful on this species in the Maritimes, as far as trees are grown until ages to bear cones (Erskine, 1992). In contrast, since the size of conifer cone crops is influential on crossbill populations, Bolgiano (2004) proposed artificial disturbances which decrease mature trees could be detrimental for crossbills. However, the artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Fundy species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	Benkman (1987) reported long-distance dispersals of this species, like movements for more than 1,000 km. This species moves along with boreal forest belts to find large conifer cones (Benkman, 1987).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species is widely distributed in not only North America (including from the northern United States to central Alaska) but also Eurasia during breeding seasons, though its breeding sites could be changed depending on seed crops of coniferous trees (Godfrey, 1986; Erskine, 1992). Therefore, Fundy is climatically situated in a middle part of the species' range.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD**	According to multivariate analyses by Kirk et al. (1996), this species was associated with dry sites in western and northern Canada.
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	Open coniferous/mixed stands are major habitats for this species (Godfrey, 1986). Imbeau et al. (1999) found the fact that this species inhabited not only mature stands but also immature stands in Quebec, suggesting that mature forests are not neccessarily requirements for this species' habitats. In contrast, according to multivariate analyses by Kirk et al. (1996), this species was associated with old forests in western and northern Canada. Since the size of conifer cone crops is influential on crossbill populations, Bolgiano (2004) proposed artificial disturbances which decrease mature trees could be detrimental for crossbills. Likewise, forest disturbances by

		budworms may have led population declines of this species (Bolgiano, 2004).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	Snowfall may restrict food availability for this species, like spruce grouse in Cape Breton Highlands.
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	Coniferous forests or mixedwoods are major habitats for this species (Godfrey, 1986). According to multivariate analyses by Kirk et al. (1996), this species was associated with old forests in western and northern Canada. The size of conifer (e.g., white spruces, black spruces, and tamaracks) cone crops is influential on crossbill populations (Benkman, 1987; Erskine, 1992; Bolgiano, 2004; Gallant, 2004), and therefore coniferous boreal forests may be primary habitats for this species. However, Hobson and Bayne (2000) reported that this species was significantly more abundant in mixedwoods than pure forests like black spruce stands, in Saskatchewan.
C4b (Diet)	Inc-**SI**-N-**SD** Inc-**SI**-N-**SD**	The size of conifer (e.g., white spruces, black spruces, and tamaracks) cone crops is influential on crossbill populations (Benkman, 1987; Erskine, 1992; Bolgiano, 2004; Gallant, 2004). Particularly, black spruces may be the most important for this species, partly due to relatively stable crop productions among years (Benkman, 1987). Like the case of hermit thrush in its wintering sites, some of the food may be unavailable during cold winter. Yet, when these foods are not available, this species could also feed on alternative foods, like deciduous tree seeds, insects, charcoals, and even fish bones (Gallant, 2004).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	This species' range in North America has shifted southwards by 160 km, according to a comparative study between 1967-1971 vs. 1998-2002 (Hitch and Leberg, 2006). Possible reasons for this change was not explicitly mentioned by the study, and it is difficult to attribute the change to climate change. In New York State, the same species has shifted its distribution northwards by 17 km between 1980-1985 and 2000-2005 (Zuckerberg et al., 2009).
D2	GI-Inc-SI-N-SD-Dec	

(Modeled change)	GI-Inc-SI-N-SD-Dec				
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	50	50
Severe scenario	0	0	0	0	100
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario		-------------------------------	-------------------------------		
Severe scenario		-------------------------------			
	Coniferous forests or mixedwoods are major habitats for this species (Godfrey, 1986). According to multivariate analyses by Kirk et al. (1996), this species was associated with old forests in western and northern Canada. The size of conifer (e.g., white spruces, black spruces, and tamaracks) cone crops is influential on crossbill populations (Benkman, 1987; Erskine, 1992; Bolgiano, 2004; Gallant, 2004), and therefore coniferous boreal forests may be primary habitats for this species. However, Hobson and Bayne (2000) reported that this species was significantly more abundant in mixedwoods than pure forests like black spruce stands, in Saskatchewan. Hence, even though this species may not be directly sensitive to thermal change, declines of boreal coniferous forests could contribute to vulnerability of the same species. In this respect, following the vulnerability of the coniferous tree species (e.g., black spruce) in Fundy National Park, vulnerability of crossbill might be MV under moderate climate change scenario and HV/MV under severe scenario. Yet, when these foods are not available, this species could also feed on alternative foods, like deciduous tree seeds, insects, charcoals, and even fish bones (Gallant, 2004). As well, drier and less snowly conditions will be somewhat positive for crossbill. Taking into account all these attributes, the species' vulnerability was judged a little more positively than the vulnerability of conifers; MV/PS under moderate scenario and MV under severe scenario.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of American eel (*Anguilla rostrata*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-N GI-Inc-**SI**-N	Erected barriers in freshwater courses could interrupt upward migration of juvenile eels (COSEWIC, 2012). Goodbrand (2009) reported that even in Fundy National Park steep river gradients may have hindered incoming elvers. Yet, this species inhabits warm water, and natural barriers, like those among cold refugia for brook trout, are not likely to affect it. Thus, only SI was chosen. Also, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered, and only SI was chosen again (assuming that Inc should be chosen for the species without highlands).
B2b (Artificial barriers)	GI-Inc-**SI**-N GI-Inc-**SI**-N	Dams and overfishing were documented as actual threats for this species (COSEWIC, 2012). Artificial barriers, like hydroelectric facilities, are considered as partial reason for a remarkable decline of eel populations in the upper St. Lawrence River and Lake Ontario system (COSEWIC, 2012). However, such reports were not explicitly given for eels in Fundy. · A lot of waterfalls have been increased because of past logging. [Expert in Fundy]
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	Silver eels could migrate from Nova Scotia to the Sargasso Sea for a distance of around 2,000 km (COSEWIC, 2012).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD**	The most optimal temperature for American eel ranges between 16.7 and 17.4◦C, while higher temperature of 22-25◦C is the best for its growth (Jessop, 2010). Also, eels are likely to migrate at temperatures > 10-12◦C (August and Hicks, 2008). Fundy is likely to be situated at a little more northern side of this species' most optimal habitats (at around 37-38° N), which means that this place is thermally stressful for American eels (Laflamme et al., 2012). This possibility was supported by relatively high RNA/DNA ratio as well as low Fulton's condition factor (Laflamme et al., 2012).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	This species inhabits a wide variety of habitats including both shallow and deep waters (COSEWIC, 2012).

hydrological niche)		
C2c (Disturbance)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	This species inhabits a wide variety of habitats including marine and freshwater circumstances (COSEWIC, 2012). Growing eels generally use rocks, sands or mud substrates with woody debris and submerged vegetation, while overwintering eels stay in mud bottoms in bay or estuary habitats (COSEWIC, 2012). In other words, every lake and river may include some comfortable habitats for this species (COSEWIC, 2012).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	A prolonged snow period in coastal areas could lead to limited good growth period for eels (Jessop et al., 2004).
C3 (Physical habitat)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-**SD**-Dec	This species inhabits a wide variety of habitats including marine and freshwater circumstances (COSEWIC, 2012). Growing eels generally use rocks, sands or mud substrates with woody debris and submerged vegetation, while overwintering eels stay in mud bottoms in bay or estuary habitats (COSEWIC, 2012). This species has a high tolerance to pH, but still low pH like the range of 4.7-5.0 could be fatal for elvers (Jessop, 2000). In other words, every lake and river may include some comfortable habitats for this species (COSEWIC, 2012). Yet, Goodbrand (2009) proposed that a lack of soft substrates in Fundy may interrupt incoming elvers.
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C4b (Diet)	Inc-SI-**N**-**SD** Inc-SI-**N**-**SD**	Leptocephali feeds on dissolved organic carbon (DOC) including fecal pellets as well as discarded shelters of larvacean tunicates (COSEWIC, 2012). Elvers could eat insect larvaes, and yellow eels are benthic omnivores, feeding on fish, crayfish, insect larvaes, plants and so on (COSEWIC, 2012).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	A population genetic study sampling yellow eels in North Atlantic did not examine populations around Fundy National Park (Cote et al., 2013).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Broadly, warming in Sub-Tropical Gyre (STG) spawning area as well as oceanographic changes could bring about negative impacts on American eels (Knights, 2003). For instance, it was suggested that eel larvae populations in Atlantic could be negatively affected by climate change through bottom-up trophic regulation (decreased primary production) (Bonhommeau et al., 2008). In contrast, recent warming in continental areas in

		northern hemisphere, like temperatures > 20◦C, could be beneficial for eel's growth (Knights, 2003). However, the former negative impacts may outweigh the latter positive influence (Knights, 2003), and also details have not been clarified yet (COSEWIC, 2012).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	100	0
Severe scenario	0	0	0	50	50
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario			-------------------------------	-------------------------------	
Severe scenario				-------------------------------	
	The most optimal temperature for American eel ranges between 16.7 and 17.4◦C, while higher temperature of 22-25◦C is the best for its growth (Jessop, 2010). Also, eels are likely to migrate at temperatures > 10-12◦C (August and Hicks, 2008). Fundy is likely to be situated at a little more northern side of this species' most optimal habitats (at around 37-38° N), which means that this place is thermally stressful for American eels (Laflamme et al., 2012). This possibility was supported by relatively high RNA/DNA ratio as well as low Fulton's condition factor (Laflamme et al., 2012). Therefore, although Goodbrand (2009) proposed that steep river gradients and/or a lack of soft substrates in Fundy may interrupt incoming elvers, temperature increase *per se* will contribute to adaptation of eel in Fundy National Park. Because a small thermal change might not be noticeable because of the interrupting subfactor, not only MA but also PS were chosen here. Also, the positive impacts of climate change on eel may be smaller than those on some other warmwater fish species (e.g., white perch), and hence HA was not given for eel.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of Atlantic salmon (*Salmo salar*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	Salmon in the inner Bay of Fundy are known not to move away from the Bay of Fundy (Trzcinski et al., 2004; Freamo et al., 2011). Topographical steepness in Fundy National Park could be a barrier, as described in the assessment of eel. Also, because the physiological thermal niche of salmon is not clear in the same park, Inc as well as SI were chosen (This scoring is between that of eel and brook trout). Also, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered, and only SI was chosen (assuming that Inc should be chosen for the species without highlands).
B2b (Artificial barriers)	GI-Inc-**SI**-N GI-Inc-**SI**-N	Construction of barriers and logging could be a partial reason for the collapse in salmon abundances in Fundy National Park (Parks Canada, 2010d). · A lot of waterfalls have been increased because of past logging. [Expert in Fundy]
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	Smolts around the Bay of Fundy migrated for < 2 km to > 125 km, while postmolts traveled for < 100 km to > 230 km (Lacroix, 2008). The travel distance was varied depending on origins of samlon (Lacroix, 2008), and also salmon in the inner Bay of Fundy are known not to move away from the Bay of Fundy (Trzcinski et al., 2004; Freamo et al., 2011). Yet, all these results indicate that this species could disperse for more than at least 10 km.
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	This species is native to temperate and subarctic regions of the north Atlantic Ocean (Aas et al., 2011). Temperature higher than 25-28°C could give thermal stress on salmon (Elliott, 1991). In support of this, laboratory experiments with this species from New Brunswick found the fact that mRNA of heat shock proteins, Hsp 30 and 70, was significantly induced at temperature of > 22°C (Lund et al., 2002). In contrast, cold temperature of 6-7°C or lower than this could suppress the species' growth, though the salmon may be able to survive at low temperature probably below 0°C (Sigholt and Finstad, 1990; Elliott, 1991). The most vulnerable stage of this species in relation with temperature is, however, egg stage. Salmon eggs could be critically damaged by temperatures colder than 0°C or hotter than 16°C (Elliott and Elliott, 2010). The most optimal temperature for this species' growth ranges between 16 to 19°C (Elliott, 1991), while the summer mean temperature of air in Fundy National Park is 15.9°C. However, because data of water temperature are

		unavailable, the impacts of temperature change should be unknown.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	
C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-**SD**-Dec	Atlantic salmon is photonegative during winter but photopositive during summer (Cunjak, 1988). Therefore, some vegetation may be beneficial for this species.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	Maintenance of limited activity of Atlantic salmon during winter in Nova Scotia was, in part, regarded as adaptation to icy and frozen water conditions (Cunjak, 1988). Earlier snowmelt could be beneficial for salmon migration in early summer (Aas et al., 2011).
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	Atlantic salmon in Nova Scotia are threatened by medium to high acidity (Amiro et al., 2006), but similar issues have not been explicitly documented in and around Fundy National Park. Also, salmon habitats for especially spawning could be characterized with excavatable substrate by female salmons together with sufficient oxygenation (Aas et al., 2011). Such habitats are generally often found in the tails of pools (Aas et al., 2011). In Fundy National Park, every accessible habitat satisfies physical requirements as salmon habitats, and therefore every part of two rivers in the park is designated as critical habitats for this species (VanderZwaag et al., 2011).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C4b (Diet)	Inc-SI-**N**-SD Inc-SI-**N**-SD	Juvenile salmon are opportunistic feeders, eating mainly mayflies, stoneflies, caddisflies, chironomids, blackflies and terrestrial invertebrates (Aas et al., 2011).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	**Inc**-SI-**N**-SD **Inc**-SI-**N**-SD	Salmon in the inner Bay of Fundy are genetically isolated from other salmon populations, suggesting a reproductive isolation within the species (Trzcinski et al., 2004). Furthermore, restriction enzyme analysis with mitochondrial genome showed no genetic variation within a salmon population in Little Salmon, which is close to Fundy National Park (Verspoor et al., 2005). Likewise, all the other populations around Chignecto Bay (Hebert and Crooked) also harbored no intra-population variation, while other examined populations in Atlantic Canada retained variations (Verspoor et al., 2005). It is noteworthy, in contrast, that Verspoor et al. (2002) found higher genetic variations of mtDNA in populations in the inner Bay of Fundy than those in the outer Bay,

		ascribing the result to an earlier colonization of salmon in the inner Bay after the Last Glacial Maximum. However, the populations in the inner Bay in their study were just populations which were situated in more southern sides than Fundy National Park (e.g., Big Salmon). Therefore, the data of Verspoor et al. (2005) are more relevant to Fundy National Park than Verspoor et al. (2002). Single nucleotide polymorphisms (SNPs) loci appeared to show some levels of intra-population variations in and around this park (e.g., PWF) (Freamo et al., 2011), but detailed comparisons of variations were not given.
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Global warming could be a reason for declines of salmon populations by reducing primary productivity at sea (Trzcinski et al., 2004). Yet, in comparison with Pacific salmons, this idea has been not fully accepted yet for Atlantic salmons, needing further data (Trzcinski et al., 2004). Further, it is not known if this idea is true even in the cool Bay of Fundy.
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	100	0
Severe scenario	0	7	66	33	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario					
Severe scenario					
	This species is native to temperate and subarctic regions of the north Atlantic Ocean (Aas et al., 2011). Temperature higher than 25-28°C could give thermal stress on salmon (Elliott, 1991). In support of this, laboratory experiments with this species from New Brunswick found the fact that mRNA of heat shock proteins, Hsp 30 and 70, was significantly induced at temperature of > 22°C (Lund et al., 2002). In contrast, cold temperature of 6-7°C or lower than this could suppress the species' growth, though the salmon may be able to survive at low temperature probably below 0°C (Sigholt and Finstad, 1990; Elliott, 1991). The most vulnerable stage of this species in relation with temperature is, however, egg stage. Salmon eggs could be critically damaged by temperatures colder than 0°C or hotter than 16°C (Elliott and Elliott, 2010). The most optimal temperature for this species' growth ranges between 16 to 19°C (Elliott, 1991), while the summer mean temperature of air in Fundy National Park is 15.9°C. However, because data of water temperature are unavailable, the impacts of temperature change should be unknown. Consequently, the MVA did not determine vulnerability/adaptability of the species.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of Brook trout (*Salvelinus fontinalis*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-**Inc**-SI-N GI-**Inc**-SI-N	Although this species has both a marine-type and a freshwater-type, anadromous populations are unlikely to occur in Fundy National Park (Hebert et al., 2000). Drainage subdivision as well as upstream/downstream manner have led to population subdivision in Fundy (Hebert et al., 2000). Stream gradients and natural barriers like watersheds may have restricted the native distribution of this species (Meisner, 1990; Parks Canada, 2010d). Also, highlands also offer available refugium sites, and in this regard the species with the highlands has more adaptation opportunities than that without highlands. In the MVA, such opportunities were considered, and only SI was chosen (assuming that Inc should be chosen for the species without highlands).
B2b (Artificial barriers)	GI-Inc-**SI**-N GI-Inc-**SI**-N	Forest logging is one of strong negative factors limiting the distribution of this species (Bivens, 1984). · A lot of waterfalls have been increased because of past logging. Some brook trout completely disappeared because of dams, and the resident brook trout are in streams or lakes. Now, there are two separate populations in Fundy National Park, but interactions between the populations aren't clear to us. [Expert in Fundy]
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	In Kennebecasis River and Bay, New Brunswick, this species moved upstream for 65-100 km during spring and also moved to spawning areas for less than 10 km in autumn (Curry et al., 2002). In Wyoming, this species moved for 320 m on average (0-1,638 m) during autumn, whereas it did not move during winter (latter half of January to former half of March) (Lindstrom and Hubert, 2011).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-**N**-SD GI-**Inc**-**SI**-N-SD	This species is distributed in cool, clear waterflows in the Maritime Provinces, Newfoundland, and Labrador westward to Manitoba in Canada (Scott, 1967). Although adults of this species can be alive at temperature of less than 25.3°C, eggs of the same species will be dead at tmperature higher than 11.7°C (Chiasson, 2008). Also, groundwater whose temperature is higher than 15°C may be too warm for this trout (Meisner, 1990). Physiologically, mRNA level of heat shock protein, Hsp70, in brook trout from New Brunswick significantly increased at temperature of > 22°C in comparison with those of controls (7.5, 15, and 18°C) (Lund et al., 2003). According to one Habitat Quality Index model, the most optimal summer temperature for this species is between 12.6 and 18.6°C (Scarnecchia and Bergersen, 1987). According to another observation in Nova Scotia, a mean summer water temperature less than 16.5°C was preferred by brook trout (MacMillan et al., 2008). Although this species is the most common fish species in Fundy National Park, cold-water refugia are crucial

		for this species' survival during summer (Parks Canada, 2010d). Therefore, although mean summer water temperature in Fundy National Park is less than 16.5°C currently (Parks Canada, 2010d), temperature increase will be adverse for brook trout. · Current refugia of brook trout depend on cold water. [Expert in Fundy]
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	Deep pools could be important refugia under warming climate for this trout (MacMillan et al., 2005), but an observation in Nova Scotia did not find any significant relationship between water depth and density of this species (MacMillan et al., 2008). · Brook trout migrates to vernal pools in stressful conditions, and such pools will be important under climate change. [Expert in Fundy]
C2c (Disturbance)	Inc-SI-N-SD-Dec Inc-SI-N-SD-Dec	If snow shifts to snow-rain mix, high waterflows (floods) in winter would be frequent, negatively affecting brook trouts (Wenger et al., 2011). This is because this species spawns in autumn (Wenger et al., 2011). As well, wildfires are likely to affect negatively salmonid thermal habitats (Isaak et al., 2010), though such fires are unlikely to occur in Fundy.
C2d (Ice/Snow)	GI-Inc-SI-N GI-Inc-SI-N	Snow accumulation could contribute to stability of winter habitats of this species (Lindstrom and Hubert, 2004). If snow shifts to snow-rain mix, high waterflows (floods) in winter would be frequent, negatively affecting brook trout (Wenger et al., 2011). This is because this species spawns in autumn (Wenger et al., 2011).
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species can be more tolerant of acid envrionments than rainbow trout (pH > around 4.3) (Bivens, 1984; Hurley et al., 1989). In contrast, according to actual observation in Nova Scotia, this species was more frequent in less acid rivers (pH = around 7.1) (MacMillan et al., 2008). As well, habitat restriction by pH may be less relevant in and around Fundy National Park than Nova Scotia. Type of substrates in habitats was not significantly correlated with the frequency of this species (MacMillan et al., 2008). Adequate dissolved oxygen is crucial for this species' survival during summer in Fundy National Park (Parks Canada, 2010d).
C4a (Other spp for habitat)	GI-Inc-**SI**-N SD GI-Inc-SI-N	Beaver ponds are preferred as habitats to overwinter by this species (Lindstrom and Hubert, 2004). In the MVA, because beaver will be presumably stable or moderately adaptable under moderate climate change scenario, the subscores of N and SD were chosen instaed of SI and N.
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	This species eats insects and fish, and especially slimy sculpin (*Cottus cognatus*) is commonly predated by large brook trout (Scott, 1967). Slimy sculpin is distributed in New Brunswick, and it is a cold-water species (Gormley et al., 2005). · If they are a generalist they should decrease, not increase. [Expert in Fundy]
C4c	Inc-SI-N	

<table>
<tr><td>(Pollination)</td><td>Inc-SI-N</td><td colspan="5"></td></tr>
<tr><td>C4d
(Other spp for disp)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5"></td></tr>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5">This species has lost in an interspecific competition with an exotic salmonid, rainbow trout in many areas (Bivens, 1984). Negative impact of temeprature increase on rainbow trout can be mitigated by high waterflow during winter under climate change (Wenger et al., 2011). In other words, less snow and more winter rain may help rainbow trout to outcompete Brook trout.

· There are a number of fish species (including the small-mouthed bass) that are detrimental to brook trout, and they are just waiting for temperature change. [Expert in Fundy]</td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5">Stocked brook trout were provided at Wolfe Lake and Bennett Lake in Fundy National Park between 1956 and 1981, but populations in these lakes exhibited somewhat smaller intra-population variations than those of other examined populations in Atlantic Canada (Jones et al., 1996). This result implies the fact that stocked populations have failed to reproduce successfully due to maladaptation to the environment (Jones et al., 1996). On the other hand, Hebert et al. (2000) reported comparable levels of intra-population variations in Fundy National Park with Forillon and Kouchibouguac National Parks by examining nuclear microsatellite loci.</td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="5"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="5">Warmwater zones (a mean summer water temperature > 18.9°C) in Nova Scotia are mostly confined to its southwestern part, and such zones will be unsuitable for this trout in warming climate (MacMillian et al., 2005). Yet, according to a prediction by Chu et al. (2005), brook trout populations still persist in and around Kejimkujik under minimum and moderate climate changes (with annual temperature changes of +1.96°C and +3.23°C respectively). Therefore, this species in Fundy National Park will also experience negative impacts of climate change, but possibly persisting.</td></tr>
<tr><td rowspan="3">The CCVI [%]
Moderate Scenario
Severe scenario</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>100</td><td>0</td></tr>
<tr><td>12</td><td>38</td><td>39</td><td>11</td><td>0</td></tr>
<tr><td rowspan="4">The MVA**
Moderate Scenario
Severe scenario</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td></td><td>-------------------------------</td><td>-------------------------------</td><td></td><td></td></tr>
<tr><td>-------------------------------</td><td>-------------------------------</td><td></td><td></td><td></td></tr>
<tr><td colspan="5">This species is distributed in cool, clear waterflows in the Maritime Provinces, Newfoundland, and Labrador westward to Manitoba in Canada (Scott, 1967). Although adults of this species can be alive at temperature of less than 25.3°C, eggs of the same species will be</td></tr>
</table>

	dead at tmperature higher than 11.7°C (Chiasson, 2008). Also, groundwater whose temperature is higher than 15°C may be too warm for this trout (Meisner, 1990). Physiologically, mRNA level of heat shock protein, Hsp70, in brook trout from New Brunswick significantly increased at temperature of > 22°C in comparison with those of controls (7.5, 15, and 18°C) (Lund et al., 2003). According to one Habitat Quality Index model, the most optimal summer temperature for this species is between 12.6 and 18.6°C (Scarnecchia and Bergersen, 1987). According to another observation in Nova Scotia, a mean summer water temperature less than 16.5°C was preferred by brook trout (MacMillan et al., 2008). Although this species is the most common fish species in Fundy National Park, cold-water refugia are crucial for this species' survival during summer (Parks Canada, 2010d). Therefore, although mean summer water temperature in Fundy National Park is less than 16.5°C currently (Parks Canada, 2010d), temperature increase will be adverse for brook trout. If snow shifts to snow-rain mix, high waterflows (floods) in winter would be frequent, negatively affecting brook trout (Wenger et al., 2011). This is because this species spawns in autumn (Wenger et al., 2011). Further, less snow and more winter rain may help rainbow trout to outcompete Brook trout (Wenger et al., 2011). Summing up, temperature increase during summer season will be negative for the trout population. Under severe climate change scenario, not only temperature increase but also less snow (more winter rain) could be detrimental, and hence not only MV but also HV were chosen to show the species' vulnerability.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of Mainland moose (*Alces alces americana*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-**SI**-N GI-Inc-**SI**-N	Populations have been fragmented and isolated, possibly due to in part establishing and decommissioning roads (including forestry harvesting roads) in Nova Scotia (Snaith and Beazley, 2004). Therefore, similar effects may be expected around Fundy in New Brunswick. As well, deer, which often carry a fatal parasite, *Paralephostrongylus tenuis*, could utilize roads to approach habitats of moose (Robinson et al., 2010).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	According to dispersal records of this species in several regions, moose can migrate for more than 10 km (possibly up to 50 km) (Parker, 2003).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-**N**-SD GI-**Inc**-**SI**-N-SD	Although heat-stress threshold of this species during summer was supposed to be between 14-20°C, some recent studies have shown that moose could be more tolerant to heat stress (McCann et al., 2013). McCann et al. (2013) reported heat-stress thresholds of 17°C under calm conditions and 24°C under windy ones, by observing moose at the Minnesota Zoological Garden. Broders et al. (2012) observed the fact that moose seeked for cooler sites when temperature reached at 14°C in summer nights and 24°C in summer days in mainland Nova Scotia. For instance, proportions of moose staying in softwoods or watersides were higher at warmer conditions (Broders et al., 2012). Nova Scotia is near to the southern limit of this species' distribution, and it is likely to be affected by heat stress (Snaith and Beazley, 2004). Fundy National Park is cooler than Nova Scotia, but still this park is in the southern side of the species' distribution. Therefore, increasing temperature may adversely affect moose populations' survival.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	Riverine and marsh habitat are beneficial for this species by alleviating heat stress (Dou et al., 2013). Parker (2003) suggested that post-fire forest regeneration often produces many aspen trees and that such aspen trees could be beneficial for beavers. Beavers then create wetlands, and such wetlands are useful for moose during summer season (Parker, 2003).
C2c	Inc-SI-N-**SD**-Dec	Early successional vegetation and/or burned areas are beneficial for this species, though severe and repeated

(Disturbance)	Inc-SI-N-**SD**-Dec	burning is harmful (Feldhamer, 2003; Snaith and Beazley, 2004; Fisher and Wikinson, 2005). Parker (2003) suggested that post-fire forest regenration often produces many aspen trees and that such aspen trees could be beneficial for beavers. Beavers then create wetlands, and such wetlands are useful for moose during summer season (Parker, 2003). Parks Canada (2010d) suggested that current density of moose in Fundy National Park is unlikely to cause singificant disturbances in the forests.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-N	Moose are morphologically capable to move through snow, and only much deep snow (> 70cm) could restrict their movements in Atlantic Canada (Kelsall, 1969). Smaller amount of snowfall will increase the exposure of this species to *Paralephostrongylus tenuis*, leading to higher mortality of moose (Beazley et al., 2006).
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	No preference for certain geological features.
C4a (Other spp for habitat)	GI-Inc-**SI**-N SD GI-Inc-**SI**-N	Preferring early successional deciduous vegetation (Snaith and Beazley, 2004). Parker (2003) suggested that post-fire forest regeneration often produces many aspen trees and that such aspen trees could be beneficial for beavers. Beavers then create wetlands, and such wetlands are useful for moose during summer season (Parker, 2003). Further, mature coniferous stands could be also useful for this species to adjust its body temperature during summer season (Parker, 2003). In support of this idea, Broders et al. (2012) observed moose in mostly softwood or mixed forests during summer season in mainland Nova Scotia. In the MVA, because beaver will be presumably stable or moderately adaptable under moderate climate change scenario, the subscores of N/SD were additionally chosen.
C4b (Diet)	Inc-**SI**-N-SD Inc-**SI**-N-SD	In Nova Scotia, important foods for this species include red, sugar, and mountain maple, white and yellow birch, hazelnut, and balsam fir (Parker, 2003; Snaith and Beazley, 2004). Similar diet could be expected in New Brunswick as well.
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	Northward expansion of deer's distribution could partly lead to decline of moose populations via interspecific competition of food/habitats and bringing a parasitic nematode, *P. tenuis* (Robinson et al., 2010). There are already many deer in Fundy, but negative influences of deer on moose may be enhanced with a larger number of deer in warmer climates.
C5a (Genetic variation)	Inc-SI-**N**-SD Inc-SI-**N**-SD	Microsatellite loci exhibited moderate level of expected heterozygosity in a moose population in New Brunswick in comparison with other populations in eastern Canada (Wilson et al., 2003).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1	GI-Inc-SI-N-SD-Dec	Northward expansion of deer's distribution has partly led to decline of moose populations in eastern Canada and

(Documented response)	GI-Inc-SI-N-SD-Dec	the United States via interspecific competition of food/habitats and bringing a parasitic nematode, Paralephostrongylus tenuis (Robinson et al., 2010). However, this trend is a macro-geographic pattern, but not a more local pattern focusing on Fundy or New Brunswick.			
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Climate change will increase thermal stress and mortality caused by transmission of *P. tenuis* for this species in Nova Scotia (Beazley et al., 2006). Similar change may be expected even in New Brunswick, but no documents have explicitly mentioned so.			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	100	0
Severe scenario	0	0	0	100	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario		-------------------------------	-------------------------------		
Severe scenario		-------------------------------			
	Although heat-stress threshold of this species during summer was supposed to be between 14-20°C, some recent studies have shown that moose could be more tolerant to heat stress (McCann et al., 2013). McCann et al. (2013) reported heat-stress thresholds of 17°C under calm conditions and 24°C under windy ones, by observing moose at the Minnesota Zoological Garden. Broders et al. (2012) observed the fact that moose seeked for cooler sites when temperature reached at 14°C in summer nights and 24°C in summer days in mainland Nova Scotia. For instance, proportions of moose staying in softwoods or watersides were higher at warmer conditions (Broders et al., 2012). Nova Scotia is near to the southern limit of this species' distribution, and it is likely to be affected by heat stress (Snaith and Beazley, 2004). Fundy National Park is cooler than Nova Scotia, but still this park is in the southern side of the species' distribution. Therefore, increasing temperature may adversely affect moose populations' survival. Early successional vegetation and/or burned areas are beneficial for this species, though severe and repeated burning is harmful (Feldhamer, 2003; Snaith and Beazley, 2004; Fisher and Wikinson, 2005). Parker (2003) suggested that post-fire forest regenration often produces many aspen trees and that such aspen trees could be beneficial for beavers. Beavers then create wetlands, and such wetlands are useful for moose during summer season (Parker, 2003). Parks Canada (2010d) suggested that current density of moose in Fundy National Park is unlikely to cause singificant disturbances in the forests. Moose are morphologically capable to move through snow, and only much deep snow (> 70cm) could restrict their movements in Atlantic Canada (Kelsall, 1969). Smaller amount of snowfall will increase the exposure of this species to *Paralephostrongylus tenuis*, leading to higher mortality of moose (Beazley et al., 2006). Northward expansion of deer's distribution could partly lead to decline of moose populations via interspecific competition of food/habitats and bringing a parasitic nematode, *P. tenuis* (Robinson et al., 2010). There are already deer in Fundy, but negative influences of deer on moose may be enhanced with a larger number of deer in warmer climates. In short, this species in Fundy National Park could be affected by temperature increase as well as further infections of *P. tenuis* negatively. However, considering recent insights about moose's heat tolerance and the relatively cool climate in Fundy National Park, this species might not show noticeable declines under moderate climate change scenario. In contrast, the species' vulnerability will be articulated with less snow accumulation, like severe climate change scenario. However, the moose population in Fundy could be replenished by immigrants from outsides, and in this sense local extinction is unlikely to occur. Beavers and aspen trees will also assist persistence of moose in Fundy. Therefore, "HV" was not chosen here. Consequently, MV and PS were chosen under moderate scenario				

	while just MV was chosen under severe scenario.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of coyote (*Canis latrans*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Although some coyotes have used roads to travel, demarcate boundaries and possibly collect foods (garbage), this species generally seems to refrain from including roads in their home ranges (Gompper, 2002; Porter, 2013). However, the artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Fundy species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	In northeastern America, this species can migrate for more than 100 km on average, and some individuals travel for more than 300 km (Gompper, 2002). This species has also expanded its distribution to Newfoundland via ice bridges (Blake, 2006).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	Basically, this species is highly adaptable, ranging from 10°N latitude (Costa Rica) to 70°N latitude (northern Alaska). In cold winter, this species can predate deer, particularly dead deer, because of high mortality of deer (Gese et al., 1996). However, winter temperature lower than -10°C is critical for coyotes from even Fairbanks in Alaska (Shield, 1972). The coldest monthly temperature in Fundy is -13.8°C in January, and therefore warmer climates might mitigate negative impacts of such harsh winter season on this species.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Generally, it seems to be common in hilly country with poplar bluffs and stream banks with willows (Banfield, 1976). In some parts in northeastern America, coyotes tend to gather in frozen lakes, ericaceous bogs and/or beaver meadows to get food during winter (Gompper, 2002).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species tends to inhabit disturbed and open habitats, such as burned and logged stands (Fisher and Wilkinson, 2005).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-N	In deep snow, this species can predate deer, particularly dead deer (Gese et al., 1996; Feldhamer et al., 2003; Patterson and Messier, 2003). In southwestern Yukon, coyotes prefer harder snow, which could fall under colder temperatures. However, snow also limits the movements of coyotes, lowering the probability of harvesting snowshoe hares (Murray and Boutin, 1991). Frozen lakes are preferred by coyotes as places where

		they can acquire foods, like deer, easily during winter (Gompper, 2002). Therefore, disappearances of ice and/or snow are likely to be negative for coyotes.
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	No preference for certain geological features. Furthermore, this species can migrate for more than 100 km on average (Gompper, 2002), suggesting its great ability to be compatible with various geological conditions.
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	It seems to be common in hilly country with poplar bluffs and stream banks with willows, though it could also be distributed alpine tundra, boreal forests, aspen parklands and steppes with short-grass (Banfield, 1976).
C4b (Diet)	Inc-**SI**-N-**SD** Inc-**SI**-N-**SD**	In northeastern America, this species generally feeds on white-tailed deer, snowshoe hares and also sometimes fruits (Gompper, 2002). Both live prey and carrion are available for this species, and it is regarded as an opportunistic and generalist feeder (Feldhamer et al., 2003). According to a study in southeastern New Brunswick during fall and winter seasons, snowshoe hares, white-tailed deer and rodents accounted for 37.5, 27.9 and 27.3% of contents found in coyote stomachs respectively (Lapierre, 1985). In contrast, this species is generally known as an important disperser of some plant species (Cypher and Cypher, 1999).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	According to a study analyzing mtDNA, there is a geographical decline in genetic diversity northeastwards in coyote populations around the Great Lakes including Ontario (Kays et al., 2009). However, genetic variations of coyote populations in New Brunswick have never been documented.
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	0	100
Severe scenario	0	0	0	0	100
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario			--------------------------------	--------------------------------	
Severe scenario			--------------------------------	--------------------------------	
	Basically, this species is highly adaptable, ranging from 10°N latitude (Costa Rica) to 70°N latitude (northern Alaska). In cold winter,				

	this species can predate deer, particularly dead deer, because of high mortality of deer (Gese et al., 1996). However, winter temperature lower than -10°C is critical for coyotes from even Fairbanks in Alaska (Shield, 1972). The coldest monthly temperature in Fundy is -13.8°C in January, and therefore warmer climates might mitigate negative impacts of such harsh winter season on this species. This species tends to inhabit disturbed and open habitats, such as burned and logged stands (Fisher and Wilkinson, 2005). In northeastern America, this species generally feeds on white-tailed deer, snowshoe hares and also sometimes fruits (Gompper, 2002). Both live prey and carrion are available for this species, and it is regarded as an opportunistic and generalist feeder (Feldhamer et al., 2003). According to a study in southeastern New Brunswick during fall and winter seasons, snowshoe hares, white-tailed deer and rodents accounted for 37.5, 27.9 and 27.3% of contents found in coyote stomachs respectively (Lapierre, 1985). In contrast, this species is generally known as an important disperser of some plant species (Cypher and Cypher, 1999). Therefore, the coyote population will be presumably stable or moderately increase in response to temperature increase and possibly stronger disturbances under the climate change scenarios. Although the number of deer, the main food for coyote, may also increase under severe climate change scenario with less snow, degree of difficulty to predate deer might also increase due to less snow, canceling out the positive effect of deer increase. Given that coyote may not flourish “significantly” because of temperature increase and/or snow decline in direct ways, this species was judged to be PS/MA, but not HA, under severe scenario as well.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of beaver (*Castor canadensis*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	This species inhabits relatively warm water, and natural barriers, like those among cold refugia for brook trout, are not likely to affect it. In contrast, it is also not clear if this species inhabits just large lakes and/or main rivers, which are given an example of “neutral” subscore by Young et al. (2011). Therefore, SI as well as N are chosen here.
B2b (Artificial barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	· A lot of waterfalls have been increased because of past logging. [Expert in Fundy] [Follow-up] Effects of waterfalls on beaver are not clear, and therefore SI and N were chosen.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-**Dec** GI-Inc-SI-N-**SD**-**Dec**	Although a dispersal distance of this species could be greatly varied (Feldhamer et al., 2003), and overland movements tend to be limited in comparison with overwater dispersals (McNew and Woolf, 2005). It is plausible that some beavers move for ditances longer than 1 or 10km according to recent studies (Sun et al., 2000; McNew and Woolf, 2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	This subspecies is distributed in New Brunswick, Nova Scotia, southern Quebec, and Adirondacks in New York and previously Maine and Vermont as well (Bailey and Doutt, 1942). Beavers in southern Quebec are distributed under a mean annual temperature higher than -5.1°C (Jarema et al., 2009), whereas the mean temperature in Fundy National Park is 4.5°C. At a species level, the optimal temperature zone of *C. canadensis* ranges between 0 and 28°C (MacArthur, 1988).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Generally, beavers prefer slow-flowing streams, lakes, rivers, marshes, though they can sometimes inhabit bogs without open water (Banfield, 1976; Feldhamer et al., 2003). According to an empirical study, water drawdown has a slightly negative impact on behavior of this species (Smith and Peterson, 1991). It is also noteworthy, however, that this species has an ability to create open water in either of wet or dry climates, possibly mitigating even impacts of climate change which leads losses of wetlands (Hood and Bayley, 2008; Parks Canada, 2010d).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	Particularly willows and trembling aspens, which are early successional tree species, are the most common foods across the species’ range (Banfield, 1976; Feldhamer et al., 2003). Although fire could be beneficial for

		the regeneration of woody plants which are used by beavers, it can reduce beaver lodge occupancy, being harmful on populations of beaver itself (Hood et al., 2007). However, such fire effects may not be relevant in Fundy, where much fog could hinder fire happenings.
C2d (Ice/Snow)	GI-Inc-SI-N GI-Inc-SI-N SD	In ice-free areas, beavers can move, mark and defend their territories as well as forage more freely throughout winter (Feldhamer et al., 2003).
C3 (Physical habitat)	Inc-SI-N-**SD**-**Dec** Inc-SI-N-**SD**-**Dec**	No preference for certain geological features. Beavers can affect geological processes such as meadow development, erosion and also water quality (Feldhamer et al., 2003).
C4a (Other spp for habitat)	GI-Inc-**SI**-N SD GI-Inc-**SI**-N	Payne (1984) reported that natural mortality of beaver in Newfoundland could be mainly attaributed to insufficient deciduous forests as well as too shallow ponds. As well, aspen (*Populus spp.*) could contribute to generating habitats of beaver (Parker, 2003). Suitable habitats of aspens (*Populus grandidentata* and *P. tremuloides*) will be moved to more north than Fundy National Park under severe climate change scenario (c.f., Natural Resources Canada, 2014).
C4b (Diet)	Inc-**SI**-N-SD Inc-**SI**-N-SD	This species is a generalist herbivore that can eat tree barks, leaves, twigs, buds and so on, but particularly willows and trembling aspens are the most common foods across the species' range (Banfield, 1976; Feldhamer et al., 2003).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-N Inc-SI-N	
C4e (Other spp interaction)	Inc-SI-N Inc-SI-N	Some mammals (e.g., coyotes, bobcats, and fishers) could occassionally attack beavers, but the most important predator is wolve, which does not inhabit Fundy National Park (Payne, 1984).
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	97	3
Severe scenario	0	0	6	74	20
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario			-------------------------------	-------------------------------	

Severe scenario		-------------------------------	-------------------------------		
	This subspecies is distributed in New Brunswick, Nova Scotia, southern Quebec, and Adirondacks in New York and previously Maine and Vermont as well (Bailey and Doutt, 1942). Beavers in southern Quebec are distributed under a mean annual temperature higher than -5.1°C (Jarema et al., 2009), whereas the mean temperature in Fundy National Park is 4.5°C. At a species level, the optimal temperature zone of *C. canadensis* ranges between 0 and 28°C (MacArthur, 1988). Particularly willows and trembling aspens, which are early successional tree species, are the most common foods across the species' range (Banfield, 1976; Feldhamer et al., 2003). Payne (1984) reported that natural mortality of beaver in Newfoundland could be mainly attaributed to insufficient deciduous forests as well as too shallow ponds. Thus, the beaver population will be probably stable or somewhat flourish under climate change with deciduous forests. On the other hand, suitable habitats of aspens (*Populus grandidentata* and *P. tremuloides*) will be moved to more north than Fundy National Park under severe climate change scenario (c.f., Natural Resources Canada, 2014). So, PS and MV were chosen for beaver here.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of northern flying squirrel (*Glaucomys sabrinus*) in

Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-**SI**-N GI-Inc-**SI**-N	Based on an observation in Fundy, Ritchie et al. (2009) concluded that this species could be influenced negatively by logging, which leaves open treeless areas. In support of this, Smith (2007) suggested that human-caused disturbances as well as fires could replace such mature coniferous stands by hardwood forests (e.g., oak and hickory), negatively influencing northern flying squirrel. Smith et al. (2011a and 2013) also reported that habitat connecitivity strongly affected homing success and time of this species, highlighting the importance of protecting landscape connecitivity. So, this species is a low vagility species being sensitive to landscape fragmentation (Betts et al., 2003).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-Dec GI-Inc-SI-N-**SD**-Dec	There are several reports about dispersals of this species for several-km distance but not long-distance dispersals (Smith, 2007). Smith et al. (2011a) conducted translocation experiments with this species in and around Fundy National Park, finding the fact that return rate was lower (44%) from distances for more than 2km. As well, all the ten females which were translocated over 1.5km from their original sites did not return to the sites (Smith et al., 2011a). Such successful homing distance is not neccessarily same as maximum dispersal distance of this species, but this species seems to disperse for roughly 1-10 km.
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	The species' distribution extends from mid latitudinal parts of the United States to Alaska, though the subspecies of *G. s. gouldi* is confined to in and around Nova Scotia (Banfield, 1976). This species is still active under -20°C, but it is less likely to leave its shelters of nests (Cotton and Parker, 2000; Vernes, 2004). As well, in coastal regions in Alaska with sufficient precipitation, hypothermia in combination with wet conditions could be the most important reason for the mortality of this species (Smith, 2007). However, considering the much warmer climate in Fundy than that in Alaska, such hypothermia-related death is unlikely to occur. On the other hand, in southern New Brunswick, warmer spring temperature could lead to delivering multiple litters (offsprings) of this species in a year, but this relationship is still under investigated (Smith et al., 2011b).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Within dry forests, this species gather in riparian areas (Meyer et al., 2007; Smith, 2007). In contrast, in rain

hydrological niche)		forests, this species inhabits evenly, being not affected by the amount of surface water (Smith, 2007). Fundy National Park may come under the latter type. Smith (2007) also proposed that presence of streams and moist/wet microhabitats would be more important for this species' persistence under climate change which lowers precipitation. In contrast, in coastal regions in Alaska with sufficient precipitation, hypothermia in combination with wet conditions could be the most important reason for the mortality of this species (Smith, 2007). Considering the much warmer climate in Fundy than Alaska, such hypothermia-related death is unlikely to occur.
C2c (Disturbance)	**Inc**-**SI**-N-SD-Dec **Inc**-**SI**-N-SD-Dec	Generally, this species inhabits mature coniferous forests (Vernes, 2004). Smith (2007) suggested that human-caused disturbances as well as fires could replace such mature coniferous stands by hardwood forests (e.g., oaks and hickories), negatively influencing northern flying squirrel. Ritchie et al. (2009) confirmed the fact that older forests were more preferred by this species in Fundy. Translocation experiments by Smith et al. (2011a and 2013) showed strong dependence of this species on forest covers, but not forest gaps. All these evidences indicate negative effects of disturbances on this species.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** SD GI-Inc-**SI**-**N** SD	Generally, this species inhabits mature coniferous forests but also mixed forests including spruces (Banfield, 1976; Vernes, 2004; Menzel et al., 2006; Smith, 2007). Hemlock-yellow birch association is known as a suitable habitat for this species in eastern Canada (Banfield, 1976). Ritchie et al. (2009) confirmed the fact that mixedwood forests (coniferous-broadleaved forests) were preferred by this species in Fundy, probably because mixedwoods could contain high variety of food and nesting resources. Also, because this species utilizes cavities of live and snag trees in large sizes, it is regarded as an old-growth associated species (Rosenberg et al., 1996). In the MVA, because hemlock-yellow birch association (hemlock in particular) are presumably stable or adaptable to climate change, "SD" was additionally chosen under moderate climate change scenario.
C4b (Diet)	Inc-SI-**N**-**SD** Inc-SI-**N**-**SD**	This species is mycophagous, feeding on a wide variety of fungi, in Fundy (Rosenberg et al., 1996; Vernes et al., 2004). Vernes et al. (2004) pointed out, however, that mainly cone crops are eaten by such squirrels when seed production is high like the year of 2000. Smith (2007) stated that, in contrast, conifer seeds are not primary food for this species, despite the fact that it often inhabits coniferous forests. According to him, particularly hypogenous, mycorrhizal fungi are consumed by northern flying squirrel. Yet, this species possibly eats a wide variety of animals and plants, depending on habitats and/or seasons (Banfield, 1976; Rosenberg et al., 1996; Smith, 2007).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	

<table>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5">If hardwood forests increase due to climate change and/or land-use, a competitive species, <i>Glaucomys volans</i>, would greatly benefit such forests (Smith, 2007). Therefore, although hardwood forests are still available for <i>G. sabrinus</i>, probably populations of <i>G. sabrinus</i> would decline (Smith, 2007). Other studies have also proposed that the northern limit of <i>G. volans</i> is determined by interspecific competition with <i>G. sabrinus</i>, and sympatry of the two species will cause competition as well as hybridization between them (Lavers, 2004; Garroway et al., 2010). Such sympatry will be more likely to occur in warming climates, and actually hybridization has been already confirmed in Ontario (Bowman et al., 2005; Garroway et al., 2010). Many <i>G. sabrinus</i> individuals but no <i>G. volans</i> were captured in Fundy National Park so far (Lavers, 2004), and therefore the abovementioned change would be influencial on <i>G. sabrinus</i> populations in this park.</td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5"></td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="5"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="5">If hardwood forests increase due to climate change and/or land-use, a competitive species, <i>G. volans</i>, would greatly benefit such forests (Smith, 2007). Therefore, although hardwood forests are still available for <i>G. sabrinus</i>, probably populations of <i>G. sabrinus</i> would decline (Smith, 2007). Such negative changes with northward expansion of the distribution of <i>G. volans</i> have been already reported (e.g., the northern Great Lakes Region) (Smith, 2007; Myers et al., 2009). However, this projection is a general prediction, and little is known about modeled damage by climate change on this species in Fundy/New Brunswick. As well, it is not known whether this species could colonize northwards with northward shifts of boreal forests under climate change (Smith, 2007).</td></tr>
<tr><td>The CCVI [%]</td><td colspan="2">Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>Moderate Scenario</td><td colspan="2">0</td><td>0</td><td>0</td><td>100</td><td>0</td></tr>
<tr><td>Severe scenario</td><td colspan="2">0</td><td>0</td><td>7</td><td>93</td><td>0</td></tr>
<tr><td>The MVA**</td><td colspan="2">Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td>Moderate Scenario</td><td colspan="2"></td><td>-------------------------------</td><td>-------------------------------</td><td></td><td></td></tr>
<tr><td>Severe scenario</td><td colspan="2"></td><td>-------------------------------</td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="6">The species’ distribution extends from mid latitudinal parts of the United States to Alaska, though the subspecies of <i>G. s. gouldi</i> is confined to in and around Nova Scotia (Banfield, 1976). This species is still active under -20°C, but it is less likely to leave its shelters of nests (Cotton and Parker, 2000; Vernes, 2004). In southern New Brunswick, warmer spring temperature could lead to delivering multiple litters (offsprings) of this species in a year, but this relationship is still under investigated (Smith et al., 2011b). Generally, this species inhabits mature coniferous forests (Vernes, 2004). Smith (2007) suggested that human-caused disturbances as well as fires</td></tr>
</table>

	could replace such mature coniferous stands by hardwood forests (e.g., oaks and hickories), negatively influencing northern flying squirrel. Ritchie et al. (2009) confirmed the fact that older forests were more preferred by this species in Fundy. Translocation experiments by Smith et al. (2011a and 2013) showed strong dependence of this species on forest covers, but not forest gaps. All these evidences indicate negative effects of disturbances on this species. If hardwood forests increase due to climate change and/or land-use, a competitive species, *Glaucomys volans*, would greatly benefit such forests (Smith, 2007). Therefore, although hardwood forests are still available for *G. sabrinus*, probably populations of *G. sabrinus* would decline (Smith, 2007). Other studies have also proposed that the northern limit of *G. volans* is determined by interspecific competition with *G. sabrinus*, and sympatry of the two species will cause competition as well as hybridization between them (Lavers, 2004; Garroway et al., 2010). Such sympatry will be more likely to occur in warming climates, and actually hybridization has been already confirmed in Ontario (Bowman et al., 2005; Garroway et al., 2010). Many *G. sabrinus* individuals but no *G. volans* were captured in Fundy National Park so far (Lavers, 2004), and therefore the abovementioned change would be influencial on *G. sabrinus* populations in this park. Overall, although hemlock-yellow birch association (hemlock in particular) are presumably stable or adaptable to climate change, disturbances (declines of old-growth trees) and/or competition/hybridization with *G. volans* will be more relevant and serious to survivals of northern flying squirrel. The class of HV was not chosen, however, because its thermal niche may still allow squirrel to persist under changing climates. Therefore, it was judged as MV/PS and MV under moderate and severe climate change scenarios respectively.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of snowshoe hare (*Lepus americanus*) in Fundy

National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Once forests are clearly cut, at least 15-20 years would be needed to create suitable habitats for this species, though it needs some disturbances to maintain its habitats (Parker et al., 1983; Doyon et al., 2000). However, the artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Fundy species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species could disperse for distances of up to 20 km (Feldhamer et al., 2003).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	This species is distributed from Alaska to northern California and western Nevada (Feldhamer et al., 2003), though the subspecies of *L. a. struthopus* is restricted to the Maritime Provinces and Gaspe Peninsula of Quebec (Banfield, 1976). This species is quite tolerant to cold temperature (< -40°C) during winter (Doyon et al., 2000; Kielland et al., 2010). In contrast, according to a study in Alaska, population growth of this species seems to be at best when summer growing degree-days (GDD) during May and July are between 1,600 and 1,700 (Kielland et al., 2010). Given the GDD during June and the middle of August in a geocentroid of Fundy is 1,112, the GDD during May and July may be around or smaller than 1,100. Thus, snowshoe hares there may get much benefit from warmer temperatures in this park.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Leporidae is generally regarded as a dry-land animal, but snowshoe hare could swim in water (Johnson, 1925). This species is commonly seen in cedar bogs or coniferous forests in lowlands in the eastern side of this species' distribution (Banfield, 1976). Wet conditions, like sub-continental Canada in La Nina years, may increase food resources for snowshoe hares, in spite of no empirical evidence (Zhang et al., 2007). So, given all the information, somewhat moist conditions may be preferable for this species.
C2c (Disturbance)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	Sullivan (1994) stated that this species inhabits early to mid- successional forests (< 25 yrs). In this regard, creating forest succession caused by forest harvesting and/or forest fires is beneficial for snowshoe hares and Lynx (Parker et al., 1983; Paragi et al., 1997; Poole, 2003). Hoving et al. (2004) explained that the Canada

		Lynx is likely to inhabit early successional forests in northern Maine because its main feed, snowshoe hare, is distributed in such forests.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-**Inc**-SI-**N** SD	Snowshoe hares, which change their coat colors in winter, are less likely to be predated by coyotes in snow (Murray and Boutin, 1991), and the southern limit of this species' distribution corresponds to areas with notable snow cover (Murray, 2000). In contrast, great amounts of snow (depth > 30cm) could be detrimental for this species as well, according to an observation in interior Alaska (Olson and Euskirchen, 2010). This is probably because hares may be much less mobile in relation to their predators including coyotes in such snowy conditions (Olson and Euskirchen, 2010). Lynx is more likely to catch snowshoe hares in more hard-packed snow, which would be replaced by soft snow under warming climates (Stenseth et al., 2004). These information suggests that moderate amounts of soft snow (depth = 15-30cm) are optimal for this species' survival.
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	
C4a (Other spp for habitat)	GI-Inc-**SI**-N GI-Inc-**SI**-N	Generally, snowshoe hares are commonly seen in cedar bogs or coniferous forests in lowlands in the eastern side of this species' distribution (Banfield, 1976). Cheng et al. (2014) reported higher genetic diversity in populations in boreal forests than those in the other populations, indicating the importance of boreal habitats for this species.
C4b (Diet)	Inc-SI-**N**-SD Inc-SI-**N**-SD	Snowshoe hares eat various foods of green grasses and forbs during summer, while they eat buds, twigs, bark and leaves of evergreen plants during winter (Banfield, 1976; Doyon et al., 2000). Particularly, willows, birches, hazelnuts, maples, trembling aspens, hawthorns and some conifers (e.g., tamaracks, white pines, hemlocks, balsam firs) are preferred during winter (Banfield, 1976).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	Canada lynxes and coyotes are main predators for snowshoe hares, and such predations are the primary reason for this species' mortality (Murray et al., 2008).
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	25	75
Severe scenario	0	0	0	13	87
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario			-------------------------------	-------------------------------	
Severe scenario		-------------------------------	-------------------------------		
	This species is distributed from Alaska to northern California and western Nevada (Feldhamer et al., 2003), though the subspecies of *L. a. struthopus* is restricted to the Maritime Provinces and Gaspe Peninsula of Quebec (Banfield, 1976). This species is quite tolerant to cold temperature (< -40°C) during winter (Doyon et al., 2000; Kielland et al., 2010). In contrast, according to a study in Alaska, population growth of this species seems to be at best when summer growing degree-days (GDD) during May and July are between 1,600 and 1,700 (Kielland et al., 2010). Given the GDD during June and the middle of August in a geocentroid of Fundy is 1,112, the GDD during May and July may be around or smaller than 1,100. Thus, snowshoe hares there may get much benefit from warmer temperatures in this park. The same species, which changes their coat colors in winter, is less likely to be predated by coyotes in snow (Murray and Boutin, 1991), and the southern limit of this species' distribution corresponds to areas with notable snow cover (Murray, 2000). In contrast, great amounts of snow (depth > 30cm) could be detrimental for this species as well, according to an observation in interior Alaska (Olson and Euskirchen, 2010). This is probably because hares may be much less mobile in relation to their predators including coyotes in such snowy conditions (Olson and Euskirchen, 2010). Lynx is more likely to catch snowshoe hares in more hard-packed snow, which would be replaced by soft snow under warming climates (Stenseth et al., 2004). These information suggests that moderate amounts of soft snow (depth = 15-30 cm) are optimal for this species' survival. Generally, snowshoe hares are commonly seen in cedar bogs or coniferous forests in lowlands in the eastern side of this species' distribution (Banfield, 1976). Cheng et al. (2014) reported higher genetic diversity in populations in boreal forests than those in the other populations, indicating the importance of boreal habitats for this species. Overall, under moderate climate change scenario, summer temperature increase could be possibly positive and contribute to growth of the hare population. On the other hand, under severe climate change scenario, declines of boreal coniferous forests and also declines of snow accumulation will be more influential than the slightly positive effect of summer temperature increase. Thus, MV and PS were chosen under severe scenario.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of Canada lynx (*Lynx canadensis*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is able to cross multilane highways, but lowlands and urban areas are generally obstacles for lynxes particularly in western mountainous and southern areas in this species' distribution (Poole, 2003). However, the artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Fundy species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	Dispersal for long distances (> 1,000 km) is known with this species (Poole, 2003). In line with this, this species can move for 9 km/day in summer and 8 km/day on average in Cape Breton (Parker et al., 1983).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	This species is distributed from Alaska to the northern United States, but the southern limit of the distribution has receded northwards in the Maritimes and southern Ontario (Banfield, 1976; Koen et al., 2014). Very severe winter (e.g., < -35°C) could be fatal for lynx (Poole, 2003). Yet, this species' distribution in eastern North America corresponds with snowy areas where mean annual snowfall is larger than 268 cm (Hoving, 2001). So, temperature may be relatively irrelevant to this species' vulnerability, but no studies are available to confirm this idea.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD**	Generally, this species refrains from using waterbodies (Poole, 2003), though it can swim and cross rivers (Banfield, 1976). As well, in terms of its distribution range, lynx seems to avoid wet coastal forests in the western side of Canada (Poole, 2003).
C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-**SD**-Dec	Generally, this species prefers older regenerating stands (more than 20 yrs) than younger forests (Poole, 2003). In Cape Breton, this species tends to use advanced successional habitats of mixed forests (around 20 yrs after cutting) (Parker et al., 1983), and halted forest successions by moose are serious problems for lynx (Bridgland et al., 2007). More quantitatively, Parker et al. (1983) suggested a combination of 50% mature coniferous forests, 30% mature mixed forests, 12% successional forests and 8% wet areas for lynx in Cape Breton. In this

		regard, creating forest succession caused by forest harvesting and/or forest fires is beneficial for snowshoe hares and Lynxes (Parker et al., 1983; Paragi et al., 1997; Poole, 2003). Particularly in the southern edges of this species' distribution, suppressing fires could lead to decline of Lynx number (Mowat and Slough, 2003). Hoving et al. (2004) explained that this species is likely to inhabit early successional forests in northern Maine because its main feed, snowshoe hare, is distributed in such forests.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-**Inc**-SI-N	This species' distribution in eastern North America corresponds with snowy areas where mean annual snowfall is larger than 268 cm (Hoving, 2001). According to an observation in Yukon, this species travels in more snowy areas (snow depth ≈ 50-60 cm) than travel routes by coyotes (Murray et al., 1994). As well, deep snow might assist lynxes to predate deer (Fuller, 2004). Lynx is more likely to catch snowshoe hares in more hard-packed snow, which would be replaced by soft snow under warming climates (Stenseth et al., 2004).
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	No preference for certain geological features. Furthermore, this species can migrate for more than 100 km on average (Poole, 2003), suggesting its great ability to be compatible with various geological conditions.
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	Generally, this species prefers older regenerating stands (more than 20 yrs), such as *Picea*, *Pinus* and *Abies balsamifera* (Poole, 2003). Hoving (2001) described deciduous vegetation as inappropriate habitats for this species in eastern North America. In Cape Breton, this species inhabits mature coniferous forests during summer but advanced successional habitats of mixed forests (around 20 yrs after cutting) during winter (Parker et al., 1983). More quantitatively, Parker et al. (1983) suggested a combination of 50% mature confierous forests, 30% mature mixed forests, 12% successional forests and 8% wet areas for lynx in Cape Breton.
C4b (Diet)	**Inc**-**SI**-N-SD **Inc**-**SI**-N-SD	Snowshoe hare is a main food for lynx, and rarely white-tailed deer and ruffed grouse are also predated by lynx (Parker et al., 1983; Murray et al., 1994; Fuller, 2004). It is noteworthy, however, lynx predates more diverse foods in summer than in winter (Parker et al., 1983). As well, in more southern side of this species' distribution, greater variety of preys for this species could be expected (e.g., red squirrels) (Roth et al., 2007).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	Even lynx could be predated by coyotes (Poole, 2003). Also, bobcats might compete with lynx in Cape Breton (Parker et al., 1983; Poole, 2003). Interspecific hybridization between lynx and bobcat has been also confirmed in not only Minnesota but also New Brunswick (Schwartz et al., 2003; Homyack et al., 2008; Murray et al., 2008).
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	Lynx populations in eastern Canada were highly differentiated from those in other regions at mtDNA, but detailed information about intra-population variation in New Brunswick was not documented (Rueness et al., 2003).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6	Inc-SI-N-SD	

(Phenol response)	Inc-SI-N-SD				
D1 (Documented response)	**GI**-**Inc**-SI-N-SD-Dec **GI**-**Inc**-SI-N-SD-Dec	Warming regional climate in the last 20-30 years has decreased snow amounts, being negative for Canada lynxes but positive for bobcats in eastern North America (Hoving, 2001). Morris (1948) documented that Canada lynx populations in New Brunswick were nearly extirpated in 1940s already, though he did not mention possible effects of climate change on the observed population decline. This situation is still continued up to 2000s (Poole, 2003). More recently, a map-based modelling of this species' distribution, based on data of snowfall and deciduous cover, suggested that Fundy is outsides of likely occurrence areas of this species (Hoving et al., 2005).			
D2 (Modeled change)	GI-Inc-**SI**-N-SD-Dec GI-**Inc**-SI-N-SD-Dec	The lynx populations in New Brunswick are predicted to decline assuming smaller amounts of snowfall (Carroll, 2007).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	88	12	0
Severe scenario	0	0	88	12	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario					
Severe scenario					
	This species is distributed from Alaska to the northern United States, but the southern limit of the distribution has receded northwards in the Maritimes and southern Ontario (Banfield, 1976; Koen et al., 2014). Very severe winter (e.g., < -35°C) could be fatal for lynx (Poole, 2003). Yet, this species' distribution in eastern North America corresponds with snowy areas where mean annual snowfall is larger than 268 cm (Hoving, 2001). So, temperature may be relatively irrelevant to this species' vulnerability, but no studies are available to confirm this idea. Therefore, physiological thermal niche should be "unknown" in this assessment. Consequently, the MVA did not determine vulnerability/adaptability of the species.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of southern American marten (*Martes americana*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-**Inc**-**SI**-N GI-**Inc**-**SI**-N	The marten has been distributed in just northern region in New Brunswick, probably due to habitat changes by anthropogenic factors (Dilworth, 1974). The isolated distribution of marten in Fundy was also described by Carroll (2007). Parks Canada (2010d) also stated that Fundy National Park is not enough to protect this species with viable population size.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-Dec GI-Inc-SI-N-**SD**-Dec	A parent–offspring distance σ of this species is 3.8-7.25 km (Broquet et al., 2006). Its maximam dispersal distance is 40 km (Carroll, 2007).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	This species' distribution traverses north-central North America (circumboreal forests), being in a more northern side than the distribution of fishers (Banfield, 1976; Feldhamer et al., 2003; Krohn, 2012). Therefore, high temperature might be a partial reason for this distribution, but also the marten's distribution might be restricted by just boreal forest distribution. There have been no relevant studies to this issue.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	This species occurs in mesic, conifer-dominated forests (Banfield, 1976).
C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	Preferring old-growth forests but not burned-over or logged areas, though martens occasionally use the latter as well (Banfield, 1976; Bowman and Robitaille, 1997; Fisher and Wilkinson, 2005). Forest fires could seriously damage marten populations (Banfield, 1976). Halted forest successions by moose are serious problems for marten in Cape Breton (Bridgland et al., 2007). Also, any stochastic events including forest fire and excessive snowfall could be fatal for the small populations of this species in Cape Breton (Nova Scotia American Marten Recovery Team, 2006). However, such fires are unlikely to occur in Fundy, and therefore fire effects should not be overestimated.
C2d	GI-Inc-SI-**N**	Requiring deep snowpacks (Carroll, 2007; Wasserman et al., 2012). Being able to move more freely in deep

<table>
<tr><td>(Ice/Snow)</td><td>GI-**Inc**-SI-N</td><td colspan="4">snow than predators and/or competitors (Godbout and Ouellet, 2010; Krohn, 2012).</td></tr>
<tr><td>C3
(Physical habitat)</td><td>Inc-SI-N-**SD**-Dec
Inc-SI-N-**SD**-Dec</td><td colspan="4">No preference for certain geological features.</td></tr>
<tr><td>C4a
(Other spp for habitat)</td><td>GI-Inc-**SI**-N
GI-**Inc**-**SI**-N</td><td colspan="4">Preferring mature coniferous forests (Banfield, 1976; Godbout and Ouellet, 2010), particularly balsam firs and black spruces in Eastern Canada (Banfield, 1976). Marten is an indicator species of old spruce–fir forests (Betts et al., 2003). Because balsam fir as well as black spruce will be vulnerable to severe climate change scenario, not only “SI” but also “Inc” were chosen in this scenario.</td></tr>
<tr><td>C4b
(Diet)</td><td>Inc-**SI**-N-**SD**
Inc-**SI**-N-**SD**</td><td colspan="4">This species is an opportunistic predator which feeds on rodents, lagomorphs, birds, and sometimes insects, fruits, as well as seeds (Feldhamer et al., 2003). In implications for management of Fundy ecosystem, Rosenberg et al. (2003) suggested that martens are main predators of northern flying squirrels. In northern New Brunswick, 95% of total calories consumed by this species was consisted of snowshoe hares, grouses, and squirrels in early winter (Cumberland et al., 2001).</td></tr>
<tr><td>C4c
(Pollination)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C4d
(Other spp for disp)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="4"></td></tr>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="4">Its closely related species, fishers, can compete with and predate martens, possibly limiting the distribution of martens in the future with less snow (Krohn, 2012). Yet, it is also true that the both species have been already codistributed in New Brunswick.

· Climate change favors fishers rather than martens because of their flexibility. [Expert in Fundy]</td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4">· Genetically, the marten population might face a bottleneck effect. [Expert in Fundy]</td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4">The population in Fundy was artificially reintroduced (Thompson, 1991; Parks Canada, 2010d).</td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-**SI**-N-SD-Dec
GI-**Inc**-SI-N-SD-Dec</td><td colspan="4">Fundy National Park will be unlikely to be suitable habitats for this species with less snow under climate change (Carroll, 2007).</td></tr>
<tr><td rowspan="3">The CCVI [%]
Moderate Scenario
Severe scenario</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>100</td><td>0</td></tr>
<tr><td>0</td><td>68</td><td>32</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">The MVA**
Moderate Scenario</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Severe scenario					
	This species' distribution traverses north-central North America (circumboreal forests), being in a more northern side than the distribution of fishers (Banfield, 1976; Feldhamer et al., 2003; Krohn, 2012). Therefore, high temperature might be a partial reason for this distribution, but also the marten's distribution might be restricted by just boreal forest distribution. There have been no relevant studies to this issue. Therefore, physiological thermal niche should be "unknown" in this assessment. Consequently, although the marten is probably vulnerable to climate change, the MVA did not determine vulnerability/adaptability of the species.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was not determined due to a lack of information about physiological thermal niche.

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[Assessment sheet] Climate change vulnerability assessments of little brown bat (*Myotis lucifugus*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species could be still found in fragmented parks, because its high ability to utilize a wide variety of covers as habitats as well as move for long distances larger than 200 km (Johnson et al., 2008). However, it is also true that this species was more frequently found in forested areas than fragmented landscapes, probably due to effects of proximity to hibernacula (Johnson et al., 2008). According to a study in Alberta, this species inhabited transional zones between urban and rural areas, rejecting a possible benefits of urbanization on this species (Coleman and Barclay, 2011). However, the artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Fundy species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	This species could return to its homes by moving for long distances (possibly 122 km per five nights or 290 km per two years) (Banfield, 1976). Johnson et al. (2008) documented that this spcies could migrate for more than 200 km. As well, in Fundy National Park, some individuals of the same species traveled for more than 1.5 km to forage from their homes (Broaders et al., 2006), indicating a high dispersability of this species.
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD**	This species is distributed from Mexico to Alaska, though the subspecies of *M. l. lucifugus* is also extensively distributed except for western side of the Rockey Mountains (Banfield, 1976). Insects, which are main foods for little brown bat, vanish in winter, and also the bat is not morphologically adapted to cold winter (Banfield, 1976). Therefore, these bats migrate to large caves where they could hibernate at temperatures higher than around 4°C, in early November (Banfield, 1976). Humphries et al. (2002) showed that 2°C was the temperature at which this species requires the smallest amount of hibernation energy. According to Boyles and Willis (2010), warmer conditions (e.g., artificial heat refugia at 28°C) in hibernacula lead to higher survivals of bats that were infected with White-nose syndrome due to reduced energetic costs. As well, in summer, temperature was positively correlated with activity levels of this species in Fundy, probably because higher temperature could reduce thermoregulation costs but increase prey availability (Broders et al., 2006). Unexpectedly, average minimum temperature between April and October was not correlated with survival rate of this species in southern New Hampshire, but this result may be just due to limited interannual variability of temerature (Frick

		et al., 2010). Syme et al. (2001) also reported limited impacts of temporal global cooling caused by eruption on this species, attributing them to the use of sheltered roosts as well as feeding on aquatic insects.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	Cumulative precipitation between April and October was strongly and positively correlated with survival rate of this species, probably due to increased prey availability, in southern New Hampshire (Frick et al., 2010). Again, for foraging, the presence of waterbodies around sites of this species were positively correlated with activity levels of male bats in Fundy National Park (Broders et al., 2006). Frick et al. (2010) then forecasted that drier climates caused by climate change could be harmful on the bat species by limiting prey availability. Likewise, droughts are also deterimental for bat species which depend on flying insects (Rodenhouse et al., 2009).
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	White-nose syndrome has rapidly spread, leading to high mortality of the bat species (Frick et al., 2010). Furthermore, this disease could be dispersed by raccoons from cave to cave, though activity levels of raccoons are reduced during winter at northern latitudes like eastern Canada (McAlpine et al., 2011). Therefore, under warmer climates, such an effect of raccoons as pathogen vectors could be stronger in Fundy. However, be aware that, according to Boyles and Willis (2010), warmer conditions (e.g., artificial heat refugia at 28°C) in hibernacula lead to higher survivals of bats that were infected with White-nose syndrome due to reduced energetic costs. This positive effect of climate change on infected bats was reflected in the subfactor of C2aii, because the effect is mainly related to its physiological thermal niche.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-N-**SD**-**Dec** Inc-SI-N-**SD**-**Dec**	This species was originally distributed in forests during summer and caves during winter, but urban areas are now also available for this species to dwell (Banfield, 1976).
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	This species was originally distributed forests during summer and caves during winter, but urban areas are now also available for this species to dwell (Banfield, 1976). In Fundy National Park, coniferous trees and snags are relevant for roosting of male little brown bats (Broders and Forbes, 2004; Broders et al., 2006). The amount of mature deciduous forests around sites of such male bats were negatively correlated with their activity levels (Broders et al., 2006). In contrast, females of the same species utilize buildings around the park to roost (Broders and Forbes, 2004; Broders et al., 2006).
C4b (Diet)	Inc-SI-**N**-SD Inc-SI-**N**-SD	Insects, such as moths, beetles, and bugs, are main foods for this species (Banfield, 1976). Frick et al. (2010) proposed that these preys, like mosquitos, flies, and moths, could be more abundant under more wet conditions. In other words, this bat species heavily relies on aquatic emergent insects (Frick et al., 2010). On the other hand, by conducting meta-analysis across North America, Moosman et al. (2012) found the fact that such a bat species predates more beetles in more eastern sides of the species' distributions, where summer is moist.
C4c (Pollination)	Inc-SI-N Inc-SI-N	

<table>
<tr><td>C4d
(Other spp for disp)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4">Adams (2010) observed significant decline of reproductive outputs of this species with higher temperature in the Front Range of Colorado, though this observation may be attributed to impacts of less precipitation caused by climate change.</td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4">The northern limit of this species' distribution was predicted to expand northwards to 60°N or more north in 2080 by global warming (Humphries et al., 2002). According to their prediction, Fundy National Park would be too warm to hibernate for this species during future winters. Yet, it may be needed to discriminate survival and hibernation (i.e., unsuitable habitats for hibernation are not neccessarily linked to vulnerability of this species.).</td></tr>
<tr><td rowspan="3">The CCVI [%]
Moderate Scenario
Severe scenario</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>87</td><td>14</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>12</td><td>88</td></tr>
<tr><td rowspan="4">The MVA**
Moderate Scenario
Severe scenario</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td></td><td></td><td>-------------------------------</td><td>-------------------------------</td><td></td></tr>
<tr><td></td><td></td><td>-------------------------------</td><td>-------------------------------</td><td></td></tr>
<tr><td colspan="5">This species is distributed from Mexico to Alaska, though the subspecies of *M. l. lucifugus* is also extensively distributed except for western side of the Rockey Mountains (Banfield, 1976). Insects, which are main foods for little brown bat, vanish in winter, and also the bat is not morphologically adapted to cold winter (Banfield, 1976). Therefore, these bats migrate to large caves where they could hibernate at temperatures higher than around 4°C, in early November (Banfield, 1976). Humphries et al. (2002) showed that 2°C was the temperature at which this species requires the smallest amount of hibernation energy. According to Boyles and Willis (2010), warmer conditions (e.g., artificial heat refugia at 28°C) in hibernacula lead to higher survivals of bats that were infected with White-nose syndrome due to reduced energetic costs. As well, in summer, temperature was positively correlated with activity levels of this species in Fundy, probably because higher temperature could reduce thermoregulation costs but increase prey availability (Broders et al., 2006). Frick et al. (2010) forecasted that drier climates caused by climate change could be harmful on the bat species by limiting prey availability. Likewise, droughts are also deterimental for bat species which depend on flying insects (Rodenhouse et al., 2009). Adams (2010) observed significant decline of reproductive outputs of this species with higher temperature in the Front Range of Colorado, though this observation may be attributed to impacts of less precipitation caused by climate change. However, given that hydrological change will be limited in Fundy National Park and that there will be ample precipitation under changing climate, the bat</td></tr>
</table>

	population will be stable or possibly adaptable under changing climates. However, there is no evidence about strongly positive impacts of climate change on bat population growth, and therefore it was judged as just presumably stable or moderately adaptable.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was not determined due to a lack of information about physiological thermal niche.

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[Assessment sheet] Climate change vulnerability assessments of white-tailed deer (*Odocoileus virginianus*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species prefers feeding in disturbed and early successional forests (Russell et al., 2001). However, some road-kills of deer were also found in New Brunswick (Whitlaw et al., 1998). · This is Neutral not SI due to increased food availability from roadsides etc. [Expert in Kejimkujik]
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-**Dec** GI-Inc-SI-N-SD-**Dec**	In northern ranges, whitetails showed migration distances ranging from 6 to 23 km (Feldhamer et al., 2003), whereas female whitetails migrated for 18-168 km in northeastern Minnesota (Nelson and Mech, 1992). Some of male whitetails monitored to the end of their second fall moved for distances of around 19 km on average, but female whitails moved very little (Patterson et al., 1999). Also, at Canaan, which is close to Fundy, migrating deer moved for 13.7 km on average even in straight-line distance (Sabine et al., 2002).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD**	This species seems to be comfort in an ambient summer temperature ranging between 17 and 18°C (Holter et al., 1975), which is larger than the summer average temperature in Fundy (15.9°C). The most optimal winter temperature for this species is between 5 and 20 °C (Holter et al., 1975), whereas the winter average temperature in this park is -7.6°C. Moreover, cold temperature may increase the likelihood of depredation by coyotes (Feldhamer et al., 2003). Records in Nova Scotia showed that the individual number of this species increased after mild winter and decreased after severe winter (Patterson and Power, 2001). South facing slopes and gentle slopes are typical habitat characteristics for this species' wintering sites in New Brunswick (Boer, 1978). · I don't believe that deer will be as stressed by summer warmth to the point where it will outweigh the benefits from an increased winter temperature. [Expert in Kejimkujik]
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii	GI-Inc-SI-**N**-SD	No preference for certain hydrological features. Furthermore, this species can move for long distances (up to

(Physiological hydrological niche)	GI-Inc-SI-**N**-SD	168 km) (Nelson and Mech, 1992), suggesting its great ability to be compatible with various hydrological conditions.
C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-**SD**-Dec	This species prefers feeding in disturbed and early successional forests (Russell et al., 2001), and artificial fire experiments confirmed the fact that fires could contribute to browsing by deer (Dills, 1970). However, during winter, a combination of forest cover and browse is important for deer, and they choose mature mixedwoods (e.g., white spruce and balsam fir) rather than submature mixedwoods in New Brunswick (Boer, 1978; Morrison et al., 2002).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD Dec	Deep snow may increase the probability of depredation by coyotes (Feldhamer et al., 2003; Patterson and Messier, 2003) and occassionally lynxes (Fuller, 2004). Actually, whitetails tend to avoid snow depth larger than 35 cm by migration (Whitlaw et al., 1998; Brinkman et al., 2005).
C3 (Physical habitat)	Inc-SI-N-SD-**Dec** Inc-SI-N-SD-**Dec**	At high altitudes in New Brunswick, white-tailed deer are infrequent, partly due to its body shape which is not adaptive to heavy snow (> 40 cm) (Kelsall, 1969). Yet, such highlands are limited in Fundy National Park. South facing slopes and gentle slopes are typical habitat characteristics for this species' wintering sites in New Brunswick (Boer, 1978), likely in order to avoid cold temperature and heavy snow accumulation.
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species prefers feeding in disturbed and early successional forests (Russell et al., 2001). However, during winter, a combination of forest cover and browse is important for deer, and they choose mature mixedwoods (e.g., white spruce and balsam fir) rather than submature mixedwoods in New Brunswick (Boer, 1978; Morrison et al., 2002). As well, softwoods were previously believed to be important for this species during particularly severe winters, but a study in southern New Brunswick suggested that mixedwood stands may be more suitable for deer during less severe winters (Sabine et al., 2001). · It may be a stretch to say deer depend on other species- no obligation to other species. [Expert in Kejimkujik]
C4b (Diet)	Inc-**SI**-**N**-SD Inc-**SI**-**N**-SD	Foods eaten by white-tailed deer are varied depending on habitats and latitudes, and therefore whitetails are opportunistic, concentrate selectors (Feldhamer et al., 2003). Although acorns are important food for this species in oak forests in autumn, whitetails would be herbivorous generalists without such typical foods (Feldhamer et al., 2003). According to rumen analysis with deer in southern and central New Brunswick, they eat herbs and woody browse in spring but fruit and mast in summer/autumn seasons (Skinner and Telfer, 1974). Under warmer climates, availability of such foods will be improved. · More food does not make deer more vulnerable to climate change. [Expert in Kejimkujik] [Follow-up] It is true that more food does not make deer more vulnerable to climate change, and therefore only Neutral score was chosen in the MVA. However, the CCVI assessment tries to determine subscores based on resource specificity of assessed species. Here, to follow Young et al.'s protocol, the subscores of SI as well as N may need to be retained. Moreover, to reflect the possibility of increasing food under changing climates, SD should be chosen.

C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	Deer are predated by mainly coyotes (Feldhamer et al., 2003; Patterson and Messier, 2003) and occassionally lynxes (Fuller, 2004). Whitlaw et al. (1998) found this fact by an actual observation in northern and southern New Brunswick during 1994 and 1997.
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	0	100
Severe scenario	0	0	0	0	100
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario				-------------------------------	
Severe scenario				-------------------------------	-------------------------------
	This species seems to be comfort in an ambient summer temperature ranging between 17 and 18°C (Holter et al., 1975), which is larger than the summer average temperature in Fundy (15.9°C). The most optimal winter temperature for this species is between 5 and 20 °C (Holter et al., 1975), whereas the winter average temperature in this park is -7.6°C. Moreover, cold temperature may increase the likelihood of depredation by coyotes (Feldhamer et al., 2003). South facing slopes and gentle slopes are typical habitat characteristics for this species' wintering sites in New Brunswick (Boer, 1978). Also, deep snow may increase the probability of depredation by coyotes (Feldhamer et al., 2003; Patterson and Messier, 2003) and occassionally lynxes (Fuller, 2004). Actually, whitetails tend to avoid snow depth larger than 35 cm by migration (Whitlaw et al., 1998; Brinkman et al., 2005). In short, although the fact that this species might receive heat stress during summer season, warmer winter and less snow will positively influence survivals of deer. Therefore, this species will flourish under climate change at least moderately. As well, under severe climate change scenario, high adaptation could be also possible, because the severe winter in Fundy National Park will be much milder with less snow accumulation. Such a possibility was also supported by records in Nova Scotia, which showed that the individual number of this species increased after mild winter and decreased after severe winter (Patterson and Power, 2001).				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of raccoon (*Procyon lotor*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	Urban and suburban areas are available for this species (Feldhamer et al., 2003). Also, in a fragmented landscape in north-central Indiana, Dharmarajan et al. (2009) did not find genetic differentiations due to possible barriers like single-lane county roads. Rather, farming and forestry may have contributed to expansion of this species' distribution historically in North America (Rosatte, 2000).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-**Dec** GI-Inc-SI-N-**SD**-**Dec**	The largest dispersal distance of this species was much varied among previous studies (11-275 km), indicating difficulty of determining the distance (Feldhamer et al., 2003). According to a molecular parentage analysis by Cullingham et al. (2008), most raccoons dispersed for less than 3 km while a small proportion (< 4%) traveled for more than 20 km. McAlpine et al. (2011) considered the result of Cullingham et al. (2008) rather than rare long-distance dispersals (> 100 km) as typical movement scales of raccoons. Additionally, such movements may be suppressed in cold winters in northern areas, including eastern Canada (McAlpine et al., 2011). Yet, in north-central Indiana, around 10% of studied raccoons moved for 20 km or more (Dharmarajan et al., 2009).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	This species is distributed from southern Canada south to Mexico, while also succeeded in being introduced to elsewhere (e.g., Russia) (Banfield, 1976; Feldhamer et al., 2003). The subspecies of *P. l. lotor* is distributed in eastern Canada, but not central and northern Quebec, Newfoundland and Cape Breton (Banfield, 1976). Morris (1948) documented that New Brunswick is in the northern periphery of this species' distribution. Therefore, Fundy National Park should be also regarded as a northern limit of this species' range. In such northern part of the distribution, raccoons hibernate (in dens) during severe winters (Banfield, 1976; Feldhamer et al., 2003). In contrast, in mild or subtropical climates, raccoons often lose weights to lose heat by evaporative cooling during summer season (Feldhamer et al., 2003). However, under a relatively mild and stable climate like Florida, temperature is scarcely influential on population growth/decline of raccoon (Troyer et al., 2014).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	Originally, this species inhabits water-related areas, such as river valleys, bottomlands, and wetlands, being capable to swim well (Morris, 1948; Banfield, 1976; Rosatte, 2000; Feldhamer et al., 2003).

C2c (Disturbance)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	This species could experience flooding, because raccoons often inhabit riparian areas (Feldhamer et al., 2003).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	According to observations in Russia and Japan, deep snow troubles raccoons to move and find food, possibly contributing to mortality (Aliev and Sanderson, 1966; Ikeda et al., 2004).
C3 (Physical habitat)	Inc-SI-N-**SD**-**Dec** Inc-SI-N-**SD**-**Dec**	Originally, this species inhabits water-related areas, such as river valleys, bottomlands, and wetlands, being capable to swim well (Banfield, 1976; Feldhamer et al., 2003). In other words, uplands are avoided (Feldhamer et al., 2003), and a same distributional pattern was reported in New Brunswick (Morris, 1948).
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** SD GI-Inc-**SI**-**N** SD	Originally, this species inhabits forested areas near waterbodies (Morris, 1948; Banfield, 1976; Feldhamer et al., 2003). Dens in hollow trees of elms, maples, and basswoods are often utilized by this species (Banfield, 1976). Prince (1968) reported raccoon dens in elm and silver maple trees, both of which are dominant species in floodplain forests in central New Brunswick. In the MVA, because these tree species are generally adaptable to climate change, the subscore of SD was chosen.
C4b (Diet)	Inc-SI-N-**SD** Inc-SI-N-**SD**	This species is omnivorous, eating sweet corns, fruits, crayfish, insects, fish, frogs, and so on (Banfield, 1976). Seed ingestion by this species contributes to decreasing intraspecific competition and possibly inceasing seed germination rate of some plant species (Cypher and Cypher, 1999). In North America, this species is also known as a main predator feeding on eggs of songbirds, seasbirds, waterfowls, ducks, and turtles (Larivière, 2004). McAlpine et al. (2011) also observed consumption of bats by raccoons in New Brunswick.
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Generally, this species is likely to colonize new areas under warmer climates, in which richer food and longer growing season could be expected (Larivière, 2004).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	93	7
Severe scenario	0	0	0	31	69

The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario			-------------------------------	-------------------------------	
Severe scenario				-------------------------------	
	This species is distributed from southern Canada south to Mexico, while also succeeded in being introduced to elsewhere (e.g., Russia) (Banfield, 1976; Feldhamer et al., 2003). The subspecies of *P. l. lotor* is distributed in eastern Canada, but not central and northern Quebec, Newfoundland and Cape Breton (Banfield, 1976). Morris (1948) documented that New Brunswick is in the northern periphery of this species' distribution. Therefore, Fundy National Park should be also regarded as a northern limit of this species' range. In such northern part of the distribution, raccoons hibernate (in dens) during severe winters (Banfield, 1976; Feldhamer et al., 2003). In contrast, in mild or subtropical climates, raccoons often lose weights to lose heat by evaporative cooling during summer season (Feldhamer et al., 2003). However, under a relatively mild and stable climate like Florida, temperature is scarcely influential on population growth/decline of raccoon (Troyer et al., 2014). Therefore, temperature increase (and richer foods as well as longer growing periods) will be beneficial for this species to moderate degrees, while drastic benefits of climate change are unlikely to happen. Dens in hollow trees of elms, maples, and basswoods are often utilized by this species (Banfield, 1976). Prince (1968) reported raccoon dens in elm and silver maple trees, both of which are dominant species in floodplain forests in central New Brunswick. These tree species are then generally adaptable to climate change. In these regards, the class of MA was given under severe climate change scenario. Under moderate climate change scenario, in contrast, both PS and MA were chosen, because the effects of climate change might be unclear (at least so far, population growth of the species due to climate change has never been reported with scientific evidence).				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of eastern chipmunk (*Tamias striatus*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Given forest dependence of this species, chipmunks are likely to be influenced by forest fragmentation (Bowman and Fahrig, 2002). Also, roads are avoided by this species, likely leading to population subdivision (Ford and Fahrig, 2008). However, some empirical studies showed the fact that this species could move across forest gaps without troubles, detecting no isolation effects (Bowman and Fahrig, 2002). Mahan and Yahner (1998) also documented that this species originally inhabits mature deciduous forests despite the fact that it could also utilize forests which are damaged by cutting. According to the cited study, forest fragmentation did not bring about significant changes in population/individual conditions of this species in central Pennsylvania. The artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Fundy species.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Adult males of this species are sedentary during non-breeding seasons, but they become more mobile in breeding seasons to find females (Yahner, 1978). However, the movement distance is longer for summer breeding season (possibly > 200 m) than winter one (usually < 50 m) probably due to low intolerance of cold ambient temperatures (Yahner, 1978). Such movements for mating in morning are the largest locomotion of this species (Yahner, 1978). Munro et al. (2008) wrote that movements for longer than 250 m have never been reported with this species. However, male and female natal juveniles of this species disperse for 345 m and 85 m on average respectively (Loew, 1999).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	This species is distributed from the southern side of James Bay south to the Gulf of Mexico in eastern North America (Banfield, 1976). However, the subspecies of *T. s. lysteri* is confined to southern Ontario and the Maritimes, but not Newfoundland and Prince Edward Island (Banfield, 1976). Given low intolerance of cold ambient temperatures (Yahner, 1978), however, warming climates may be partly beneficial for this species.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	

C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	In comparison with yellow pine chipmunks (*Tamias amoenus*), Vander Wall and Jenkins (2011) stated that eastern chipmunk is a species inhabiting mesic deciduous forests. However, dry hardwood forests are considered to be suitable habitats for this species (Banfield, 1976). Rivers could be major barriers for this species' dispersal (Chambers and Garant, 2010).
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	This species originally inhabits mature deciduous forests, but it could also utilize forests which are damaged by cutting (Mahan and Yahner, 1998). In New Brunswick, this species inhabits small hardwood forests which are close to cleared lands (Morris, 1948).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-**N**	According to Vander Wall and Jenkins (2011), the distribution range of eastern chipmunk includes areas with different levels of snow. Snow could be, however, marginally positive for population growth of this species in the Appalachian Plateau of Pennsylvania, likely because snow could insulate against cold temperature to burrows where this species overwinters (Merritt et al., 2001).
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** SD GI-Inc-**SI**-**N** SD	Dry hardwood (deciduous) forests, such as oaks, beeches, and maples, are suitable habitats for this species (Banfield, 1976; Mahan and Yahner, 1998; Munro et al., 2008). A strong association between chipmunk and deciduous forests in North America since the Last Glacial Maximum was also supported by mitochondrial DNA analyses (Rowe et al., 2006). In particular, various structures covering grounds (e.g., stumps, rocks, and bushes) are useful for this species (Banfield, 1976). In contrast, Yahner (1978) proposed that, because this species is diurnal and depending on vision, habitats with many herbaceous and understory plants are avoided. In New Brunswick, this species inhabits small hardwood forests that are close to cleared lands (Morris, 1948). In the MVA, because the aforementioned tree species are generally adaptable to climate change, the subscore of SD was chosen.
C4b (Diet)	Inc-**SI**-N-**SD** Inc-**SI**-N-**SD**	This species eats various foods including seeds, fruits, nuts, green leaves, and a number of animals (Banfield, 1976; Yahner, 1978). However, there is much seasonal variation in the diets, and Mahan and Yahner (1998) as well as Munro et al. (2008) documented that hard mast (i.e., acorns) are crucial for this species from fall to early spring. Mahan and Yahner (1998) observed low body weights of this species in just 1993, ascribing the result to a poor mast crop in the autumn in 1992. Furthermore, northern populations are more likely to suffer from a limited number of foods and/or masting failure (Munro et al., 2008). For instance, since oak trees are rare in Fundy National Park due to its cool climate, chipmunks cannot depend on oak acorns in this park. Such a situation will be improved under new climates, and only SD was given in the MVA to reflect such positive impact of climate change on dietary resource.
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e	Inc-SI-**N**	

(Other spp interaction)	Inc-SI-**N**				
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	This species has colonized from refugia which were situated in multiple sites in North America after the Last Glacial Maximum, according to mitochondrial DNA analyses (Rowe et al., 2004 and 2006). However, there have been no studies examining populations of this species in New Brunswick yet.			
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N				
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD				
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	According to a simulation in the United States in consideration of associated vegetation distributions, chipmunks will not be much sensitive to influences of doubling of CO_2 concentrations (Johnston and Schmitz, 1997). The populations may be retained and expanded westwards from the current position in the United States (Johnston and Schmitz, 1997).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	100	0
Severe scenario	0	0	2	83	15
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario			-------------------------------	-------------------------------	
Severe scenario				-------------------------------	
	This species is distributed from the southern side of James Bay south to the Gulf of Mexico in eastern North America (Banfield, 1976). However, the subspecies of *T. s. lysteri* is confined to southern Ontario and the Maritimes, but not Newfoundland and Prince Edward Island (Banfield, 1976). Given low intolerance of cold ambient temperatures (Yahner, 1978), however, warming climates may be partly beneficial for this species. Dry hardwood (deciduous) forests, such as oaks, beeches, and maples, are suitable habitats for this species (Banfield, 1976; Mahan and Yahner, 1998; Munro et al., 2008). A strong association between the chipmunk and deciduous forests in North America since the Last Glacial Maximum was also supported by mitochondrial DNA analyses (Rowe et al., 2006). In particular, various structures covering grounds (e.g., stumps, rocks, and bushes) are useful for this species (Banfield, 1976). In contrast, Yahner (1978) proposed that, because this species is diurnal and depending on vision, habitats with many harbaceous and understory plants are avoided. In New Brunswick, this species inhabits small hardwood forests which are close to cleared lands (Morris, 1948). The aforementioned tree species are then generally adaptable to climate change. For instance, since oak trees are rare in Fundy National Park due to its cool climate, chipmunks cannot depend on oak acorns in this park now. However, it means that chipmunk population will grow, when red oak flourish in the park due to warmer climates. Hence, although there is no clear evidence about positive impacts of climate change on the species, it will possibly flourish with temperate hardwood tree species under climate change. However, high adaptation, like instant increase of deer after mild winter, has not been reported or considered with chipmunk. Less snow accumulation will not be positive for the species' adaptation, if not negative. Therefore, HV was not chosen for chipmunk.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are

the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.
**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of red squirrel (*Tamiasciurus hudsonicus*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
B2a (Natural barriers)	GI-Inc-SI-N GI-Inc-SI-N	
B2b (Artificial barriers)	GI-Inc-SI-N GI-Inc-SI-N	Road kills of red squirrels were reported in Nova Scotia (Fudge et al., 2007). However, in the southern boreal mixedwood zone of north-central Saskatchewan, Bayne and Hobson (2000) found significantly more abundant red squirrels in fragmented forests than continuous forests. These artificial barriers outside national parks should not be generally considered here according to the expert consulation in Kejimkujik National Park, unless assessed species require wide-range habitats. Thus, the subcore in this subfactor was determined neutral even for Fundy species.
B3 (CC mitigation)	Inc-SI-N-SD-Dec Inc-SI-N-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	In Alberta, most adults out of their original territories were within their neighborhoods by intervals of up to 135 m (Larsen and Boutin, 1994). In contrast, the largest long-distance movement of this species was documented as around 1.61 km (Bowman et al., 2002). As well, Francl et al. (2010) stated 4 km/yr was the possibly largest migration distance of the same species.
C2ai (Historical thermal niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	This species is distributed from Alaska to southern Arizona and New Mexico, whereas the subspecies *of T. h. gymnicus* is in just the Maritimes and Quebec (south of the St Lawrence River) (Banfield, 1976; Feldhamer et al., 2003). According to Pauls (1978), red squirrels in Winipeg showed more locomotive activities outside their nests in warmer temperatures (tested temperatures: -30 to +30 °C). Increase of spring temperature was positive on breeding success of the same species, at least in the range between 4 to 7°C in Yukon (Descamps et al., 2008). However, these results were inconsistent with another study conducted in a laboratory where red squirrels were more active in cooler conditions (tested temperatures: 10-35°C) (Clarkson and Ferguson, 1972).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2c	Inc-SI-N-SD-Dec	This species is associated with climax coniferous forests (Banfield, 1976; Vernes, 2004). In contrast, according

(Disturbance)	Inc-**SI**-N-SD-Dec	to a study of *T. h. grahamensis* in southeastern Arizona, most red squirrels survived forest ground fires (Koprowski et al., 2006). Yet, such fire-tolerance may not be relevant in Fundy, where forest fires are unlikely to occur.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	White spruce buds are predated by red squirrels during deep-snow periods, when other food is not available, though the same species in interior Alaska could access to cone supplies via open tunnel systems (Smith, 1968). Therefore, snow sometimes hinder access to foods for red squirrels.
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	
C4a (Other spp for habitat)	GI-Inc-**SI**-N GI-**Inc**-**SI**-N	This species could inhabit both boreal coniferous forests as well as hardwood deciduous forests, though it prefers mixed forests including white pines and hemlocks on north-facing slopes (Banfield, 1976). Vernes (2004) suggested that this species was associated with mature coniferous forests as well. · Red squirrels tie to spruce. [Expert in Fundy] [Follow-up] Because spruce species were judged as mostly HV under severe climate change scenario, both Inc and SI were chosen here under the same scenario.
C4b (Diet)	Inc-SI-**N**-**SD** Inc-SI-**N**-**SD**	This species could eat a wide variety of foods, including conifer cones (e.g., pines and spruces), hardwood nuts, buds, flowers, fleshy fruits, bark, mashrooms and tree sap (Banfield, 1976; Feldhamer et al., 2003). Furthermore, larvaes of spruce bark beetle are predated by red squirrels, providing around 20% of total energy requirements in Yukon Territory (Pretzlaw et al., 2006). Such a dietary change is likely to have been led by climate change (Pretzlaw et al., 2006). Based on an observation New Brunswick, Vernes et al. (2004) documented that fungus (at least 19 fungus species) could be key food resources for red squirrels especially when other foods are hard to obtain. Furthermore, caches of jack pine seeds by red squirrels were reported in two plantations in southern New Brunswick (Setterington and Keppie, 1997).
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	This species could compete with northern flying squirrels (*Glaucomys sabrinus*) (Pyare et al., 2010).
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	This species in Yukon showed advanced timing of breeding by 18 days over the last decade, when spring temperature has increased, by plastic and genetic changes (directional selection) (Reale et al., 2003). However,

		the genetic change was not based on molecular evidences and may have been overestimated (Postma, 2006).			
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	This species was forecasted to disappear in mid latitudinal areas of the United States, such as Great Smoky Mountains, Shenandoah, and Zion National Parks, due to climate change (Burns et al., 2003). As well, global warming was supposed to lower habitat quality of coniferous forests for red squirrels, and such a change in combination with reduced genetic variations could threat the persistence of squirrel populations (Ditto and Frey, 2007).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	100	0
Severe scenario	0	0	0	100	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario					
Severe scenario					
	This species is distributed from Alaska to southern Arizona and New Mexico, whereas the subspecies *of T. h. gymnicus* is in just the Maritimes and Quebec (south of the St Lawrence River) (Banfield, 1976; Feldhamer et al., 2003). According to Pauls (1978), red squirrels in Winipeg showed more locomotive activities outside their nests in warmer temperatures (tested temperatures: -30 to +30 °C). Increase of spring temperature was positive on breeding success of the same species, at least in the range between 4 to 7°C in Yukon (Descamps et al., 2008). However, these results were inconsistent with another study conducted in a laboratory where red squirrels were more active in cooler conditions (tested temperatures: 10-35°C) (Clarkson and Ferguson, 1972). Therefore, physiological thermal niche should be "unknown" in this assessment. Consequently, the MVA did not determine vulnerability/adaptability of the species.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of black bear (*Ursus americanus*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B2b (Artificial barriers)	GI-Inc-**SI**-N GI-Inc-**SI**-N	Bears are not affected by not busy roads, but they still refrain from crossing main roads where more than 10,000 vehicles run per day (Macmichael, 2007; Robinson et al., 2010). As well, Landry et al. (2001) and Parks Canada (2010d) indicated that wilderness areas around national parks in Atlantic Canada are crucial for maintaining bear populations due to this species' wide minimum critical area.
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-**Dec** GI-Inc-SI-N-**SD**-**Dec**	According to a genetic study, a male bear killed in Texas is likely to have migrated across 300 km from New Mexico (Onorato et al., 2004). Such high mobility of males was confirmed by other studies as well (e.g. 15-68 km in Costello (2010)), but females are less mobile, settling within 0-7 km from their home ranges (Costello, 2010).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	This species is found in forested regions in 39 states of the United States, 11 Canadian provinces and territories, and some parts of Mexico (Feldhamer et al., 2003).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	No preference for certain hydrological features.
C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-**SD**-Dec	This species' preference to early/late successional habitats could be altered depending on seasons and/or places. For instance, early-successional habitats created by logging or fire are preferred during summer, whereas mature forests are preferred during autumn and winter (USDA, n.d.). Also, black bears in post-fire places could consume more vegetation and/or moose calves, leading to better growth and reproduction (Schwartz and Frantzmann, 1991; USDA, n.d.).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-**N**	According to a study in west-central Idaho, due to insulative effect of snow cover and/or moist soils sustained by snow cover, American bear tends to select north-facing slopes to overwinter (in dens) (Beecham et al.,1983).

		However, Hayes and Pelton (1994) pointed out that slope aspect that bears chose was different among previous case studies, possibly depending on availability of dens. Therefore, the positive effect of snow cover for American bear is not clear.
C3 (Physical habitat)	Inc-SI-N-**SD**-**Dec** Inc-SI-N-**SD**-**Dec**	No preference for certain geological features. Furthermore, according to a genetic study, a male bear killed in Texas is likely to have migrated across 300 km from New Mexico (Onorato et al., 2004). Such high mobility of males was confirmed by other studies as well (e.g. 15-68 km in Costello (2010)), suggesting its great ability to be compatible with various geological conditions.
C4a (Other spp for habitat)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	This species' preference to early/late successional habitats could be altered depending on seasons and/or places. For instance, early-successional habitats created by logging or fire are preferred during summer, whereas mature forests are preferred during autumn and winter (USDA, n.d.).
C4b (Diet)	Inc-**SI**-N-**SD** Inc-**SI**-N-**SD**	This species is omnivorous and opportunistic predators of ungulate (Banfield, 1974; Zagar and Beecham, 2006). More specifically, fruits and seeds, are the main resources (Beeman & Pelton, 1980). Availability of nuts, produced by oak and beech, during autumn season is crucial for black bear populations (Beeman & Pelton, 1980; Elowe & Dodge, 1989). Yet, since oak trees are rare in Fundy National Park due to its cool climate, bears cannot depend on oak acorns in this park. As well, beeches in the park have been weakened by beech barck canker disease, and consequently bears have been unable to depend on these trees as food resources (Parks Canada, 2010d). Alternatively, they forage to blueberry fields, apple orchards, and bait stations around this park (Parks Canada, 2010d). In New Brunswick, black bear is also an important predator of deer neonates (Whitelaw et al., 1998; Ballard et al., 1999). To show such specific dietary preference, not only SD but also SI were chosen for the CCVI calculation. However, under warming climates, most of these foods will flourish but not decline (c.f., assessment result of oak, beech, and deer). Thus, in the MVA, only SD was chosen.
C4c (Pollination)	Inc-SI-N Inc-SI-N	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-**SI**-**N**-SD Inc-**SI**-**N**-SD	According to a study analyzing mtDNA of bear populations throughout North America at macro-scale, a population in Fundy showed smaller gene diversity in comparison with its adjacent populations in Quebec (LMNP) and Newfoundland (TNNP) (Wooding and Ward, 1997). However, sample number was limited (around ten from each population). As well, the authors wrote that such genetic diversity at mtDNA might be different from that at nuclear loci, given the fact that mtDNA in bears are inherited just by maternally. In their view, male bears are more likely to disperse and contribute to mixing among populations. In this sense, nuclear DNA may show more homogeneous genetic structures. This idea was supported by a study in Ontario (Pelletier et al., 2011).

C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N				
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD				
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	100	0
Severe scenario	1	5	45	50	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario			------------------------------	------------------------------	
Severe scenario			------------------------------	------------------------------	
	This species is omnivorous and opportunistic predators of ungulate (Banfield, 1974; Zagar and Beecham, 2006). More specifically, fruits and seeds, are the main resources (Beeman & Pelton, 1980). Availability of nuts, produced by oak and beech, during autumn season is crucial for black bear populations (Beeman & Pelton, 1980; Elowe & Dodge, 1989). Yet, since oak trees are rare in Fundy National Park due to its cool climate, bears cannot depend on oak acorns in this park. As well, beeches in the park have been weakened by beech barck canker disease, and consequently bears have been unable to depend on these trees as food resources (Parks Canada, 2010d). Alternatively, they forage to blueberry fields, apple orchards, and bait stations around this park (Parks Canada, 2010d). In New Brunswick, black bear is also an important predator of deer neonates (Whitelaw et al., 1998; Ballard et al., 1999). In other words, given that red oak will flourish under warmer climates, such vegetational change will possibly lead to richer food resources for bear in Fundy National Park. However, there will be no directly positive effect of climate change on bear in terms of its thermal niche. High adaptation, like instant increase of deer after mild winter, has not been reported or considered with American bear. Therefore, both of PS and MA, but not HA, were given for bear under the both climate change scenarios.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of balsam fir (*Abies balsamea*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	The northern part in Fundy National Park is highlands, and therefore slopes may hinder migration of the species to northern and higher areas in the future. However, the topography is not much steep as well. To reflect this partial barrier, SI and N were selected here. These scores were also retained in the MVA, reflecting kind of adaptation opportunity (note that the same species without any highlands should be assessed with more negative scores like Inc due to lack of adaptation opportunity).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	A maximum seed dispersal distance of this species is around 160 m, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-**N**-SD GI-**Inc**-**SI**-N-SD	Fir stands are known to be distributed in relatively cold sites, such as highlands and the coolest coastal areas, whereas red spruce and yellow birch often dominate in a little warmer sites in Eastern Canada (Clayden et al., 2011). This species has been extensively distributed in Fundy National Park (Burzynski et al., 1986; Parks Canada, 2010d). The annual mean temperature of the entire species' range, 2.9°C (range: -5.3 to 11.9°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.5°C. This species grows best under the average summer temperature of around 21°C or below (Fowells, 1965), while the summer temperature in Fundy National Park is 15.9°C. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the middle of the species' distribution, but it will be hotter than the warmer limit of the distribution under severe climate change scenario (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	This species generally grows in a cold and moist condition, and particularly seed germination and seedling growth are sensitive to dry summer weather (Fowells, 1965). Pardy (1997) reported that balsam fir could be observed in both drier and wetter sites in Cape Breton. In contrast, in Quebec, black spruce is likely to replace balsam fir in extreme conditions, such as dry and coarse deposits or humid organic deposits (Messaoud et al., 2007). Given that this species has been extensively distributed in Fundy (Burzynski et al., 1986), a little drier

		conditions in the future will be somewhat negative or irrelevant to this species' vulnerability.
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	This species is shade tolerant and much susceptible to windfall and fire (Fowells, 1965; Achim et al., 2005; Scheller and Mladenoff, 2005). Yet, Telfer (2004) recorded remarkable regeneration of this species in forest gaps which were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. In Quebec, this species was confined to riversides or lakesides, which could buffer influences of fires (Messaoud et al., 2007). However, in perhumid fir forests like the foggy coastal area of the Bay of Fundy, insect epidemics, fungal diseases and/or wind are more likely to regulate population demography than fires (Clayden et al., 2011). According to 585 plots in New Brunswick, mortality of balsam fir forests was ascribed to mainly blowdown (Taylor and MacLean, 2005; 2007). As well, spruce budworm outbreaks could reduce growth of this species and finally kill it in New Brunswick (Ostaff and MacLean, 1989), and such budworm deofoliation may be more intense in moist/rich conditions than wet/poor conditions (MacKinnon and MacLean, 2003).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	Generally, balsam fir grows on Podzol, Podzolic, Gray Wooded or gley, covering silt loams and stony loams (Fowells, 1965). This species is likely to distribute at pH ranging between 4.0 and 6.0 (Fowells, 1965). Organic matters could lead dominance of black spruce rather than balsam fir (Messaoud et al., 2007).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is shade tolerant (Fowells, 1965; Achim et al., 2005; Scheller and Mladenoff, 2005).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated.
C4d (Other spp for disp)	Inc-**SI**-**N** Inc-**SI**-**N**	This is a wind-dispersed species, but rodents spread its seeds as well (Fowells, 1965).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-**Inc**-SI-N-SD-Dec **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural

		Resources Canada, 2014).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	100	0	0
Severe scenario	0	30	70	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario		-------------------------------			
Severe scenario	-------------------------------	-------------------------------			
	Fir stands are known to be distributed in relatively cold sites, such as highlands and the coolest coastal areas, whereas red spruce and yellow birch often dominate in a little warmer sites in Eastern Canada (Clayden et al., 2011). This species has been extensively distributed in Fundy National Park (Burzynski et al., 1986; Parks Canada, 2010d). The annual mean temperature of the entire species' range, 2.9°C (range: -5.3 to 11.9°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.5°C. This species grows best under the average summer temperature of around 21°C or below (Fowells, 1965), while the summer temperature in Fundy National Park is 15.9°C. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the middle of the species' distribution, but it will be hotter than the warmer limit of the distribution under severe climate change scenario (c.f., Appendix). Because other subfactors could also be relevant to the species' survival but not be strongly linked to climate change, temperature increase will be the most relevant to the fir in the context of climate change in Fundy National Park. The MVA classes were given following the subscores of the subfactor of C2aii.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of red maple (*Acer rubrum*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	The northern part in Fundy National Park is highlands, and therefore slopes may hinder migration of the species to northern and higher areas in the future. However, the topography is not much steep as well. To reflect this partial barrier, SI and N were selected here. These scores were also retained in the MVA, reflecting kind of adaptation opportunity (note that the same species without any highlands should be assessed with more negative scores like Inc due to lack of adaptation opportunity).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species can regenerate by sprouting after cutting and often observed in post-harvest sites in New Brunswick (Franklin et al., 2000; Veinotte et al., 2003).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Sugar maple seeds can be dispersed for around 100 m but rarely beyond 5 km (He and Mladenoff, 1999; Clark et al., 2003). This species may have spread at the pace of 80-90 m/yr (McLachlan et al., 2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD** Dec	This species has been extensively distributed in Fundy (Burzynski et al., 1986; Parks Canada, 2010d). However, the annual mean temperature of the entire species' range, 10.8°C (range: -0.3 to 23.9°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.5°C. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently close to cooler limit of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	Although this species is often observed in extreme soil-moisture conditions, either very wet or very dry (Fowells, 1965), multiple studies suggested that it somewhat prefers swamps, riversides and moist soils (Fowells, 1965; Farrar, 1995; Boland, 2012). Saeki et al. (2011) documented that swamps and wet/mesic upland forests were primary habitats for this species before European settlement in North America but that even dry upland forests are also included in current (i.e., post- European settlement) habitats. This species is extensively distributed in Fundy (Burzynski et al., 1986).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species was regarded as being weak for fire damage (Fowells, 1965), though fires are not expected to occur frequently in Fundy. Also, disturbances (e.g., fire, hurricanes) have contributed to an increasing number of red maple trees (Walter & Yawney, 1990; Saunders, 1996), probably because red maple is an

		early-successional colonist with wind-dispersed samaras (McLachlan et al., 2005). In support of this, this species can regenerate by sprouting after cutting and often observed in post-harvest sites in New Brunswick (Franklin et al., 2000; Veinotte et al., 2003).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N** SD	This species is not resilient to damages of ice and snow (Fowells, 1965).
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	Saeki et al. (2011) documented that swamps and wet/mesic upland forests were primary habitats for this species before European settlement in North America but that even dry upland forests are also included in current (i.e., post-settlement) habitats. In other words, such a habitat generalist trait has led to a wide spread distribution of this species (Saeki et al., 2011). In New Brunswick, this species is common in swamps and alluvial lowlands as well as moist uplands.
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species can tolerate moderately to shade environments (Farrar, 1995) and can grow in combination with more than 70 commercial tree species (Fowells, 1965).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-**SI**-**N** Inc-**SI**-**N**	This species was supposed to be just wind-pollinated, but insects could help its pollination (USDA, 2011).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Wind-dispersed species (Fowells, 1965).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	A habitat generalist trait of this species has led to a wide spread distribution in the past, being reflected in high diversity of chloroplast haplotypes throughout this species' range (Saeki et al., 2011). However, there is insufficient information about genetic variation within maple populations in New Brunswick yet.
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-**SD**-Dec GI-Inc-**SI**-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	90	10
Severe scenario	0	0	0	12	88
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario				------------------------------	

Severe scenario					-------------------------------
	This species has been extensively distributed in Fundy (Burzynski et al., 1986; Parks Canada, 2010d). However, the annual mean temperature of the entire species' range, 10.8°C (range: -0.3 to 23.9°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.5°C. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently close to cooler limit of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). This species was regarded as being weak for fire damage (Fowells, 1965), though fires are not expected to occur frequently in Fundy. Also, disturbances (e.g., fire, hurricanes) have contributed to an increasing number of red maple trees (Walter & Yawney, 1990; Saunders, 1996), probably because red maple is an early-successional colonist with wind-dispersed samaras (McLachlan et al., 2005). In support of this, this species can regenerate by sprouting after cutting and often observed in post-harvest sites in New Brunswick (Franklin et al., 2000; Veinotte et al., 2003). This species is not resilient to damages of ice and snow (Fowells, 1965). Hence, although this maple species has been already common, it will flourish under climate change due to temperature increase, disturbances, and less snow accumulation. To reflect such adaptability, MA and HA were given for the species under moderate and severe climate change scenarios respectively.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of sugar maple (*Acer saccharum*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	The northern part in Fundy National Park is highlands, and therefore slopes may hinder migration of the species to northern and higher areas in the future. However, the topography is not much steep as well. To reflect this partial barrier, SI and N were selected here. These scores were also retained in the MVA, reflecting kind of adaptation opportunity (note that the same species without any highlands should be assessed with more negative scores like Inc due to lack of adaptation opportunity).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Sugar maple seeds can be dispersed for around or more than 100 m (Johnson, 1988; He and Mladenoff, 1999). A maximum seed dispersal distance of this species is around 200 m, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** Dec GI-Inc-SI-N-**SD** Dec	This species has been extensively distributed in Fundy National Park (Burzynski et al., 1986; Parks Canada, 2010d). However, the annual mean temperature of the entire species' range, 7.5°C (range: -0.4 to 19.5°C) (Natural Resources Canada, 2014), is higher than the mean temperature of the park, 4.5°C. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently close to the cooler limit of the species' distribution, and it will be in the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	Generally, preferring moist and well-drained soils (Fowells, 1965; Farrar, 1995). River floodplains and stream banks are primary habitats for this species (Saeki et al., 2011). This species has been extensively distributed in Fundy National Park (Burzynski et al., 1986). Phillips (2009) proposed that this species in southern New Brunswick would experience more drought stress due to increased evapotranspiration as well as decreased summer precipitation in the future.
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	This species was previously regarded as just a late-successional species, and its seedlings has decreased after some burnings (Swan, 1970). Some shade is needed for this species, and its seedlings may dry out without any

		shade (Betts and Forbes, 2005). However, the latest studies observed that it is able to regenerate competitively after disturbances like hurricanes, forest fires and clear-cuttings, indicating this species as a trans-successional species (Nolet et al., 2008; Vargas-Rodriguez and Platt, 2012).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-**Inc**-**SI**-N	Snow could significantly assist this species to avoid fires and also enjoy moist conditions (Henne et al., 2007). Snow removal could be harmful on sugar maple, urging replacement of this species by other tree species (Comerford et al., 2012). Also, Phillips (2009) proposed that less snow around the Bay of Fundy would lead to more frequent thaw/freeze damage for this species.
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	Generally, river floodplains and stream banks are primary habitats for this species (Saeki et al., 2011). This species can thrive on all soil types in either of acid or alkaline, if these soils are rich, moist and well drained (Fowells, 1965). In other words, this speices is intolerant of nutrient stress (Smith, 1998). More locally, this species is observed frequently on rocky/upland woods with rich soils (Hinds, 2000).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is exceeding in shade-tolerance among hardwoods (except American beech) (Godman et al., 1990; Smith, 1998; Nolet et al., 2008). However, a congeneric species, *Acer platanoides*, has invaded in the northeastern part of North America including New Brunswick from Europe, showing greater colonization than sugar maple (Meiners, 2005).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-**SI**-**N** Inc-**SI**-**N**	This species was supposed to be bee-pollinated, but recently this species is likely to pollinate without the helps of insects (Godman et al., 1990).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Wind-dispersed species (Fowells, 1965). Although its postdispersed seeds are predated by small mammals like eastern chipmunks, seed dispersal by these animals have not been confirmed (Hsia and Francl, 2009).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-**N**-SD Inc-SI-**N**-SD	A population of this species in Fundy National Park showed comparable heterozygosity with those of other examined populations without any significant differences (Young et al., 1993). Saeki et al. (2011) stated that limited diversity of this species' chloroplast haplotypes throughout the species' range could be attributed to its restricted geographic range during Last Glacial Maximum without vast coastal plains.
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-**SI**-N-SD-Dec GI-Inc-**SI**-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely

Moderate Scenario	0	0	0	100	0
Severe scenario	0	0	50	50	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario				-------------------------------	-------------------------------
Severe scenario				-------------------------------	
	This species has been extensively distributed in Fundy National Park (Burzynski et al., 1986; Parks Canada, 2010d). However, the annual mean temperature of the entire species' range, 7.5°C (range: -0.4 to 19.5°C) (Natural Resources Canada, 2014), is higher than the mean temperature of the park, 4.5°C. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently close to the cooler limit of the species' distribution, and it will be in the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). Snow could significantly assist this species to avoid fires and also enjoy moist conditions (Henne et al., 2007). Snow removal could be harmful on sugar maple, urging replacement of this species by other tree species (Comerford et al., 2012). Also, Phillips (2009) proposed that less snow around the Bay of Fundy would lead to more frequent thaw/freeze damage for this species. Therefore, although temperature increase may be beneficial for this species' survival, less snow cover will be damaging to the same species species in this park. The positive effect of thermal change was considered to be more relevant than the negative impact of less snow accumulation, but this maple species will be more adaptable to moderate climate change scenario than severe climate change scenario.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of yellow birch (*Betula alleghaniensis*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	The northern part in Fundy National Park is highlands, and therefore slopes may hinder migration of the species to northern and higher areas in the future. However, the topography is not much steep as well. To reflect this partial barrier, SI and N were selected here. These scores were also retained in the MVA, reflecting kind of adaptation opportunity (note that the same species without any highlands should be assessed with more negative scores like Inc due to lack of adaptation opportunity).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD -Dec	A maximum seed dispersal distance of this species is around 400 m, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-SI-**N**-**SD**	This species has been extensively distributed in Fundy National Park (Burzynski et al., 1986; Parks Canada, 2010d). Hinds (2000) described that this species inhabits commonly cool places in New Brunswick. However, the annual mean temperature of the entire species' range, 5.0°C (range: -0.7 to 17.9°C) (Natural Resources Canada, 2014), is similar to the mean temperature of the park, 4.5°C. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the cooler side of the species' distribution, and it will be in the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species is distributed on moist soils (Farrar, 1995; Hinds, 2000), being extensively distributed in Fundy National Park (Burzynski et al., 1986). In less moist sites, yellow birch is likely to be replaced by other tolerant species gradually (Fowells, 1965). Also, droughts can be critical for germination and seedling development of this species (Jackson and Booth, 2002).
C2c (Disturbance)	Inc-**SI**-N-**SD**-Dec Inc-**SI**-N-**SD**-Dec	This species could occur at any point of forest successions, but it is regarded as a climax species (Fowells, 1965). However, disturbances to some degrees (including fire and windthrow) in forest floor are beneficial for germination of this species (Fowells, 1965; Betts and Forbes, 2005). Windthrow is important to maintain this species' occurrence (Schulte and Mladenoff, 2005). Small forest gaps are also helpful for development of this

		species' seedlings (Fowells, 1965). This species may be injured in forest fire (Fowells, 1965), though frequent forest fires are not plausible in this park.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-**Inc**-**SI**-N	Secondary seed dispersal of this species on snow allows it to move for hundreds of feet from mother trees (Fowells, 1965: Saunders, 1996). As well, early spring thaw-freeze events have led to dieback of yellow birch in the Maritime Regions during 1930s-1950s, and little snow cover pronounces the negative effects of such events (Bourque et al., 2005). Climate change, especially temperature variability, will prolong length of such thaw events (Zhu et al., 2002).
C3 (Physical habitat)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	This species occurs on podzolic soils, and its best habitat is moderately well-drained sandy loams (Fowells, 1965). Hinds (2000) described that this species often inhabits acid soils in New Brunswick. In contrast, foliar tissues of this species could be harmed by strongly acid mist (pH < 3.0) (Wood and Bormann, 1974), and acid fogs in the Bay of Fundy could also trigger similar results (Cox et al., 1996).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species could occur at any point of forest successions, but it is regarded as a climax species (Fowells, 1965). It is tolerant of most other birch species but not much competitive with other tree species (Fowells, 1965).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Fowells, 1965).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-**SI**-N-SD-Dec GI-**Inc**-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	100	0
Severe scenario	0	6	94	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable

Moderate Scenario			-------------------------------	-------------------------------	
Severe scenario		-------------------------------	-------------------------------		
	This species has been extensively distributed in Fundy National Park (Burzynski et al., 1986; Parks Canada, 2010d). Hinds (2000) described that this species inhabits commonly cool places in New Brunswick. However, the annual mean temperature of the entire species' range, 5.0°C (range: -0.7 to 17.9°C) (Natural Resources Canada, 2014), is similar to the mean temperature of the park, 4.5°C. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the cooler side of the species' distribution, and it will be in the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). Secondary seed dispersal of this species on snow allows it to move for hundreds of feet from mother trees (Fowells, 1965: Saunders, 1996). As well, early spring thaw-freeze events have led to dieback of yellow birch in the Maritime Regions during 1930s-1950s, and little snow cover pronounces the negative effects of such events (Bourque et al., 2005). Climate change, especially temperature variability, will prolong length of such thaw events (Zhu et al., 2002). Hence, under moderate climate change scenario, yellow birch will be stable or slightly flourishing due to a thermally milder condition. Even under severe climate change scenario, temperature increase *per se* will not be so harmful, but less snow accumulation will afftect this species negatively, and hence it was judged presumably stable or moderately vulnerable.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of mountain paper birch/heart-leaved birch (*Betula cordifolia*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	The northern part in Fundy National Park is highlands, and therefore slopes may hinder migration of the species to northern and higher areas in the future. However, the topography is not much steep as well. To reflect this partial barrier, SI and N were selected here. These scores were also retained in the MVA, reflecting kind of adaptation opportunity (note that the same species without any highlands should be assessed with more negative scores like Inc due to lack of adaptation opportunity).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-**SD**-Dec GI-Inc-SI-**N**-**SD**-Dec	Seed dispersal distance of mountain paper birch has not been reported. However, assuming that mountain paper birch disperses seeds in a similar way with white birch, they disperse seeds for considerable distances thanks to its light seed weight while most seeds may fall in just neighborhoods of their mother trees (Fowells, 1965). A maximum seed dispersal distance of white birch is around 5 km, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	This species was originally regarded as a variety of white birch, but it is distributed in the Maritime region with cool summer climate (Grant and Thompson, 1975). Also, mountain paper birch is often seen in north facing slopes or high elevations (800-2,000 m) because of its cool microclimates (Fowells, 1965; Thomson et al., 2014). The optimum temperature for germination is 21 °C for *B. cordifolia* but 22 °C for *B. papyrifera*, suggesting that mountain paper birch is suited with a little cooler climate than white birch (Hughes and Cox, 1993). The annual mean temperature of the entire species' range, 9.5°C (range: 3.9 - 12.7°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.5°C. However, the data may not be accurate, considering the aforementioned habitat preference of the mountain paper birch. Information about the species' range in terms of Growing-Degree Days (GDD5) is also unavailable, and therefore the physiological thermal niche was not evaluated in the current assessment.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological	GI-Inc-**SI**-**N**-SD GI-Inc-**SI**-**N**-SD	According to Hinds (2000), the mountain paper birch is distributed in moist and rocky slopes or in rich open forests.

hydrological niche)		
C2c (Disturbance)	Inc-SI-N-SD-Dec Inc-SI-N-SD-Dec	The mountain paper birch grows slower than white birch, while it is less susceptible to insect damages than white birch (Grant and Thompson, 1975). So, unlike white birch, it might not be a typical pioneer species. However, mountain paper birch still respond to lights well and grow in forest gaps (Perkins et al., 1988). Lodding et al. (2000) noted that mountain paper birch is less shade-tolerant than yellow birch.
C2d (Ice/Snow)	GI-Inc-SI-N GI-Inc-SI-N	White birch decline in northeastern North America may be ascribed to early spring thaw-freeze events, which were reported with yellow birches, due to shallow roots of birches (Mohan et al., 2009; Auclair et al., 2010). Little snow cover pronounces the negative effects of such events (Bourque et al., 2005). Climate change, especially temperature variability, will prolong length of such thaw events (Zhu et al., 2002). Decline of the mountain paper birch probably due to such thaw-freeze events was reported in the Green Mountains of Vermont (Beckage et al., 2008).
C3 (Physical habitat)	Inc-SI-N-SD-Dec Inc-SI-N-SD-Dec	According to Hinds (2000), mountain paper birch is distributed in moist and rocky slopes or in rich open forests. In Fundy, acid fogs could lead to diebacks of twigs and braches of birch species (Cox et al., 1996). In particular, mountain paper birch is more sensitive to the acid marine fog (pH < 3.0 or below) and show higher mortality rate than white birch (Cox et al., 1996).
C4a (Other spp for habitat)	GI-Inc-SI-N GI-Inc-SI-N	
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-N Inc-SI-N	Wind-pollinated.
C4d (Other spp for disp)	Inc-SI-N Inc-SI-N	Wind-dispersed species (Fowells, 1965).
C4e (Other spp interaction)	Inc-SI-N Inc-SI-N	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	This species has been considered as a product of hybridization between white birch vs. various other birch species (e.g., *Betula glandulosa*) (Hinds, 2000). Thomson et al. (2014) detected a significantly small cpSSR haplotype richness with mountain paper birch in comparison with a couple of other birch species in northeastern North America. As well, the population in/around Fundy National Park was genetically fixed by just one haplotype (type 10) (Thomson et al., 2014).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	

D2 (Modeled change)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	Natural Resources Canada (2014) using Maxent modeling was not employed here, because this modeling does not fit with the current distribution of this species in Fundy National Park.			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	100	0
Severe scenario	0	4	49	47	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario					
Severe scenario					
	This species was originally regarded as a variety of white birch, but it is distributed in the Maritime region with cool summer climate (Grant and Thompson, 1975). Also, mountain paper birch is often seen in north facing slopes or high elevations (800-2,000 m) because of its cool microclimates (Fowells, 1965; Thomson et al., 2014). The optimum temperature for germination is 21 °C for *B. cordifolia* but 22 °C for *B. papyrifera*, suggesting that mountain paper birch is suited with a little cooler climate than white birch (Hughes and Cox, 1993). The annual mean temperature of the entire species' range, 9.5°C (range: 3.9 - 12.7°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.5°C. However, the data may not be accurate, considering the aforementioned habitat preference of mountain paper birch. Information about the species' range in terms of Growing-Degree Days (GDD5) is also unavailable, and therefore the physiological thermal niche was not evaluated in the current assessment. Consequently, the MVA did not determine vulnerability/adaptability of the species.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of white birch (*Betula papyrifera*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	The northern part in Fundy National Park is highlands, and therefore slopes may hinder migration of the species to northern and higher areas in the future. However, the topography is not much steep as well. To reflect this partial barrier, SI and N were selected here. These scores were also retained in the MVA, reflecting kind of adaptation opportunity (note that the same species without any highlands should be assessed with more negative scores like Inc due to lack of adaptation opportunity).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species can regenerate by sprouting after cutting and often observed in post-harvest sites in New Brunswick (Fowells, 1965; Franklin et al., 2000).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-**SD**-Dec GI-Inc-SI-**N**-**SD**-Dec	This species disperses seeds for considerable distances thanks to its light seed weight, but most seeds may fall in just neighborhoods of their mother trees (Fowells, 1965). A maximum seed dispersal distance of this species is around 5 km, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-**N**-SD GI-**Inc**-SI-N-SD	This species is distributed in Alaska and most of Canada, reaching northward nearly to the tree growth limit (Fowells, 1965). It is unlikely that white birch grows under an average July temperature higher than 21°C (Fowells, 1965), while the monthly temperature in Fundy in July is 17.2°C. The annual mean temperature of the entire species' range, 3.9°C (range: -4.8 to 12.5°C) (Natural Resources Canada, 2014), is slightly lower than the mean temperature of the park, 4.5°C. This species showed declined growth and diebacks likely due to its sensitivity to temperature and moisture in warmer and less moist years than normal ones in northern Michigan (Jones, 1993). In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, the same park will be hotter than the warmer limit.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-**SD** GI-Inc-**SI**-N-**SD**	This species could be distributed on soils in a wide range of moisture conditions, though it tends to be more common in somewhat drier sites (Fowells, 1965). Wang et al. (1998) reported that this species is tolerant of droughts. Because white birch is physiologically tolerant of extreme site conditions, it is distributed in upper

		ridges of the plateau in Cape Breton as well (Bourque et al., 2000). In contrast, this species showed declined growth and diebacks likely due to its sensitivity to temperature and moisture in warmer and less moist years than normal ones in northern Michigan (Jones, 1993).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species is not shade-tolerant, being often found in forest edges, lakeshores, and roadsides (Farrar, 1995; Scheller and Mladenoff, 2005). This species can regenerate by sprouting after fire and cutting (Fowells, 1965; Franklin et al., 2000). Fire could contribute to establishments of this species' stands, but moderate fires could be also harmful on already established stands by burning trees (Fowells, 1965; Couillard et al., 2012). Wang et al. (1998) reported that this species is tolerant of droughts. On the other hand, rootlet mortality and birch dieback-like symptom are expected with increased soil temperatures (Fowells, 1965).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-**Inc**-**SI**-N	White birch decline in northeastern North America may be ascribed to early spring thaw-freeze events, which were reported with yellow birches, due to shallow roots of birches (Mohan et al., 2009; Auclair et al., 2010). Little snow cover pronounces the negative effects of such events (Bourque et al., 2005). Climate change, especially temperature variability, will prolong length of such thaw events (Zhu et al., 2002).
C3 (Physical habitat)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	This species grows on podzol soils, but sometimes it could grow on brown podzolic soils as well (Fowells, 1965). Shallow, stony soils and also bog and peat soils are available for white birch (Fowells, 1965; Hinds, 2000). In Fundy, acid fogs could lead to diebacks of twigs and braches of birch species, but fog-related mortality rate was small (< 3%) (Cox et al., 1996).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is more intolerant than most other tree species in the northeastern United States, except aspen, pin cherry, and gray birch (Fowells, 1965).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated.
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Wind-dispersed species (Fowells, 1965).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2	GI-Inc-**SI**-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural

(Modeled change)	**GI**-Inc-SI-N-SD-Dec	Resources Canada, 2014).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	100	0
Severe scenario	0	12	88	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario		-------------------------------			
Severe scenario	-------------------------------				
	This species is distributed in Alaska and most of Canada, reaching northward nearly to the tree growth limit (Fowells, 1965). It is unlikely that white birch grows under an average July temperature higher than 21°C (Fowells, 1965), while the monthly temperature in Fundy in July is 17.2°C. The annual mean temperature of the entire species' range, 3.9°C (range: -4.8 to 12.5°C) (Natural Resources Canada, 2014), is slightly lower than the mean temperature of the park, 4.5°C. This species showed declined growth and diebacks likely due to its sensitivity to temperature and moisture in warmer and less moist years than normal ones in northern Michigan (Jones, 1993). In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, the same park will be hotter than the warmer limit. This species is not shade-tolerant, being often found in forest edges, lakeshores, and roadsides (Farrar, 1995; Scheller and Mladenoff, 2005). This species can regenerate by sprouting after fire and cutting (Fowells, 1965; Franklin et al., 2000). Fire could contribute to establishments of this species' stands, but moderate fires could be also harmful on already established stands by burning trees (Fowells, 1965; Couillard et al., 2012). Wang et al. (1998) reported that this species is tolerant of droughts. On the other hand, rootlet mortality and birch dieback-like symptom are expected with increased soil temperatures (Fowells, 1965). White birch decline in northeastern North America may be ascribed to early spring thaw-freeze events, which were reported with yellow birches, due to shallow roots of birches (Mohan et al., 2009; Auclair et al., 2010). Little snow cover pronounces the negative effects of such events (Bourque et al., 2005). Climate change, especially temperature variability, will prolong length of such thaw events (Zhu et al., 2002). Therefore, although some disturbances may be positive for white birch, temperature increase makes it vulnerable to both of moderate and severe climate change scenarios. Furthermore, less snow accumulation will contribute to the vulnerability. Because white birch will still persist under moderate climate change scenario but not so under severe scenario, the classes of MV and HV were chosen for each scenario.				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of American beech (*Fagus grandifolia/Fagus americana*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	The northern part in Fundy National Park is highlands, and therefore slopes may hinder migration of the species to northern and higher areas in the future. However, the topography is not much steep as well. To reflect this partial barrier, SI and N were selected here. These scores were also retained in the MVA, reflecting kind of adaptation opportunity (note that the same species without any highlands should be assessed with more negative scores like Inc due to lack of adaptation opportunity).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-N-**SD**-Dec GI-Inc-SI-N-**SD**-Dec	A past migration speed of this species was estimated as roughly 80-90 m/yr (sustained 4 km per reproduction), probably by long-distance dispersal (Cogbill, 2005; McLachlan et al., 2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD** Dec	In North America, *F. grandifolia* is distributed in and around the temperate zone (Fang and Lechowicz, 2006). The annual mean temperature of the entire species' range, 9.8°C (range: 0.7 - 21.0°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.5°C. Sufficient growing season warmth was crucial for this species' northwards migration, and a lack of growing season warmth has prevented its migration to the Atlantic Islands (Fang and Lechowicz, 2006). In terms of Growing-Degree Days (GDD5), Fundy National Park is currently close to the cooler limit of the species' distribution, and it will be closer to the middle of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be just in the middle of the distribution.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	Moist soils with low base saturation allow beech to occupy and dominate in late-successionlal forests (Kitamura and Kawano, 2001; Canham, 2004). This species tends to prefer moist conditions more strongly at its northern limit than its southern limit (Fang and Lechowicz, 2006).
C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	This species is very vulnerable to fire injury due to its thin bark and large surface roots (Fowells, 1965). In line with this, its abundance was lowered after wildfire, being replaced by species like sugar maple, red maple, hemlock, and red spruce (Telfer, 2004). However, such fires are unlikely to occur in Fundy, and therefore fire

		effects should not be overestimated. Also, in forest gaps, sugar maple is more likely to grow well than beech (Beaudet et al., 2007). In cold regions within this species' range (e.g., highlands in west-central New Brunswick), cold winter temperature may have controlled the spread of bark disease, which is very common and serious in Acadian forests (Houston and Houston, 2000; Simpson, 2008). Warming could contribute to expand the disease infection further, though this disease has been already common in Fundy (Betts and Forbes, 2005; Ramirez et al., 2007; Parks Canada, 2010d). Positive effects of warming on growth of this species may outweigh additional negative effects of this disease in warm climates (Witter et al., 2004).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-N	Snow could somewhat assist this species to avoid fires and also enjoy moist conditions (Henne et al., 2007).
C3 (Physical habitat)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	This species is usually observed in the Gray-Brown Podzolic and the Laterite, but not limestone walleys, and timber forests including many beech trees are found in acidic conditions of pH ranging between 4.1 and 6.0 (Fowells, 1965).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is very tolerant and competitive (Fowells, 1965; Kitamura and Kawano, 2001; Canham, 2004).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Koch et al., 2010).
C4d (Other spp for disp)	Inc-**SI**-N Inc-**SI**-N	This species' seeds are secondarily dispersed by pigeons, blue jays and rodents (Kitamura and Kawano, 2001; Cogbill, 2005).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	Houston and Houston (2000) did not include any populations from New Brunswick into their target of isozyme analysis.
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-**N**-SD-Dec GI-Inc-**SI**-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	100	0
Severe scenario	0	0	50	50	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable

<table>
<tr><td rowspan="3">Moderate Scenario
Severe scenario</td><td></td><td></td><td></td><td>-------------------------------</td><td></td></tr>
<tr><td></td><td></td><td></td><td>-------------------------------</td><td></td></tr>
<tr><td colspan="5">In North America, *F. grandifolia* is distributed in and around the temperate zone (Fang and Lechowicz, 2006). The annual mean temperature of the entire species' range, 9.8°C (range: 0.7 - 21.0°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.5°C. Sufficient growing season warmth was crucial for this species' northwards migration, and a lack of growing season warmth has prevented its migration to the Atlantic Islands (Fang and Lechowicz, 2006). In terms of Growing-Degree Days (GDD5), Fundy National Park is currently close to the cooler limit of the species' distribution, and it will be closer to the middle of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be just in the middle of the distribution. This species is very vulnerable to fire injury due to its thin bark and large surface roots (Fowells, 1965). In line with this, its abundance was lowered after wildfire, being replaced by species like sugar maple, red maple, hemlock, and red spruce (Telfer, 2004). However, such fires are unlikely to occur in Fundy, and therefore fire effects should not be overestimated. Also, in forest gaps, sugar maple is more likely to grow well than beech (Beaudet et al., 2007). In cold regions within this species' range (e.g., highlands in west-central New Brunswick), cold winter temperature may have controlled the spread of beech bark disease, which is very common and serious in Acadian forests (Houston and Houston, 2000; Simpson, 2008). Warming could contribute to expand the disease infection further, though this disease has been already common in Fundy (Betts and Forbes, 2005; Ramirez et al., 2007; Parks Canada, 2010d). Positive effects of warming on growth of this species may outweigh additional negative effects of this disease in warm climates (Witter et al., 2004). Snow could somewhat assist this species to avoid fires and also enjoy moist conditions (Henne et al., 2007). Overall, beech will flourish drastically due to temperature increase in Fundy National Park. In this sense, MA and HA should be appropriate to show the adaptability under moderate and severe climate change scenarios respectively. Yet, moderately negative influences of less snow accumulation, hydrological change and/or beech bark disease might cancel such a positive effect of thermal change in part. Therefore, just MA was chosen for beech here.</td></tr>
</table>

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of Eastern larch/American larch/Tamarack (*Larix laricina*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	The northern part in Fundy National Park is highlands, and therefore slopes may hinder migration of the species to northern and higher areas in the future. However, the topography is not much steep as well. To reflect this partial barrier, SI and N were selected here. These scores were also retained in the MVA, reflecting kind of adaptation opportunity (note that the same species without any highlands should be assessed with more negative scores like Inc due to lack of adaptation opportunity).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Artificial disturbances, such as logging and farming, in the last 200 years have favoured such a pioneer species, allowing it to expand its distribution to neighboring uplands in southern New Brunswick (Ying and Morgenstern, 1991).
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-**SI**-N-SD-Dec GI-Inc-**SI**-N-SD-Dec	Only 2% of larch seeds were disseminnated for 60 m or more in an observation in Minnesota (Duncan, 1954). The numbers of filled seeds dispersed for 9 m and 18 m were around 11% and 6% of that dispersed just under mother trees respectively in Alaska, indicating limited seed dispersal ability of this species in comparison with other coniferous species (Fowells, 1965; Brown et al., 1988).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-**N**-SD GI-**Inc**-**SI**-N-SD	This species is distributed from Alaska south to Maryland and West Virginia, suggesting the widest distribution of American coniferous tree species (Fowells, 1965; Park and Fowler, 1982). However, according to a study in Ontario, this species is likely to be highly differentiated in terms of cold hardiness, specializing to each microclimate (Joyce, 1988). The annual mean temperature of the entire species' range, 2.3°C (range: -7.3 to 10.3°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.5°C. This species dominates wet acid peat softwoods in cool/cold areas in the Acadian Forest Region (Loos and Ives, 2003). The highest temperature in this species' distribution is between 29 and 43°C (Fowells, 1965). In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii	GI-Inc-**SI**-N-SD	This species is associated with bogs and swamps especially in the southern part of the species' distribution,

(Physiological hydrological niche)	GI-Inc-**SI**-N-SD	while it could be distributed in a wide range of sites in more northern parts (Fowells, 1965; Park and Fowler, 1982). Bogs are suitable habitats for larch in New Brunswick including Fundy (Burzynski et al., 1986; Hinds, 2000). High watertables in floodplain wetlands also could contribute to protecting this species from fire-related damages (Brown et al., 1988). However, prolonged water periods, like flooding, may decrease germination rate of this species (Duncan, 1954; Fowells, 1965).
C2c (Disturbance)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	Generally, the eastern larch is a pioneer and intolerant species, beginning forest successions in bog lands (Fowells, 1965; Duncan, 1954). This species dominates wet acid peatsoftwoods in the Acadian Forest Region, and there are stand-replacing fires and small patch blowdowns (Loos and Ives, 2003). However, strong fires and winds could be negative for this species because of its shallow roots (Fowells, 1965). Artificial disturbances, such as logging and farming, in the last 200 years have favoured such a pioneer species, allowing this species to expand its distribution to neighboring uplands in southern New Brunswick (Ying and Morgenstern, 1991). Larch sawfly and larch beetle have also influenced the forests by defoliation and/or damaging seeds (Fowells, 1965; Loos and Ives, 2003). As well, larch seeds are often damaged by chalcids, which are likely to be killed by low temperature (e.g., mortality rate is 100% in -20°C for 12 weeks) according to a study in Ontario (Prevost, 2002). In contrast, disturbances by browsing mammals are not influential on this species (Duncan, 1954).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Snowfall amount greatly varies within this species' distribution between 76 and 406 cm (Fowells, 1965).
C3 (Physical habitat)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species dominates wet acid peat softwoods with poor organic soils in the Acadian Forest Region (Fowells, 1965; Hinds, 2000; Loos and Ives, 2003). Burzynski et al. (1986) documented that this species has been distributed in bogs in Fundy. Ying and Morgenstern (1991) stated that this species was generally confined to bog areas but subsequently colonized to some parts of uplands in New Brunswick. Duncan (1954) suggested that this species could grow in uplands even in the southern side of this species' distribution, given favourable moisture conditions without harsh interspecific competition. The same author also proposed that pH (at least in the range between 4.5 and 7.5) has little influences on germination of this species.
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species dominates wet acid peat softwoods with black spruce in the Acadian Forest Region (Fowells, 1965; Loos and Ives, 2003). Eastern larch is a very fast growing species, though the growth is negatively correlated with latitude of seedlings' origins (Park and Fowler, 1982)
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Ying and Morgenstern, 1990).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	

<table>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-**N**-SD
Inc-SI-**N**-SD</td><td colspan="4">Ying and Morgenstern (1991) reported moderate genetic variability of larch populations in central New Brunswick using allozyme markers. They did not examine populations in Fundy but proposed that larch populations in central and southern New Brunswick were not much isolated (Ying and Morgenstern, 1991).</td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-**Inc**-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4">These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).</td></tr>
<tr><td rowspan="3">The CCVI [%]
Moderate Scenario
Severe scenario</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>0</td><td>0</td><td>100</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>0</td><td>100</td><td>0</td><td>0</td></tr>
<tr><td rowspan="4">The MVA**
Moderate Scenario
Severe scenario</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td></td><td>-------------------------------</td><td>-------------------------------</td><td></td><td></td></tr>
<tr><td></td><td>-------------------------------</td><td></td><td></td><td></td></tr>
<tr><td colspan="5">This species is distributed from Alaska south to Maryland and West Virginia, suggesting the widest distribution of American coniferous tree species (Fowells, 1965; Park and Fowler, 1982). However, according to a study in Ontario, this species is likely to be highly differentiated in terms of cold hardiness, specializing to each microclimate (Joyce, 1988). The annual mean temperature of the entire species' range, 2.3°C (range: -7.3 to 10.3°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.5°C. This species dominates wet acid peat softwoods in cool/cold areas in the Acadian Forest Region (Loos and Ives, 2003). The highest temperature in this species' distribution is between 29 and 43°C (Fowells, 1965). In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate and severe climate change scenarios (c.f., Appendix). Generally, eastern larch is a pioneer and intolerant species, beginning forest successions in bog lands (Fowells, 1965; Duncan, 1954; Smith, 1998). Therefore, thermal change will be harmful on larch, though the same species will still persist under severe climate change scenario, being partly assisted by disturbance regimes. Thus, not HV, but MV was given for the larch under severe scenario.</td></tr>
</table>

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of white spruce (*Picea glauca*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	The northern part in Fundy National Park is highlands, and therefore slopes may hinder migration of the species to northern and higher areas in the future. However, the topography is not much steep as well. To reflect this partial barrier, SI and N were selected here. These scores were also retained in the MVA, reflecting kind of adaptation opportunity (note that the same species without any highlands should be assessed with more negative scores like Inc due to lack of adaptation opportunity).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	White spruces could disseminate its seeds for 100 m on average but sometimes over than 300 m (Fowells, 1965). According to a modelling study, seed rain of this species halves at a distance of 30 m, but around 3% of dispersed seeds could move for more than 800 m (Wirth et al., 2008). Maximum seed dispersal distance of this species is around 200 m, according to Scheller and Mladenoff (2005). Moreover, a cpDNA phylogeographical study suggested that postglacial migration rates of 1,500-2,000 m/yr, presumed by a fossil pollen analysis, was an overestimation (Anderson et al., 2006).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-**N**-SD GI-**Inc**-**SI**-N-SD	The annual mean temperature of the entire species' range, 1.2°C (range: -11.9 to 10.6°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.5°C. However, some of this species' range has experienced considerably hot temperature (e.g., 43°C in southwestern Manitoba) (Fowells, 1965), indicating a high climatic flexibility of this species (Farrar, 1995). Yet, even this species showed inhibited photosynthesis with heat treatment at 42°C or higher (Bigras, 2000). In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be hotter than the warmer limit of the distribution.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-SI-N-**SD** GI-Inc-SI-N-**SD**	This species inhabits wet insular Nova Scotia but also semi-arid continental areas in southwestern Manitoba (Fowells, 1965). Hinds (2000) documented that this species is common in dry uplands in New Brunswick. Therefore, even considering that Fundy is generally in moist conditions, a little drier environment should be

		suitable for this species in Fundy National Park.
C2c (Disturbance)	Inc-**SI**-**N**-SD-Dec Inc-**SI**-**N**-SD-Dec	This species is intermediately shade-tolerant and classified as a climax species, but still it is unlikely to compete well with hardwoods (Fowells, 1965; Scheller and Mladenoff, 2005). In other words, some gaps are needed for regeneration of this species (e.g., abandoned agricultural fields in Cape Breton) (Smith, 1998; Bouman et al., 2004). It is susceptible to windthrow but more tolerant of winds than black spruce and balsam fir on uplands (Fowells, 1965). Fires could allow white spruce to replace black spruce, if there is no effect of permafrost, in Alaska (Wirth et al., 2008). However, white spruce is generally regarded as a fire-intolerant species, and its populations in central Quebec may have been declining due to fire disturbances as well as postfire growth of black spruce stands (Lafontaine et al., 2010). In Cape Breton during latter 1970s, spruce budworm outbreaks killed it at relatively moderate mortality (i.e., 27% (Ostaff and MacLean, 1989) or 50% (Smith, 1998)), whilst spruce beetles have simltaneously killed another spruces which corresponded around 39% of total volume (Ostaff and MacLean, 1989). Therefore, even in Fundy National Park, disturbances including budworm/beetle outbreaks could be detrimental to this species.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-**SI**-**N** SD	Most parts of this species' distribution are in the permafrost zone in northern Canada (Fowells, 1965), though it was documented, for instance, that white spruce was distributed without permafrost in some parts in Alaska (Wirth et al., 2008). Wamer climates may generally lead to earlier snowmelting, enabling this species to grow better (Wilmking et al., 2004), while snow-free conditions could bring about winter desiccation and cold-induced photoinhibition at alpine-treeline in Yukon (Danby and Hik, 2007). Secondary seed dispersal of this species on snow may be relevant to this species' colonization as well (Wirth et al., 2008).
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	This species could occur on a wide range of pH and various types of soils which are characterized with glacial, lacustrine, marine, or alluvial origins, whereas it grows best on podozolized gamma gley loams or clays (Fowells, 1965). As well, white spruce requires much more nutrient than other associated tree species, being able to respond well to fertilizer treatments (Fowells, 1965).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	This species is intermediately shade-tolerant and classified as a climax species, but still it is unlikely to compete well with hardwoods (Fowells, 1965; Scheller and Mladenoff, 2005).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Andalo et al., 2005).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Many birds attempt to obtain seeds of white spruce (Fowells, 1965). Also, it was documented that white spruce was preferred in comparison with black spruce by red squirrels, though spruce seeds dispersed by squirrels were unlikely to germinate successfully (Brink and Dean, 1966). Secondary seed dispersal of this species on snow may be relevant to this species' colonization as well (Wirth et al., 2008).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a	Inc-SI-**N**-SD	Haplotypic diversity in cpDNA regions was slightly above the mean in a population in Fundy, compared to

(Genetic variation)	Inc-SI-**N**-SD	those in other parts of the species' range (Lafontaine et al., 2010).			
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N				
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD				
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec				
D2 (Modeled change)	GI-**Inc**-SI-N-SD-Dec **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).			
The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	100	0	0
Severe scenario	0	3	97	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario		-------------------------------	-------------------------------		
Severe scenario	-------------------------------	-------------------------------			
	The annual mean temperature of the entire species' range, 1.2°C (range: -11.9 to 10.6°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.5°C. However, some of this species' range has experienced considerably hot temperature (e.g., 43°C in southwestern Manitoba) (Fowells, 1965), indicating a high climatic flexibility of this species (Farrar, 1995). Yet, even this species showed inhibited photosynthesis with heat treatment at 42°C or higher (Bigras, 2000). In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be hotter than the warmer limit of the distribution. Therefore, although white spruce is a little tolerant to thermal change, it is still vulnerable to climate change. Under severe climate change scenario, in particular, white spruce could be extirpated because of too high temperature and possibly budworm/beetle outbreaks. In this respect, HV and MV were chosen for white spruce under severe scenario. However, be aware that, the determined vulnerability under moderate climate change scenario is slightly less serious than that of black spruce. White spruce is likely to replace black spruce under warming climates in Alaska, likely because the former species is slightly more fitting to a warm climate than the latter one (Wirth et al., 2008).				

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of black spruce (*Picea mariana*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	The northern part in Fundy National Park is highlands, and therefore slopes may hinder migration of the species to northern and higher areas in the future. However, the topography is not much steep as well. To reflect this partial barrier, SI and N were selected here. These scores were also retained in the MVA, reflecting kind of adaptation opportunity (note that the same species without any highlands should be assessed with more negative scores like Inc due to lack of adaptation opportunity).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-**SI**-**N**-SD-Dec GI-Inc-**SI**-**N**-SD-Dec	Seeds of this species can be dispersed for just short distance of up to 79 m (USDA, n.d.). However, indirect evidences of long-distance seed dispersal (tens of metres or more) of black spruce has been also reported (e.g., Payette and Delwaide, 1994).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-**SI**-**N**-SD GI-**Inc**-**SI**-N-SD	This species has been extensively distributed in Fundy National Park (Burzynski et al., 1986). However, the annual mean temperature of the entire species' range, 0.9°C (range: -9.0 to 9.9°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.5°C. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be hotter than the warmer limit of the distribution. However, this species' range is latitudinally wide from 41°N to 68°N, indicating a high thermal flexibility of this species (Fowells, 1965). USDA (n.d.) also suggested elevation is less important for determining this species' distribution than local topography and drainage. Further, reproduction of this species (e.g, cone crop, number of seeds) was scarcely affected by climate, according to a study covering a wide latitudinal range in the boreal zone in Quebec (Messaoud et al., 2007b). In Quebec, balsam fir stands have been gradually replaced by black spruce stands under colder and drier climate together with more frequent fires since the last 2,500 years (Messaoud et al., 2007a).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	

C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	In New Brunswick, this species is typically distributed in wet and poor sites (MacKinnon and MacLean, 2003), being extensively distributed in Fundy (Burzynski et al., 1986).
C2c (Disturbance)	Inc-**SI**-N-SD-Dec Inc-**SI**-N-SD-Dec	Black spruce is intermediately tolerant of shade (Smith, 1998). It grows at slower pace than balsam fir and white birch, and therefore regeneration would take much time after budworm outbreaks (Pardy, 1997; Smith, 1998). In contrast, this species is more competitive than balsam fir (Messaoud et al., 2007a). Crown and surface fires kill this species, but it could regenerate soon after light fires (Fowells, 1965; Rajora and Pluhar, 2003; USDA, n.d.). Black spruce is also susceptible to wind because of its shallow root system (Fowells, 1965; USDA, n.d.). According to 585 plots in New Brunswick, mortality of balsam fir and spruce forests was ascribed to mainly blowdown (Taylor and MacLean, 2005; 2007). Moderate disturbance has led to hybridization between black spruce and red spruce, which is more a climax species than black spruce, in New Brunswick (Manley, 1972). Furthermore, in Cape Breton during latter 1970s, spruce budworm outbreaks killed black spruce at relatively moderate mortality (i.e., 50%) (Smith, 1998). However, in New Brunswick, black spruce is less susceptible to such budworms (i.e. defoliation rate: 9% between 1984 and 1992) than balsam fir (29%) (MacLean and MacKinnon, 1997; Hennigar et al., 2008). Hybridization with red spruce could increase such budworm-related defoliation rate, and such interspecific hybridization may be led by artificial disturbances (Betts and Forbes, 2005).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	In most areas of this species' distribution, there are snow depths of around 50-75 cm in the end of February (Fowells, 1965). However, in southern or western peripheries of the distribution, snow depths could be less than 38 cm (Fowells, 1965). In areas where the total annual precipitation is less than 635 mm, spring snowmelt could compensate for water shortage for black spruce (Fowells, 1965). Given wet and foggy conditions in Fundy, this effect is unlikely to be significant.
C3 (Physical habitat)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	This species can be found on organic as well as mineral soils (Fowells, 1965). Loams, sandy loams and rocky soils are available for black spruce as well (Fowells, 1965). In Atlantic Canada, this species is distributed on sandy and gravelly outwash plains, river terraces, eskers, and similar landforms with acidic and podzolized soils (Fowells, 1965). In New Brunswick including Fundy, this species is typically distributed in wet and poor sites (Burzynski et al., 1986; Hinds, 2000; MacKinnon and MacLean, 2003). As well, Manley (1972) observed black spruces often in bogs but red spruces in uplands in New Brunswick. It is then noteworthy that gentle slopes and flat topographies between bogs and uplands have allowed frequent hybridization between black spruce and red spruce by connecting two species' distributions (Manley, 1972; Perron and Bousquet, 1997; Hinds, 2000).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Black spruce is intermediately tolerant of shade (Smith, 1998). It grows at slower pace than balsam fir and white birch (Pardy, 1997; Smith, 1998).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c	Inc-SI-**N**	Wind-pollinated.

(Pollination)	Inc-SI-**N**	
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Its cones are often moved by red squirrels (Fowells, 1965). However, a later study reported that black spruce was not preferred in comparison with white spruce by red squirrels, and even spruce seeds dispered by them were unlikely to germinate successfully (Brink and Dean, 1966).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	White spruce is likely to replace black spruce under warming climates in Alaska, likely because the former species is slightly more fitting to a warm climate than the latter one (Wirth et al., 2008). However, under severe climate change, even white spruces will no longer flourish.
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	A lineage originated from New England and the central Appalachians might have migrated northeastwards to Newfoundland and Labrador, according to a wide-scale analysis of mtDNA of this species (Jaramillo-Correa et al., 2004). Also, in southern Quebec, which is next to New Brunswick, this species exhibited high mtDNA diversity probably reflecting past mixture from multiple origins (Jaramillo-Correa et al., 2004). However, a level of genetic variation in New Brunswick have not been clarified yet.
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-**Inc**-SI-N-SD-Dec **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	100	0	0
Severe scenario	0	50	50	0	0

The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario		-------------------------------			
Severe scenario	-------------------------------	-------------------------------			
	This species has been extensively distributed in Fundy National Park (Burzynski et al., 1986). However, the annual mean temperature of the entire species' range, 0.9°C (range: -9.0 to 9.9°C) (Natural Resources Canada, 2014), is lower than the mean temperature of the park, 4.5°C. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the middle of the species' distribution, but it will be close to the warmer limit of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be hotter than the warmer limit of the distribution. However, this species' range is latitudinally wide from 41°N to 68°N, indicating a high thermal flexibility of this species (Fowells, 1965). USDA (n.d.) also suggested elevation is less important for determining this species' distribution than local topography and drainage. Further, reproduction of this species (e.g, cone crop, number of seeds) was scarcely affected by climate, according to a study covering a wide latitudinal range in the boreal zone in Quebec (Messaoud et al., 2007b). In Quebec, balsam fir stands have been gradually replaced by black spruce stands under colder and drier climate together with more frequent fires since the last 2,500 years (Messaoud et al., 2007a). Black spruce is intermediately				

	tolerant of shade (Smith, 1998). It grows at slower pace than balsam fir and white birch, and therefore regeneration would take much time after budworm outbreaks (Pardy, 1997; Smith, 1998). In contrast, this species is more competitive than balsam fir (Messaoud et al., 2007a). Crown and surface fires kill this species, but it could regenerate soon after light fires (Fowells, 1965; Rajora and Pluhar, 2003; USDA, n.d.). Black spruce is also susceptible to wind because of its shallow root system (Fowells, 1965; USDA, n.d.). According to 585 plots in New Brunswick, mortality of balsam fir and spruce forests was ascribed to mainly blowdown (Taylor and MacLean, 2005; 2007). Moderate disturbance has led to hybridization between black spruce and red spruce, which is more a climax species than black spruce, in New Brunswick (Manley, 1972). Furthermore, in Cape Breton during latter 1970s, spruce budworm outbreaks killed black spruce at relatively moderate mortality (i.e., 50%) (Smith, 1998). However, in New Brunswick, black spruce is less susceptible to such budworms (i.e. defoliation rate: 9% between 1984 and 1992) than balsam fir (29%) (MacLean and MacKinnon, 1997; Hennigar et al., 2008). Hybridization with red spruce could increase such budworm-related defoliation rate, and such interspecific hybridization may be led by artificial disturbances (Betts and Forbes, 2005). White spruce is likely to replace black spruce under warming climates in Alaska, likely because the former species is slightly more fitting to a warm climate than the latter one (Wirth et al., 2008). However, under severe climate change, even white spruces will no longer flourish. In short, under moderate climate change scenario, not only temperature increase but also competition with white spruce will be negative for black spruce, resulting in moderate vulnerability. Under severe climate change scenario, like balsam fir and white spruce, black spruce could be highly vulnerable (HV) (almost extirpated locally). At the same time, however, considering that the temperature is still within the current temperature range of the species' distribution and that it has a high thermal flexibility, the class of MV was also chosen.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of red spruce (*Picea rubens*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	· If the sea level rises, we are going to lose land around the coast. Fundy National Park will almost become an island, and people are going to want to live somewhere. So, even if it is legally protected, we can't rule out encroachment on the land base. [Expert in Fundy] · The context is complex enough that we don't have to add that parameter. [Expert in Fundy]
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	The northern part in Fundy National Park is highlands, and therefore slopes may hinder migration of the species to northern and higher areas in the future. However, the topography is not much steep as well. To reflect this partial barrier, SI and N were selected here. These scores were also retained in the MVA, reflecting kind of adaptation opportunity (note that the same species without any highlands should be assessed with more negative scores like Inc due to lack of adaptation opportunity).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	A mean dispersal distance of this species was reported as around 61 m (Govindaraju, 1988). However, its congeneric species, black spruce, disseminates its seeds for around 31 m, while 15.2% and 2.9% of the seeds were predicted by a modelling study to be dispersed for longer distances of 300-800 m respectively (Wirth et al., 2008).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-**SI**-**N**-SD	This species has been extensively distributed in Fundy National Park (Burzynski et al., 1986; Parks Canada, 2010d). The annual mean temperature of the entire species' range, 4.4°C (range:-0.5 to 13.9°C) (Natural Resources Canada, 2014), is very close the mean temperature of the park, 4.5°C. Coastal fog in combination with local cooling effect by the Bay of Fundy have created local refugia for this species in the east coast of Maine between 6,000 and 5,000 years ago, and probably this species recolonized extensively from these refugia especially during the last cooling 1,000 years (Schauffler and Jacobson, 2002). However, cool and wet conditions in the coastal Maritime, like Quiddy River, may have led to poor pollination (e.g., seed abortion) of this species (Mosseler et al., 2000). In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the cooler side of the species' distribution, and it will be close to the middle of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be in the warmer side of the distribution.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii	GI-Inc-**SI**-**N**-SD	This species can grow best on well-drained soils (Saunders, 1996), being distributed extensively in Fundy

(Physiological hydrological niche)	GI-Inc-**SI**-**N**-SD	National Park (Burzynski et al., 1986). This is one of typical species in mature forests on moist upland sites, being often observed in moist sites like north-facing slopes and lakesides in Ontario and Quebec (Farrar, 1995). Coastal fog in combination with local cooling effect by the Bay of Fundy have created local refugia for this species in the east coast of Maine between 6,000 and 5,000 years ago, and probably this species recolonized extensively from these refugia especially during the last cooling 1,000 years (Schauffler and Jacobson, 2002). However, cool and wet conditions in the coastal Maritime, like Quiddy River, may have led to poor pollination (e.g., seed abortion) of this species (Mosseler et al., 2000). · Annual precipitation in Fundy National Park is 1,400 mm or above. [Expert in Fundy] · The fungi associated with spruce could be affected, if soils are affected by increased precipitation. Thus, this subfactor should not be neutral on the vulnerability of red spruce. [Expert in Fundy] · It is neutral, because I can’t see climate change affecting this subfactor to any great degree. [Additional expert] [Follow-up after consultation] Negative effects of reduced precipitation on red spruce has been studied (Koo et al., 2014), and also heavy rainfall in August is beneficial for reproduction of ectomycorrhizal- basidiomycete communities in red spruce stands (Bills et al., 1986). In contrast, effects of increase in precipitation on fungi in red spruce stands have not been clarified yet. However, mean annual precipitation of the entire distribution of red spruce is 1,134 mm [5-95%: 979-1,350 mm] (Natural Resources Canada, 2014), while the current annual precipitation in Fundy National Park is 1,393 mm. Therefore, more increase in precipitation in this park will make this site less suitable for the species in terms of precipitation. In this respect, the subscore of C2bii was determined as SI and N.
C2c (Disturbance)	**Inc**-SI-N-SD-Dec **Inc**-SI-N-SD-Dec	This is one of typical species in mature forests on moist upland sites (Farrar, 1995), and spruce communities have been reduced and/or damaged sometimes by exntensive fire or intensified winds (Harrington, 1986; Adams and Stephenson, 1989). However, such fires are unlikely to occur in Fundy National Park, and therefore fire effects should be irrelevant. Along the Bay of Fundy, red spruce is distributed mainly in deep ravines, which are protected from strong winds (Clayden et al., 2011). According to 585 plots in New Brunswick, mortality of spruce forests was ascribed to mainly blowdown (Taylor and MacLean, 2005; 2007). However, red spruce can be tolerant to moderate disturbances and forest canopy openings (White et al., 1985). In support of this, Telfer (2004) recorded regeneration of this species in forest gaps which were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. Moderate distrubance has led to hybridization between black spruce and red spruce, which is more climax species than black spruce, in New Brunswick (Manley, 1972; Betts and Forbes, 2005). Hybridization with black spruce could decrease budworm-related defoliation rate, but still hybridization could be thereatening for the pure gene pool of this species (Betts and Forbes, 2005). Furthermore, warm climates allow spruce bark beetle to complete one generation cycle in a single year but also survive winter easily (Bentz et al., 2010). Hence, global warming

		could contribute to population growth of spruce beetle (Bentz et al., 2010). As well, increase in growing degree days (GDD) will lead to greater fitness of this species (Phillips, 2013). In contrast, low spring temperature retards water uptake by spruce trees, and particularly spruces on north-facing slopes have been stressed (Berg et al., 2006). Therefore, warm spring temperature could lesson such seasonal stresses on spruces, possibly reducing probability of beetle infestations (Berg et al., 2006). Overall, benefits of warmer climates may outweigh demerits of climate change for spruce beetle. In line with, warmer winter will contribute to higher survival rate of this species throughout winter in Fundy National Park (Phillips, 2013). Thus, such beetle outbreaks could devastate red spruce populations. · GDD has gone up since 2006 (around 1,600), with increase in water temperature and decrease in freezing DD in the past decades. Now we are getting bark beetle outbreak. In Cape Chignecto, they have been devastated by bark beetle, but I don't know if this outbreak will be persistent or die out and allow regeneration. The years where the water was warmer, fishers were saying 5 degrees warmer in the fall. I think the disturbance rating should be more extreme (than "Inc and SD") based on what is happening in this particular location. [BP] · Eastern dwarf mistletoe may become a problem in climate change. It affects growth, though seed can still be produced. We are likely to get more disturbances, not less, and red spruce won't like that. This will change the fire regime. Red spruce still needs a period of tranquility so gap disturbance may not benefit it. [Expert in Kejimkujik]
C2d (Ice/Snow)	GI-Inc-SI-N GI-Inc-SI-N	· I always suspected ice storms would hit seed crops really hard, and we have had more storms in the last 20 years than in the 20 years before. The 1998 ice storm hit us really hard too. [Expert in Fundy] [Follow-up after consultation] Richards & Daigle (2011) estimated a temporal increase of snow days in Amherst (e.g., +23% increase in 2020s in comparison with the 1980s), which is consistent with ED's view. They also projected a slight increase of snow days until 2050s in comparison with that of 1980s, but they predicted decrease in number of snow days and increase in number of rain days in winter in 2080s. As well, Dalton et al. (2009) projected that decrease in number of snow days but increase in number of rain days in winter in 2080s in towns around Fundy National Park (e.g.,; -16 days in Moncton and -13 days in Saint Jones). Therefore, the opinion given by ED will be valid 2050s, but the snow trend will change in the opposite direction after 2050s. Thus, the subscore of "N" was not changed after all.
C3 (Physical habitat)	Inc-SI-N-SD-Dec Inc-SI-N-SD-Dec	Along the Bay of Fundy, red spruce is distributed mainly in deep ravines, which are protected from strong winds (Clayden et al., 2011). This species prefers the podzolic soils with low pH ranging between 4.0 and 5.5 (Fowells, 1965). However, more acid fog (pH = 3.0) from the bay could be harmful by reducing frost hardiness of this species, and such damage may be enhanced by warming climates (Mohan et al., 2009). As well, Manley (1972) observed black spruces often in bogs but red spruces in uplands in New Brunswick. It is then noteworthy that gentle slopes and flat topographies between bogs and uplands have allowed frequent hybridization between black spruce and red spruce by connecting two species' distributions (Manley, 1972;

		Perron and Bousquet, 1997; Hinds, 2000). · We had impacts on birch because of acid fog in the past, but we don't see that much now because of pollution control. We expect to see a decrease in fog acidity and therefore the subfactor of C3 should be neutral. [Expert in Fundy]
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Being tolerant to interspecific competitions particularly in Canada (Fowells, 1965; White et al., 1985). · If you consider bark beetle disturbance and removing large shade tree and this desiccates soils, I am not sure how fungus would fare. It may affect regenerating trees. [Expert in Fundy] · Red squirrel move fungi around. [Expert in Fundy] ·These mycchorizal fungi are ubiquitous. [Expert in Fundy]
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	All spruce species are wind-pollinated (Haselhorst and Buerkle, 2013).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	This species' seeds are mainly disseminated by wind (Govindaraju, 1988), but they could be scatterhoarded by some animals like red squirrels (Dempsey and Keppie, 1993). · Crossbills might contribute to dispersal if they don't digest all the seeds. [Expert in Fundy] · They probably don't contribute to seed dispersal much. [Expert in Fundy] · The bulk of dispersal is not dependent on other species. Squirrels don't go long distances, they hoard seeds in their own territory. [Expert in Fundy]
C4e (Other spp interaction)	Inc-**SI**-**N** Inc-**SI**-**N**	· The fungi associated with spruce could be affected, if soils are affected by increased precipitation. Thus, this subfactor should not be neutral on the vulnerability of red spruce. [Expert in Fundy] · This is neutral, simply because assessing such interspecific competitive interactions is purely speculative. [Additional expert]
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	A population around the Quiddy River, which is close to Fundy National Park, exhibited somewhat smaller genetic diversity than the average diversity of examined populations (Rajora et al., 2000). However, coastal fog in combination with local cooling effect by the Bay of Fundy have created local refugia for this species in the east coast of Maine between 6,000 and 5,000 years ago, and probably this species recolonized extensively from these refugia especially during the last cooling 1,000 years (Schauffler and Jacobson, 2002). In this sense, this species in Fundy National Park may still retain rich allelic diversity. · We don't know the degree to which genetic diversity would be causing an effect in persistence to climate change. [Expert in Fundy]
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	

<table>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4">· Red spruce is a later bud burst than white/black spruce, which makes it more resilient to bud worms, because the worms will go to the other species first. [Expert in Fundy]
· However, in Quebec, red spruce is being readily attacked by bud worm. [Expert in Fundy]</td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-**SI**-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4">These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).</td></tr>
<tr><td>The CCVI [%]</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>Moderate Scenario</td><td>0</td><td>0</td><td>0</td><td>100</td><td>0</td></tr>
<tr><td>Severe scenario</td><td>0</td><td>45</td><td>55</td><td>0</td><td>0</td></tr>
<tr><td>The MVA**</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td>Moderate Scenario</td><td></td><td>-------------------------------</td><td>-------------------------------</td><td></td><td></td></tr>
<tr><td>Severe scenario</td><td>-------------------------------</td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td colspan="5">This species has been extensively distributed in Fundy National Park (Burzynski et al., 1986; Parks Canada, 2010d). The annual mean temperature of the entire species' range, 4.4°C (range:-0.5 to 13.9°C) (Natural Resources Canada, 2014), is very close the mean temperature of the park, 4.5°C. Coastal fog in combination with local cooling effect by the Bay of Fundy have created local refugia for this species in the east coast of Maine between 6,000 and 5,000 years ago, and probably this species recolonized extensively from these refugia especially during the last cooling 1,000 years (Schauffler and Jacobson, 2002). However, cool and wet conditions in the coastal Maritime, like Quiddy River, may have led to poor pollination (e.g., seed abortion) of this species (Mosseler et al., 2000). In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the cooler side of the species' distribution, and it will be close to the middle of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be in the warmer side of the distribution. This is one of typical species in mature forests on moist upland sites (Farrar, 1995), and spruce communities have been reduced and/or damaged sometimes by intensified winds (Harrington, 1986; Adams and Stephenson, 1989). Along the Bay of Fundy, the red spruce is distributed mainly in deep ravines, which are protected from strong winds (Clayden et al., 2011). According to 585 plots in New Brunswick, mortality of spruce forests was ascribed to mainly blowdown (Taylor and MacLean, 2005; 2007). However, red spruce can be tolerant to moderate disturbances and forest canopy openings (White et al., 1985). In support of this, Telfer (2004) recorded regeneration of this species in forest gaps which were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. Moderate distrubance has led to hybridization between black spruce and red spruce, which is more climax species than black spruce, in New Brunswick (Manley, 1972; Betts and Forbes, 2005). Hybridization with black spruce could decrease budworm-related defoliation rate, but still hybridization could be thereatening for the pure gene pool of this species (Betts and Forbes, 2005). Furthermore, warm climates allow spruce bark beetle to complete one generation cycle in a single year but also survive winter easily (Bentz et al., 2010). Hence, global warming could contribute to population growth of spruce beetle (Bentz et al., 2010). As well, such beetle outbreaks could devastate red spruce populations with temperature increase. Red spruce prefers the podzolic soils with low pH ranging between 4.0 and 5.5 (Fowells, 1965). However, more acid fog (pH = 3.0) from the bay could be harmful by reducing frost hardiness of this species, and such damage may be enhanced by warming climates (Mohan et al., 2009). In short, in terms of thermal niche, red spruce is not much vulnerable (or possibly</td></tr>
</table>

	grow better under moderate climate change scenario). Yet, beetle outbreaks and acid fog in Fundy could be detrimental for the same species. Considering that negative effects of climate change seem to be clearer and more influential than positive effects of temperature increase, MV/PS as well as HV/MV were chosen for red spruce under moderate and severe climate change scenarios. Although red spruce will not be completely extirpated in Fundy National Park, it is vulnerable to climate change. However, expert consultation flaged "MV" as a question mark under severe climate change scenario, because the consultation found a number of subfactors contributing to vulnerability. For instance, the fungi associated with spruce could be affected, if soils are affected by increased precipitation. Thus, based on the consultation, the final judgement was changed into just "HV".

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of red pine (*Pinus resinosa*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	The northern part in Fundy National Park is highlands, and therefore slopes may hinder migration of the species to northern and higher areas in the future. However, the topography is not much steep as well. To reflect this partial barrier, SI and N were selected here. These scores were also retained in the MVA, reflecting kind of adaptation opportunity (note that the same species without any highlands should be assessed with more negative scores like Inc due to lack of adaptation opportunity).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-**SI**-N-SD-Dec GI-Inc-**SI**-N-SD-Dec	Its effective seeding distance is 12 m, though seeds can be disseminated up to 900 feet (Fowells, 1965; He and Mladenoff, 1999).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-**N**-**SD** GI-Inc-**SI**-**N**-SD	This species grows well under cool-to-warm summers and cold winters (Fowells, 1965). As well, the annual mean temperature of the entire species' range, 4.8°C (range:-0.4 to 13.5°C) (Natural Resources Canada, 2014), is close to the mean temperature of the park, 4.5°C. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently close to the cooler limit of the species' distribution, and it will be in the middle of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be close to the warmer limit of the distribution.
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	The lightest soils (sandy soils) with low to moderate precipitaion are considerably preferred by this species, though it could be observed on swamp borders and lakesides as well (Roland, 1980; Fowells, 1965).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species can regenerate well after certain fires, windthrows and on bedrock slabs (Fowells 1965; Engstrom and Mann, 1993; Malliak and Roberts, 1994). Particularly, moderate fires are optimal disturbances for this species, removing inter-specific competitions with other tree species (Flanningan and Bergeron, 1998; Sutton et al., 2002). However, it should be noted that fires will not be common under the moist Fundy climate.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3	Inc-SI-**N**-SD-Dec	This species is distributed in the Podzol region with pH ranging between 4.5 and 6.0 (Fowells, 1965), and its

(Physical habitat)	Inc-SI-**N**-SD-Dec	seedlings prefers mineral soil exposure to grow (Flanningan and Bergeron, 1998).
C4a (Other spp for habitat)	GI-Inc-SI-**N** GI-Inc-SI-**N**	Although red pine is not competitive (Fowells, 1965; Flanningan and Bergeron, 1998), it could be associated with various tree and shrub species (Fowells, 1965).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	This species is self-pollinated without insects/animals (Fowler, 1964).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Wind-dispersed species (Greene and Johnson, 1993).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-**SD** Inc-SI-N-**SD**	Relatively high haplotypic diversity was found in a population in southern New Brunswick (Walter and Epperson, 2005). As well, nuclear microsatellite markers revealed relatively high intra-population diversity in New Brunswick, reflecting genetic structure originated from multiple refugia (Boys et al., 2005).
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-**SI**-N-SD-Dec **GI**-Inc-SI-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

The CCVI [%]	Extremely Vulnerable	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Increase Likely
Moderate Scenario	0	0	0	100	0
Severe scenario	0	0	100	0	0
The MVA**	Highly Vulnerable	Moderately Vulnerable	Presumably Stable	Moderately Adaptable	Highly Adaptable
Moderate Scenario				-------------------------------	
Severe scenario		-------------------------------	-------------------------------		
	This species grows well under cool-to-warm summers and cold winters (Fowells, 1965). As well, the annual mean temperature of the entire species' range, 4.8°C (range:-0.4 to 13.5°C) (Natural Resources Canada, 2014), is close to the mean temperature of the park, 4.5°C. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently close to the cooler limit of the species' distribution, and it will be in the middle of the distribution under moderate climate change scenario (c.f., Appendix). Further, under severe climate change scenario, this park will be close to the warmer limit of the distribution. This species can regenerate well after certain fires, windthrows and on bedrock slabs (Fowells 1965; Engstrom and Mann, 1993; Malliak and Roberts, 1994). Particularly, moderate fires are optimal disturbances for this species, removing inter-specific competitions with other tree species (Flanningan and Bergeron, 1998; Sutton et al., 2002). However, it should be noted that fires will not be common under the moist Fundy climate. In				

	other words, under moderate climate change scenario, red pine will flourish because of an improved thermal condition and intensified disturbances. In contrast, under severe climate change scenario, although increase of disturbance intensity may be a little beneficial for this species, temperature increase will be excessive and negative for red pine.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of white pine (*Pinus strobus*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	The northern part in Fundy National Park is highlands, and therefore slopes may hinder migration of the species to northern and higher areas in the future. However, the topography is not much steep as well. To reflect this partial barrier, SI and N were selected here. These scores were also retained in the MVA, reflecting kind of adaptation opportunity (note that the same species without any highlands should be assessed with more negative scores like Inc due to lack of adaptation opportunity).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Its effective seed dispersal is around 100 m (He and Mladenoff, 1999). Some of the seeds can be gathered and cached by animals (Vander Wall, 2003).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** Dec GI-Inc-SI-**N**-**SD** Dec	The annual mean temperature of the entire species' range, 5.8°C (range: -1.1 to 17.2°C) (Natural Resources Canada, 2014), is slightly higher than the mean temperature of the park, 4.5°C. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the cooler side of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species can grow on a wide range of soils, though it grows best on moist, well drained sandy loam (Farrar, 1995; Joyce and Rehfeldt, 2013).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	It can tolerate of several disturbance types and survive in open canopies (Farrar, 1995; Weyenberg et al., 2004). Actually, there are multiple post-fire places where this species has grown (Saunder, 1996; Weyenberg et al., 2004). In support of this, Telfer (2004) recorded regeneration of this species in forest gaps which were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954.
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
C3 (Physical habitat)	Inc-SI-**N**-**SD**-Dec Inc-SI-**N**-**SD**-Dec	Commonly found in Nova Scotia including Kejimkujik National Park, but not Cape Breton (Roland, 1980; Boland, 2012). This species prefers certain soil bases, such as granites (Fowells, 1965).
C4a	GI-Inc-SI-**N**	It is a moderately shade-tolerant species, usually being mixed with other species like red oak (Fowells, 1965;

(Other spp for habitat)	GI-Inc-SI-**N**	Farrar, 1995).
C4b (Diet)	Inc-SI-N-SD Inc-SI-N-SD	
C4c (Pollination)	Inc-SI-**N** Inc-SI-**N**	Wind-pollinated (Walter and Epperson, 2004).
C4d (Other spp for disp)	Inc-SI-**N** Inc-SI-**N**	Wind-dispersed species (Walter and Epperson, 2004).
C4e (Other spp interaction)	Inc-SI-**N** Inc-SI-**N**	
C5a (Genetic variation)	Inc-SI-N-SD Inc-SI-N-SD	
C5b (Genetic bottleneck)	Inc-SI-N Inc-SI-N	
C6 (Phenol response)	Inc-SI-N-SD Inc-SI-N-SD	
D1 (Documented response)	GI-Inc-SI-N-SD-Dec GI-Inc-SI-N-SD-Dec	
D2 (Modeled change)	GI-Inc-SI-N-**SD**-Dec GI-Inc-**SI**-N-SD-Dec	These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).

<table>
<tr><td>The CCVI [%]</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>Moderate Scenario</td><td>0</td><td>0</td><td>0</td><td>100</td><td>0</td></tr>
<tr><td>Severe scenario</td><td>0</td><td>0</td><td>0</td><td>50</td><td>50</td></tr>
<tr><td>The MVA**</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td>Moderate Scenario</td><td></td><td></td><td></td><td>-------------------------------</td><td></td></tr>
<tr><td>Severe scenario</td><td></td><td></td><td></td><td>-------------------------------</td><td>-------------------------------</td></tr>
<tr><td></td><td colspan="5">The annual mean temperature of the entire species' range, 5.8°C (range: -1.1 to 17.2°C) (Natural Resources Canada, 2014), is slightly higher than the mean temperature of the park, 4.5°C. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently in the cooler side of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). It can tolerate of several disturbance types and survive in open canopies (Farrar, 1995; Weyenberg et al., 2004). Actually, there are multiple post-fire places where this species has grown (Saunder, 1996; Weyenberg et al., 2004). In support of this, Telfer (2004) recorded regeneration of this species in forest gaps which were created by a powerful hurricane ("Edna") and a following logging campaign in north Queens in Nova Scotia in 1954. Hence, thermal change will be beneficial for white pine under both of the climate change scenarios in terms of GDD5, while more frequent and/or intensified disturbances would be also positive for the same species. Degrees of such positive impacts of climate change on white pine are hard to specify precisely, but future mean temperature under severe climate change scenario will be higher than the mean temperature of the species’ range, indicating a possibility of too warm condition. In this regard, the degree of adaptability may be smaller than those of a few other species that have</td></tr>
</table>

	thermally higher niche (e.g., red oak). So, MA was given for white pine under both of moderate and severe climate change scenarios.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

References cited in just this sheet (references that were already cited in the main text as common documents for many species are not shown here.)

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[Assessment sheet] Climate change vulnerability assessments of red oak (*Quercus rubra*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	The northern part in Fundy National Park is highlands, and therefore slopes may hinder migration of the species to northern and higher areas in the future. However, the topography is not much steep as well. To reflect this partial barrier, SI and N were selected here. These scores were also retained in the MVA, reflecting kind of adaptation opportunity (note that the same species without any highlands should be assessed with more negative scores like Inc due to lack of adaptation opportunity).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-**SD**-Dec GI-Inc-SI-**N**-**SD**-Dec	Its effective seeding distance is 30 m but possibly reach 3,000 m (He and Mladenoff, 1999). Jays collect and disperse viable nuts of this species for 4-5 km (Crow, 1988; USDA, n.d.). Maximum seed dispersal distance of this species is around 1 km, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** Dec GI-Inc-SI-N-**SD** Dec	The annual mean temperature of the entire species' range, 9.8°C (range: 1.3 - 19.7°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.5°C. While the Growing-Degree Days (GDD5) under the present climate is close to or below the lower limit of this species' distribution, the GDD5 under the two climate change scenarios will be within of the distribution (c.f., Appendix). In terms of Growing-Degree Days (GDD5), Fundy National Park is currently colder than the cooler side of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species is commonly seen on light or well-drained soils (Roland, 1945; Saunders, 1996; Boland, 2012). It can regenerate better on mesic soils than exposed soils, being relatively sensitive to droughts among oak species (Crow, 1988).
C2c (Disturbance)	Inc-SI-N-**SD**-Dec Inc-SI-N-**SD**-Dec	This species is tolerant to fires (Crow, 1988; Saunders, 1996; Abrams, 2003). Its seedlings require lights to grow (Farrar, 1995).
C2d (Ice/Snow)	GI-Inc-SI-**N** GI-Inc-SI-**N**	

<table>
<tr><td>C3
(Physical habitat)</td><td>Inc-SI-**N**-**SD**-Dec
Inc-SI-**N**-**SD**-Dec</td><td colspan="5">It is found on a wide range of soils, from sands and stone-free deep soils to shallow and rocky soils (Fowells, 1965; Saunder, 1996). However, slope direction and/or topography (e.g., flat or steep slope) could affect this species' growth (Fowells, 1965). In New Brunswick, sandy/gravelly acid woodland and shores are utilized as habitats for this species (Hinds, 2000).</td></tr>
<tr><td>C4a
(Other spp for habitat)</td><td>GI-Inc-SI-**N**
GI-Inc-SI-**N**</td><td colspan="5">This species is intolerant to competition (Fowells, 1965; Farrar 1995), but still it is not associated with specific co-existing species.</td></tr>
<tr><td>C4b
(Diet)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5"></td></tr>
<tr><td>C4c
(Pollination)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="5">Wind-pollinated (Grob, 2008).</td></tr>
<tr><td>C4d
(Other spp for disp)</td><td>Inc-**SI**-**N**
Inc-**SI**-**N**</td><td colspan="5">Jays collect and disperse viable nuts of this species for 4-5 km, although even other birds and mammals eat the nuts (Crow, 1988; USDA, n.d.).</td></tr>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="5"></td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5"></td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="5"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="5"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="5"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-N-SD-**Dec**
GI-Inc-SI-N-SD-**Dec**</td><td colspan="5">These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).</td></tr>
<tr><td rowspan="3">The CCVI [%]
Moderate Scenario
Severe scenario</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td><td>100</td></tr>
<tr><td rowspan="4">The MVA**
Moderate Scenario
Severe scenario</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td></td><td></td><td></td><td>------------------------------</td><td>------------------------------</td></tr>
<tr><td></td><td></td><td></td><td></td><td>------------------------------</td></tr>
<tr><td colspan="5">The annual mean temperature of the entire species' range, 9.8°C (range: 1.3 - 19.7°C) (Natural Resources Canada, 2014), is much higher than the mean temperature of the park, 4.5°C. While the Growing-Degree Days (GDD5) under the present climate is close to or below the lower limit of this species' distribution, the GDD5 under the two climate change scenarios will be within of the distribution (c.f., Appendix). In terms of Growing-Degree Days (GDD5), Fundy National Park is currently colder than the cooler side of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). This species is tolerant to fires (Crow, 1988; Saunders, 1996; Abrams, 2003). Its seedlings require lights to grow (Farrar,</td></tr>
</table>

	1995). Overall, this oak species could flourish due to temperature increase as well as more frequent and/or intensified disturbances than now, and therefore red oak will be adaptable. Under severe climate change scenario in particular, the temperature will be the most optimal temperature for the oak, and in this regard HV was chosen for this species.

*, The upper and lower lines in each subscore cell mean subscores assuming moderate and severe climate change scenarios respectively. The bold letters with underlines are the subscores rated in the CCVI program, while the red letters with grey backgrounds are those rated in the MVA.

**, the MVA index was determined qualitatively by respective rationale, and vulnerability was specified by one or two indexes with dotted lines (---).

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[Assessment sheet] Climate change vulnerability assessments of eastern hemlock (*Tsuga canadensis*) in Fundy National Park.

Subfactor	Subscore*	Rationale*
B1 (Sea level)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
B2a (Natural barriers)	GI-Inc-**SI**-**N** GI-Inc-**SI**-**N**	The northern part in Fundy National Park is highlands, and therefore slopes may hinder migration of the species to northern and higher areas in the future. However, the topography is not much steep as well. To reflect this partial barrier, SI and N were selected here. These scores were also retained in the MVA, reflecting kind of adaptation opportunity (note that the same species without any highlands should be assessed with more negative scores like Inc due to lack of adaptation opportunity).
B2b (Artificial barriers)	GI-Inc-SI-**N** GI-Inc-SI-**N**	
B3 (CC mitigation)	Inc-SI-**N**-SD-Dec Inc-SI-**N**-SD-Dec	
C1 (Dispersal/Movement)	GI-Inc-SI-**N**-SD-Dec GI-Inc-SI-**N**-SD-Dec	Effective seeding distance of this species is supposed to be around 30 m (He and Mladenoff, 1999), whereas occassionally it can disperse seeds over many tens of km (Davis, 1989). Maximum seed dispersal distance of this species is around 100 m, according to Scheller and Mladenoff (2005).
C2ai (Historical thermal niche)	GI-Inc-SI-**N**-SD GI-Inc-SI-**N**-SD	
C2aii (Physiological thermal niche)	GI-Inc-SI-N-**SD** Dec GI-Inc-SI-**N**-**SD** Dec	The annual mean temperature of the entire species' range, 6.3°C (range:-1.0 to 18.3°C) (Natural Resources Canada, 2014), is higher than the mean temperature of 4.5°C in the park. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently close to the cooler limit of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix).
C2bi (Historical hydrological niche)	GI-Inc-SI-N-SD GI-Inc-SI-N-SD	
C2bii (Physiological hydrological niche)	GI-Inc-**SI**-N-SD GI-Inc-**SI**-N-SD	This species prefers moist sites with good drainage (Roland, 1945; Farrar, 1995; Saunders, 1996; Haas and McAndrews, 2000).
C2c (Disturbance)	Inc-**SI**-N-SD-Dec **Inc**-SI-N-SD-Dec	It is shade-tolerant (Farrar, 1995) and therefore not strongly depend on forest gaps. This species is highly vulnerable to fire, and it may have been distributed more abundantly before fire disturbances (Fowells, 1965; Roland, 1980; Foster and Zebryk, 1993). In contrast, fires have contributed to colonizations of some hemlock populations in southwestern Nova Scotia, and therefore fires may be both negative and positive for this species depending on some other factors (Mosseler et al., 2003). However, such fire effects may not be relevant in Fundy, where forest fires are unlikely to occur. Wind also could harm larger-size hemlocks (Fowells, 1965).

<table>
<tr><td></td><td></td><td colspan="4">According to Mosseler et al. (2003), intense deer browsing may be the most serious pressure on this species' regeneration currently across its distribution. Given that deer will flourish especially under severe climate change scenario, here "Inc" was chosen under severe scenario.</td></tr>
<tr><td>C2d
(Ice/Snow)</td><td>GI-Inc-SI-**N**
GI-Inc-SI-**N**</td><td colspan="4"></td></tr>
<tr><td>C3
(Physical habitat)</td><td>Inc-SI-**N**-**SD**-Dec
Inc-SI-**N**-**SD**-Dec</td><td colspan="4">This species particularly perfers acidic, sandy, rocky, or glacial till soils (Roland, 1945; Natural Resources Canada, 2014). In New Brunswick, this species is common in rocky and moist soils ion north facing slopes/ravines/ridges (Hinds, 2000).</td></tr>
<tr><td>C4a
(Other spp for habitat)</td><td>GI-Inc-SI-**N**
GI-Inc-SI-**N**</td><td colspan="4">This species was considered to lose in competitions with very shade-tolerant trees (e.g., sugar maple, beech, and red spruce) (Rogers, 1977). However, this species is also shade-tolerant (Farrar, 1995), being codistributed with white pine, red spruce, yellow birch, and sugar maple (Saunders, 1996).</td></tr>
<tr><td>C4b
(Diet)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>C4c
(Pollination)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="4">Wind-pollinated (Potter et al., 2012).</td></tr>
<tr><td>C4d
(Other spp for disp)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="4">Wind-dispersed species (Davis et al., 1991).</td></tr>
<tr><td>C4e
(Other spp interaction)</td><td>Inc-SI-**N**
Inc-SI-**N**</td><td colspan="4"></td></tr>
<tr><td>C5a
(Genetic variation)</td><td>Inc-**SI**-N-SD
Inc-**SI**-N-SD</td><td colspan="4">A population in southern New Brunswick (UNB Wood Lot) showed lower intra-population genetic variation in comparion with those of other hemlock populations in this species' distribution (Potter et al., 2012). Lemieux et al. (2011) also reported remarkably lower genetic variation in a population in Fundy National Park than those of other populations by using polymorphic chloroplast DNA markers.</td></tr>
<tr><td>C5b
(Genetic bottleneck)</td><td>Inc-SI-N
Inc-SI-N</td><td colspan="4"></td></tr>
<tr><td>C6
(Phenol response)</td><td>Inc-SI-N-SD
Inc-SI-N-SD</td><td colspan="4"></td></tr>
<tr><td>D1
(Documented response)</td><td>GI-Inc-SI-N-SD-Dec
GI-Inc-SI-N-SD-Dec</td><td colspan="4"></td></tr>
<tr><td>D2
(Modeled change)</td><td>GI-Inc-SI-**N**-SD-Dec
GI-**Inc**-SI-N-SD-Dec</td><td colspan="4">These changes were predicted by Maxent (AR5-composite) assuming RCP 4.5 and 8.5 in 2071-2100 (Natural Resources Canada, 2014).</td></tr>
<tr><td rowspan="3">The CCVI [%]
Moderate Scenario
Severe scenario</td><td>Extremely Vulnerable</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Increase Likely</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>100</td><td>0</td></tr>
<tr><td>0</td><td>13</td><td>87</td><td>0</td><td>0</td></tr>
<tr><td rowspan="2">The MVA**
Moderate Scenario</td><td>Highly Vulnerable</td><td>Moderately Vulnerable</td><td>Presumably Stable</td><td>Moderately Adaptable</td><td>Highly Adaptable</td></tr>
<tr><td></td><td></td><td>------------------------------</td><td>------------------------------</td><td></td></tr>
</table>

Severe scenario			-------------------------------	-------------------------------	
	The annual mean temperature of the entire species' range, 6.3°C (range:-1.0 to 18.3°C) (Natural Resources Canada, 2014), is higher than the mean temperature of 4.5°C in the park. In terms of Growing-Degree Days (GDD5), Fundy National Park is currently close to the cooler limit of the species' distribution, and it will be closer to the middle of the distribution under moderate and severe climate change scenarios (c.f., Appendix). It is shade-tolerant (Farrar, 1995) and therefore not strongly depend on forest gaps. This species is highly vulnerable to fire, and it may have been distributed more abundantly before fire disturbances (Fowells, 1965; Roland, 1980; Foster and Zebryk, 1993). In contrast, fires have contributed to colonizations of some hemlock populations in southwestern Nova Scotia, and therefore fires may be both negative and positive for this species depending on some other factors (Mosseler et al., 2003). However, such fire effects may not be relevant in Fundy, where forest fires are unlikely to occur. Wind also could harm larger-size hemlocks (Fowells, 1965). According to Mosseler et al. (2003), intense deer browsing may be the most serious pressure on this species' regeneration currently across its distribution. Given that deer will flourish especially under severe climate change scenario, here "Inc" was chosen under severe scenario. In conclusion, temperature increase will be beneficial for hemlock, but disturbances (deer browsing in particular) will be harmful to this species. Under moderate climate change scenario, the former effect (the positive effect) may outweigh the latter effect (the negative effect), and possibly the hemlock population will moderately grow. In contrast, under severe climate change scenario, because the negative impact of deer browsing will increase with less snow accumulation, the positive effect of temperature increase might be canceled out. However, still the effect of temperature increase is more direct and guaranteed than the indirect effect of climate change via deer browsing. In this regard, not only PS but also MA were chosen under severe climate change scenario again.				

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