An Assessment of Species Vulnerability to Climate Changes in New Brunswick

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March 2022

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2022

Published by:
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This project was a collaboration between Eastern Charlotte Waterways Inc. and the New Brunswick Department of Energy and Resource Development.

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Project Overview

Introduction

The threats of climate change are predicted to intensify over the coming decades and as such, it is important to understand the evolving nature of the threat that climate change poses to species of flora and fauna in New Brunswick. The province will experience higher average temperatures across all seasons and higher annual precipitation, though extremes in precipitation (flooding and drought) will also intensify (Roy and Huard, 2016). Effects of climate change that could negatively impact key species include: shifts in forest composition as boreal species are replaced with warmer-adapted species (Vaughn et al., 2021; Taylor et al., 2017), northward shift of novel pathogens and increased favorable conditions for existing ones (e.g. Cuddington et al., 2018), increased heat stress - particularly in freshwater fishes (Todd et al., 2011; Cassie, 2013; Poesch et al., 2016) - and the degradation/loss of coastal ecosystems due to sea level rise.

This project sought to achieve Action #90 of the Province's Climate Change Action Plan: *Transitioning to a Low-Carbon Economy* which states:

> *"While balancing the economy and the environment, identify and focus on the most climate-vulnerable species, habitats, and landscapes as targets for adaptation action and manage for landscape connectivity to allow for species migration"*

Methods

This project follows the methods of Whitman et al. (2013) with some modifications. Information on species vulnerability was gathered via an online survey which featured an automated vulnerability score calculation and an opportunity for experts to indicate

their agreement with the automatic score. A virtual workshop was held to fill in gaps and discuss species that did not receive many responses in the survey.

Results

Fungi and lichens (77% scoring 'high'), plants (74% scoring 'high'), and freshwater fishes (74% scoring 'high') had the highest number of vulnerable species *relative to their own groups*[1]. The most common vulnerability traits had to do with habitat specificity and habitat availability. Traits having to do other stressors such as pathogens and physiological tolerance were less common, though this is partially due to higher uncertainty in these areas.

The workshop highlighted the need for more collaboration between climate scientists and species experts. Though province-wide temperature and precipitation projections are available and have their uses, the effects of those changes on specific ecosystems and key sites for a given species requires more investigation. Future studies could also benefit from having a standard set of climate scenarios and deterministic models to allow for more direct comparability.

Methods

This project follows the methods of Whitman et al. (2013) with some modifications. Information on species vulnerability was gathered via an online survey which featured an automated vulnerability score calculation and an opportunity for experts to indicate their agreement with the automatic score. A virtual workshop was held to fill in gaps and discuss species that did not receive many responses in the survey.

Expert Solicitation

A list of experts to contact was compiled by the New Brunswick Department of Natural Resources and Energy Development. The contact list contained 101 experts including wildlife biologists, research scientists, PhD candidates, and senior staff at organizations such as Parks Canada and the Atlantic Canada Conservation Data Center. Participants were sent an invitation to participate in the project with a link to the online survey.

[1] Comparing species vulnerability across groups was beyond the scope of this project. This survey was designed to understand species vulnerability *within* species groups, but groups cannot be directly compared to one another.

Online Survey

The online survey was written with Google Forms. Its functionality, including automated scoring and emails, was extended with the Google Apps Script platform.

The online survey broke species down into eight groups:

- Amphibians and reptiles
- Birds
- Freshwater fishes
- Fungi and lichens
- Insects
- Mammals
- Molluscs
- Plants

The survey was administered as per the methods of Whitman et al. (2013) with some modifications. In brief, the survey was composed of two parts; in part 1, respondents identified which species they were assessing and checked off statements related to vulnerability across six different trait areas. The traits areas and statements within were largely taken from Whitman et al. (2013) with some modifications to account for geographically specific concerns.

For a given response, each trait area was assigned a trait vulnerability score (TVS) depending on how many statements the respondent checked, including statements that respondents added themselves. An overall vulnerability score (OVS) was assigned based on the composition of TVSs[2] (see Box 1 for scoring logic). Participants were also asked to identify habitat(s) that are critical for a particular life stage and/or reproduction.

Respondents were emailed their automatically calculated OVS with a link to part 2, in which they were invited to modify the OVS and indicate their confidence in it. Space for final comments was provided in both surveys.

After survey data was gathered, several analyses were run to explore the characteristics of the data, including cross-comparisons of species that were identified

[2] An error in the automated score was detected after response collection in which comments written in the "Other" option were counted as additional vulnerability traits even if the respondent was only expanding on a trait already identified. The results presented reflect the dataset after this correction was fixed.

as at-risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

Box 1: Survey Scoring Logic

Trait scores:

- If no options are checked for a given trait, the trait score is “low”.
- If one option is checked, the trait score is “medium”.
- If two or more options are checked, the trait score is “high”

Overall score:

- If all trait scores are “low”, the overall score is “low”.
- If exactly one trait is “high” AND less than half are “medium”, the overall score is “medium”.
- If more then one trait is “high” OR more than half of the traits are “medium”, the overall score is “high”.
- In all other cases, the overall score is assigned as the most frequently occuring trait score.

Workshop

A ~1.5 hour virtual workshop was held on March 9th, 2022 to get experts’ feedback on the vulnerability scores. 26 of the ~50 experts invited were in attendance. Species were pre-grouped into categories (see below) and experts were invited to speak on any species they saw within that category. A virtual poll was also available for participants to answer if they did not wish to speak. The categories were presented as follows:

- Species-At-Risk with one or no assessors
- Species who ranked as ‘high’ but had only one assessor
- Species that had conflicting scores

Species Vulnerability Results

Response coverage

The vulnerability survey concluded with 304 results spread across the eight species groups (Fig. 1). Mammals were the most commonly assessed species (n=97), followed by birds (n=61) and plants (n=43). Molluscs (n=5) were the least commonly assessed group.

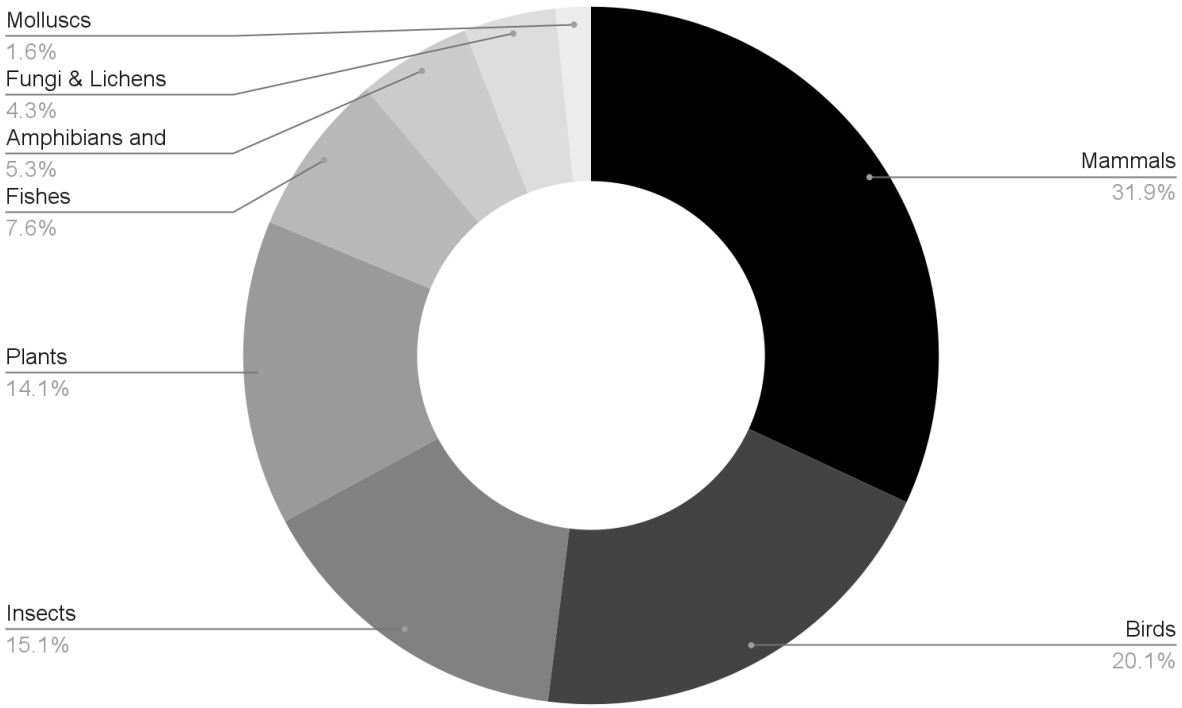

Figure 1: Survey Responses by Species Group. A total of 304 responses were received for the species vulnerability survey. Mammals were the most commonly assessed group followed by birds and plants.

Within the 304 responses there were 163 unique species (Fig. 2). Birds, mammals, and plants had the highest number of unique species (n = 50, 38, and 27 respectively). Insects (n=22) and fishes (n=11) were in the middle range, and fungi and lichens, molluscs, and amphibians and reptiles had the least unique species (n = 6, 5, and 4 respectively).

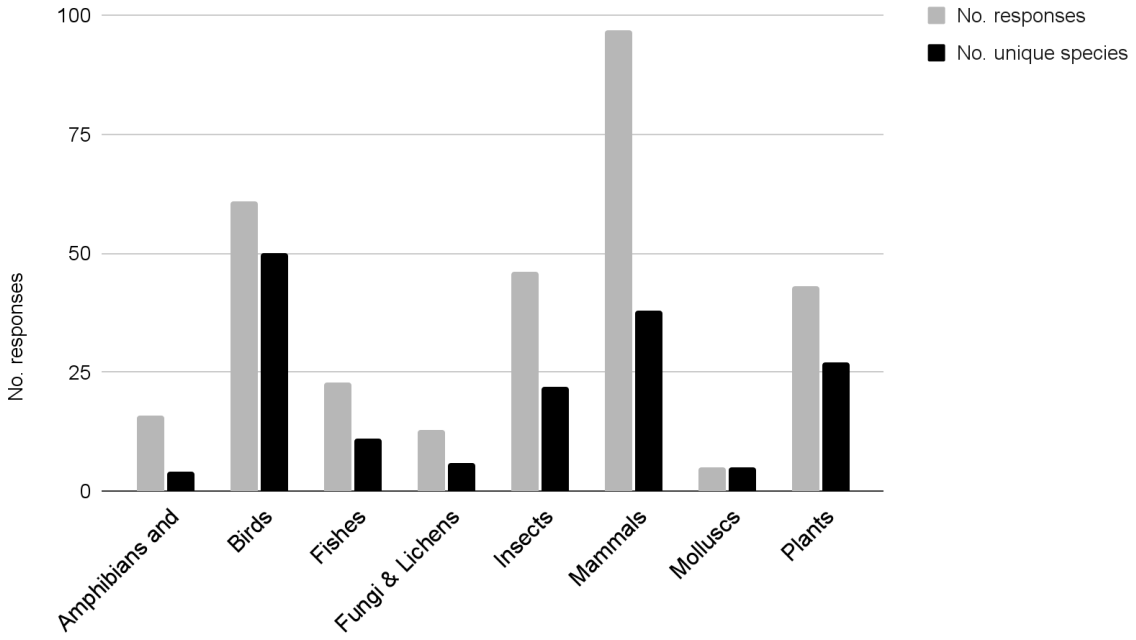

Figure 2: Number of total and unique responses by species group

Coverage of species at risk was assessed using both a federal (COSEWIC) and provincial (New Brunswick Species At Risk Public Registry or “NB-SAR”) list. Under the federal list (Fig. 3), it was found that amphibians/reptiles, fishes, and molluscs had the most coverage, with at least one response for each species at-risk (100% coverage). Insects and Mammals had good coverage (66% and 57%, respectively) while plants (28%) and birds (25%) had the least. There are no fungi/lichen species listed in the species at-risk data sheet that was used.

Under the provincial list (Fig. 4), fishes (100%) and fungi and lichens (75%) received good coverage while all other groups received a moderate (40-70%) coverage.

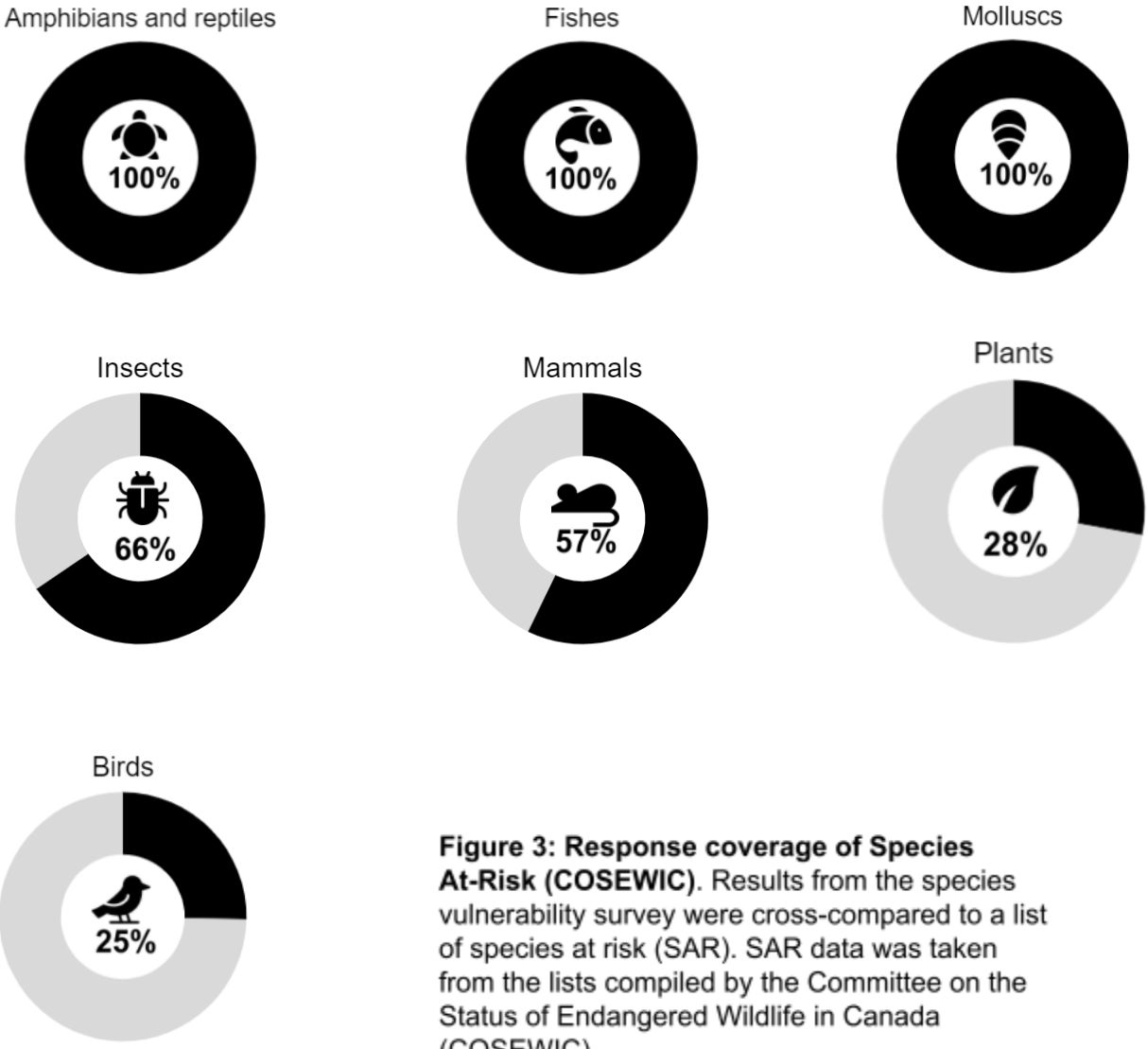

Figure 3: Response coverage of Species At-Risk (COSEWIC). Results from the species vulnerability survey were cross-compared to a list of species at risk (SAR). SAR data was taken from the lists compiled by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC).

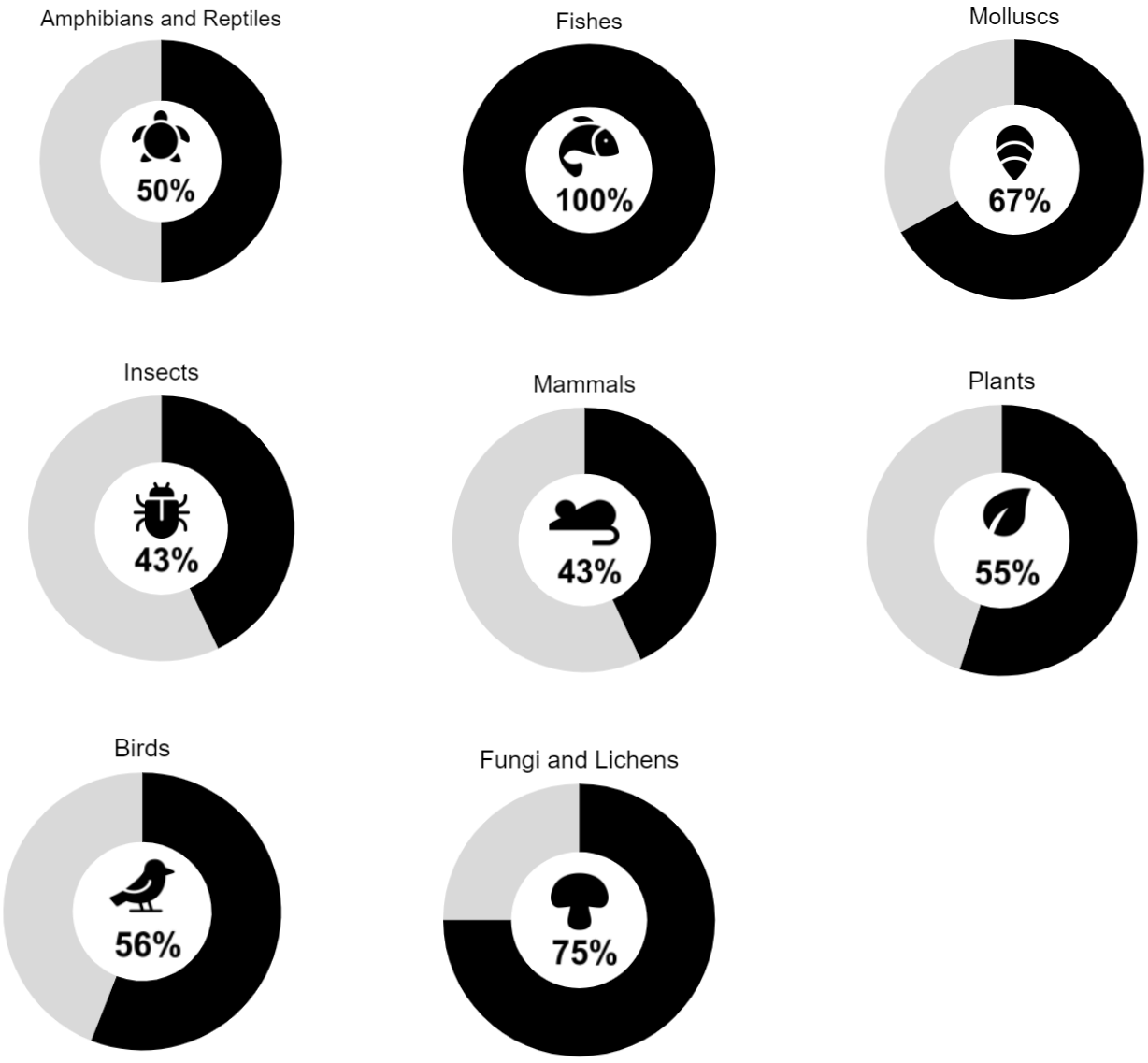

Figure 4: Response coverage of Species At-Risk (NB-SAR Act). Results from the species vulnerability survey were cross-compared to a list of species at risk (SAR). SAR data was taken from the New Brunswick Species At Risk Public Registry.

Vulnerability Analysis

According to the survey results, fungi and lichens (77% scoring 'high'), plants (74% scoring 'high'), and freshwater fishes (74% scoring 'high') have the highest number of vulnerable species *relative to their own groups* (Fig. 4). Insects and mammals had the least (24% and 14% scoring 'high' respectively), while amphibians and reptiles, birds, and molluscs fell in the middle range with between 40-50% of species assessed scoring 'high'.

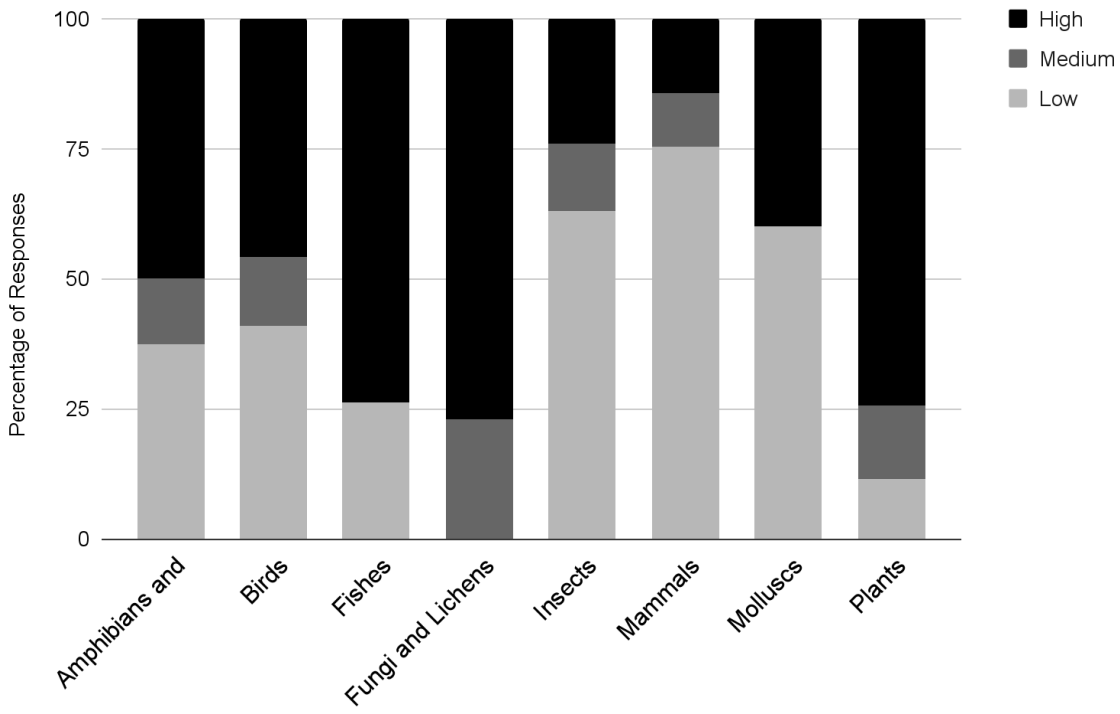

Figure 5: Distribution of vulnerability scores by species group

Across all species, of the trait scores listed as 'high', the most frequently occurring trait area was habitat availability (n=60) followed by habitat specificity (n=20; Fig. 5). The other trait areas were similar in their share of 'high' scores, ranging from 20 to 29 instances. This pattern was reflected when trait scores were broken down by species group, though responses for both fishes and amphibians and reptiles indicate more issues with pathogens relative to other groups.

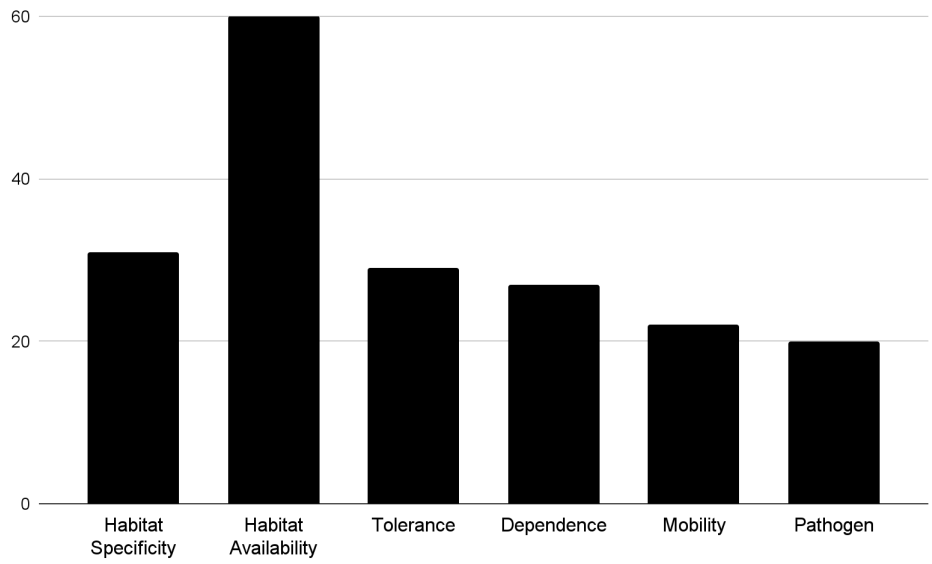

Figure 6: Number of trait scores marked as "high" (all species)

Expert feedback

Of the 304 responses received for part 1, 180 had a matching entry for part 2. Note that an error in the automated score (see footnote on page 4) resulted in some of the scores being higher than they should have.

The results for part 2 indicate that 76% of respondents agreed with their assessed score. 56% of those who agreed stated high confidence in their score and 43% stated medium confidence. A small remainder (1%) stated low confidence. Of those who adjusted their score, 65% changed it to a lower score, while 35% changed to a higher score. Of those who adjusted their score, 19% reported high confidence, 76% reported medium confidence, and 4% reported low confidence.

During the workshop, some key insights emerged regarding various aspects of the assessment, including knowledge gaps and the importance of stressors other than climate change (Box 2).

Box 2: Key insights from workshop with species experts

- Uncertainties and lags in habitat/species shifts can make it difficult to predict how climate change will impact some species.
- Protecting the integrity of key habitats should be a priority action since many species' vulnerability traits are habitat-related.
- Some habitat-related metrics such as humidity and water cycling are not well understood at the regional/site level. Additional studies would help achieve more confident vulnerability assessments.
- Some species are more affected by resource management than by climate change, although they may be impacted by climate change indirectly.

Groups with a high number of vulnerable species

Fungi & Lichens

All but one (83%) of the fungi and lichen species assessed were identified as having forested wetlands as a critical habitat. Minerotrophic forests specifically were identified as a key habitat for two species: *Leptogium hirsutum* and *Lecanora insignis*. The responses for the remaining species, the Eastern Waterfan (*Peltigera hydrothyria*), identified clear, low-order forested streams as critical habitat.

Two species, *L. hirsutum* and the *Pannaria lurida* (Wrinkled Shingle Lichen) were noted to be vulnerable to the potential advancing of the Emerald Ash borer or EAB, a species of beetle that feeds on ash trees. These results were corroborated by a respondent who assessed Black Ash tree itself. Generally, species who are currently at their northern edge may see a range expansion although experts noted that changes in precipitation cycles could still negatively affect these species because of decreased soil moisture and increasingly worse droughts.

In both the survey and workshop, fog and humidity were noted as important factors for several species in this group. The effects of climate change on these variables remains a knowledge gap in the province. Existing studies that model water cycling and climate

change (e.g. Kurylyk et al., 2013; Shrestha et al., 2017) rarely focus on fog and humidity specifically, though they could offer a foundation for future studies that do.

All fungi and lichen species listed under the NB-SAR Act received a score of 'medium' or 'high'

Table 1: Assessment scores of at-risk fungi and lichen species

Species	Score	Status (COSEWIC)	Status (NB SAR Act)
Blue Felt Lichen (*Degelia plumbea*)	high	N/A	Special Concern
Vole Ears Lichen (*Erioderma mollissimum*)	medium		Endangered
	high		
Wrinkled Shingle Lichen (*Pannaria lurida*)	medium		Pending
	high (4)		

Plants

The most common vulnerable trait areas for plants were habitat availability (29% of responses ranking 'high' in this trait area) and mobility (22% of responses ranking 'high'). Of the plant species that were ranked as high, the most commonly identified critical habitat was forested wetland (32% of species) and alkaline bedrock outcrops (28% of species).

Plant species at-risk (Table 2) received a mix of responses. Most responses for these species leaned toward 'high' although three of the four assessments for Butternut (*Juglans cinerea)* were 'low'.

Table 2: Assessment scores of at-risk plant species

Species	Score	Status (COSEWIC)	Status (NB SAR Act)
Beach pinweed (*Lechea maritima*)	medium	-	Special concern
	high (2)		
Butternut (*Juglans cinerea*)	low (3)	-	Endangered
	high		
Furbish's Lousewort (*Pedicularis furbishiae*)	high (2)	-	Endangered

Gulf of St. Laurence aster (*Symphyotrichum laurentianum*)	medium high	-	Endangered
Southern Twayblade (*Listera australis*)	high	At risk	Endangered
Van Brunt's Jacob's-ladder (*Polemonium vanbruntiae*)	high	-	Threatened

Freshwater fish

Fish species at risk mostly scored ‘low’ with the exception of the Atlantic Salmon (*Salmo salar*) and the American eel (*Anguilla rostrata*).

The Atlantic Salmon is a noteworthy species due to its previous recognition as both a culturally and ecologically important species, and, because of its migration, a species that is vulnerable to both changing oceans and freshwater systems. One respondent noted that while the salmon is vulnerable, it is also very resilient and could fare quite well given sufficient protection, such as cold water refugia and habitat restoration.

Trends in respondents' commentary in the survey indicate that thermal stress and reduced availability of cold water refugia is a top concern for freshwater fishes in the province.

The striped bass (*Morone saxatilis*) received conflicting scores; one ‘high’ and one ‘low’. Both responses identified that the species preferred habitat is uncommon, and one respondent (OVS=’low’) commented that the species’ spawning grounds is limited to one area in the province. The other respondent (OVS=’high’) offered more information about the species thermal tolerance and a known or suspected genetic bottleneck. This additional information would have increased the OVS.

The high scores of the Arctic Char (*Salvelinus alpinus*) and Lake trout (*Salvelinus namaycush*), which are not listed under the NB-SAR act but are listed as ‘Sensitive’ federally, were corroborated during a post-workshop meeting with fish experts who did not attend on March 9th. The Brook Trout, which is on neither SAR list, was also identified as highly vulnerable (see Table A3).

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Table 3: Assessment scores of at-risk freshwater fish species

Species	Score	Status (COSEWIC)	Status (NB SAR Act)
American Eel (*Anguilla rostrata*)	low high	-	Threatened
Atlantic Salmon (*Salmo salar*)	high (7)	Sensitive	Special concern (Gaspe-Southern Gulf of St. Lawrence population), Endangered (Bay of Fundy populations)
Atlantic Sturgeon (*Acipenser oxyrhynchus*)	low	Sensitive	Threatened (Maritimes population)
Rainbow Smelt (*Osmerus mordax*)	low	At risk	Threatened
Shortnose Sturgeon (*Acipenser brevirostrum*)	low	Sensitive	Special concern
Striped Bass (*Morone saxatilis*)	low high	At risk	Special concern (Southern Gulf of St. Lawrence population), Endangered (Bay of Fundy population)

Habitat and Vulnerability

This survey asked respondents to indicate habitats that are critical for a particular lifecycle stage and/or species reproduction. When species vulnerability scores are broken down by these habitats (Fig. 6), our results indicate that of the species assessed, bogs (54% scoring ‘high’), fens (50% scoring ‘high’), and forested wetlands (49.2% scoring ‘high’) are most likely to house vulnerable species. Freshwater marshes, coastal marshes, spruce-fir dominated forests, mixed-wood dominated forests, and pine-dominated forests fell in the middle range, with 20-30% of responses representing a highly vulnerable species. Hardwood and tolerant hardwood forests saw less than 20% of responses representing a highly vulnerable species.

It is also useful to look at these results in absolute numbers (Fig. 7). In absolute terms, species in forested wetlands received the highest number of ‘high’ responses (n=29) followed by spruce-fir dominated forests (n=24) and freshwater marshes (n=20). Note

that not all respondents identified critical habitats, and many identified critical habitats that were more specific than the categories discussed here. Thus within each category there may be noteworthy micro-habitats that service a particular species, or group of species.

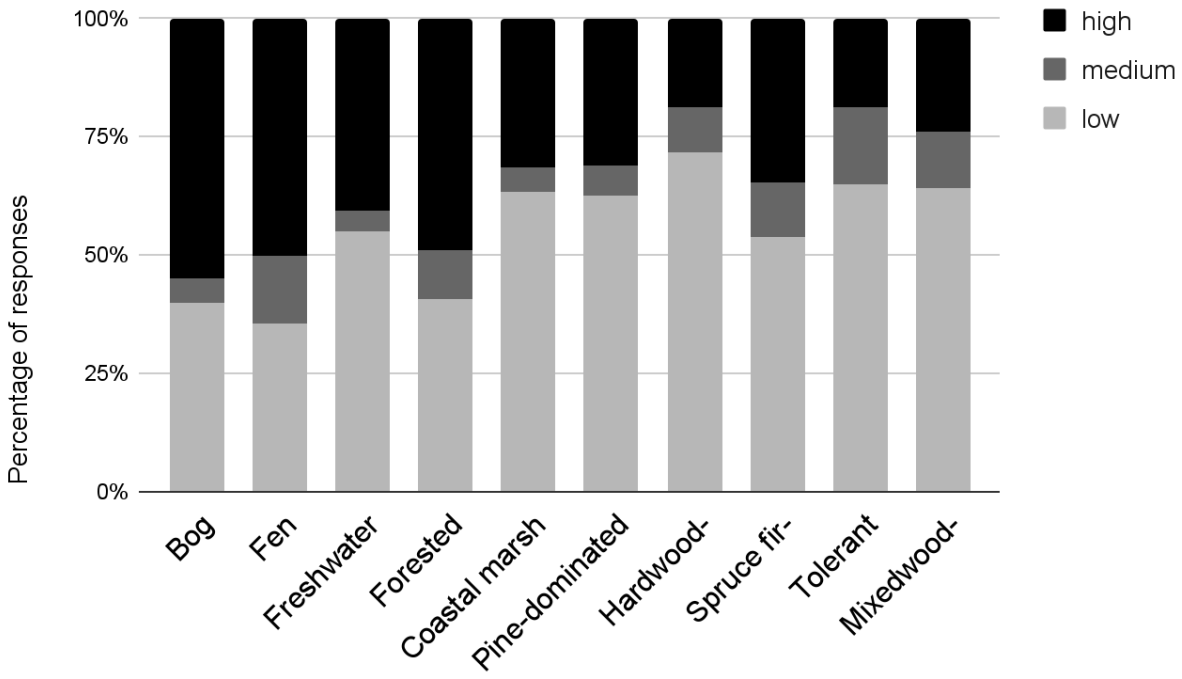

Figure 7: Species vulnerability scores by critical habitat (percentages)

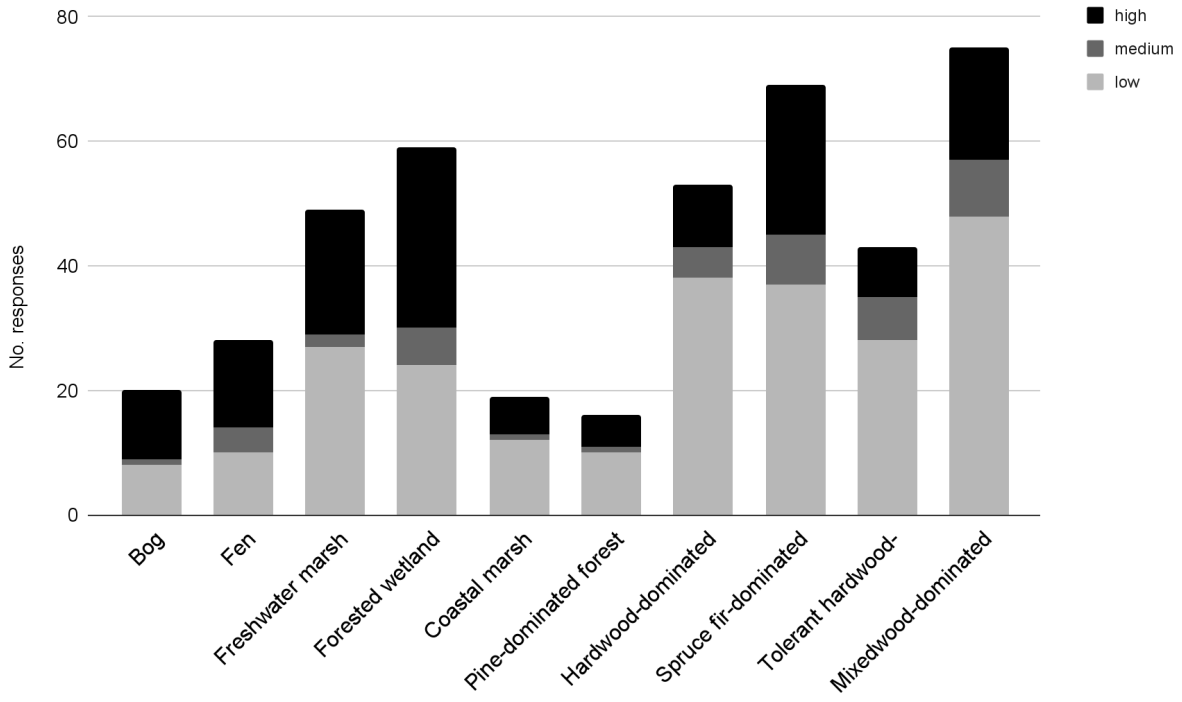

Figure 8: Species vulnerability results by critical habitat (absolute numbers)

Discussion

This project served as an important step in understanding the future of key species in the province with regards to climate change. However, it is important to understand its limitations. Several challenges arose during this project that affected the number of species assessed, the number of expert assessors and distribution of assessed species.

Firstly, one of the major challenges of this project was garnering participation from experts. Unsurprisingly, many experts from across academia, NGOs, industry and government, that were invited to participate, mentioned being busy with their own projects and workloads and, therefore, were unable to participate or devote as much

time as they wished, to completing species assessments. Consequently, experts with knowledge on a vast number of species were only able to complete relatively few species assessments. Some of these experts further commented that given their time limitation, they only assessed species that they felt were most vulnerable to the effects of climate change. Consequently, this may have led to disproportionate representation of species with high vulnerability scores rather than species with medium or low scores under this project.

A further challenge was the experts' own sense of sufficient knowledge to offer feedback. A comment that was frequently stated was that experts felt their knowledge was limited to the species itself and did not have a solid enough understanding of the climate variables and how those variables may affect the species habitat or the other inter-species relationships. Consequently, some experts declined to participate for this reason, leading to a lower number of expert participants than initially forecasted.

A limitation of this project was its design being predominately for terrestrial species rather than aquatic. Some fishes and freshwater mussels were included as species experts could select to assess (and experts were also encouraged to add other species not included); however, the list of key habitats did not include many types that pertained to aquatic species. This lack of representation may not have facilitated or encouraged experts to assess aquatic species, possibly reducing their inclusion in the project.

An overarching comment that was frequently heard during this project from both experts that participated and ones that declined, was the need for modelling of ecosystems and habitats under future climate metrics in New Brunswick and beyond. Without such information, experts reiterated the challenge of predicting species vulnerability with a strong sense of certainty. Models are only as accurate as the data and knowledge used to create them, and the uncertainty of climate change metrics decades into the future adds further complexity. Nonetheless, such model outputs could still offer experts guidance in formulating that assessments of species vulnerability. Future work could model the range and abundance of some of the key habitats and ecosystems identified in this project under future climate change scenarios. Experts could then assess species after reviewing the findings of the modelled habitats.

Conclusions

This project found that fungi and lichen, plants, and freshwater fish had the highest number of vulnerable species *relative to their own groups*. Traits related to habitat

specificity and availability were the most common sources of vulnerability. These results are congruent with Whitman et al. (2013).

Based on these results, efforts related to habitat restoration and habitat health would generate the most benefit for the most species. Conservation and protection efforts may also benefit from studies that model the effects of climate change and a local scale for key sites/ecosystems, especially studies related to water dynamics. This could help address some of the knowledge gaps noted by experts.

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Appendix A - Species Vulnerability Scores

Table A1: Amphibians and reptiles

Species	Score	Status (COSEWIC)	Status (NB SAR Act)
Dusky Salamander (*Desmognathus fuscus*)	medium high (2)	Sensitive	-
Mink Frog (*Lithobates septentrionalis*)	high	-	-
Snapping Turtle (*Chelydra serpentina*)	low (4) high (2)	-	Special concern
Wood Turtle (*Glyptemys insculpta*)	low (2) medium high (2)	At risk	Threatened

Table A2: Birds

Species	Score	Status (COSEWIC)	Status (NB SAR Act)
American bittern (*Botaurus lentiginosus*)	high	-	-
American Crow (*Corvus brachyrhynchos*)	low	-	-
American woodcock (*Scolopax minor*)	low	-	-
Atlantic Puffin (*Fratercula arctica*)	high	Sensitive	-
Bald Eagle (*Haliaeetus leucocephalus*)	low	At risk	Endangered
Bank Swallow (*Riparia riparia*)	high (2)	Sensitive	Pending
Barn Swallow (*Hirundo rustica*)	high (2)	Sensitive	Threatened
Barred Owl (*Strix varia*)	low	-	-
Bay-breasted warbler (*Setophaga castanea*)	high (2)	-	-
Bicknell's Thrush (*Catharus bicknelli*)	low medium high (2)	May be at risk	Threatened
Black Scoter (*Melanitta nigra*)	high	Sensitive	-
Black Tern (*Chlidonias niger*)	high	Sensitive	-
Black-backed Woodpecker (*Picoides arcticus*)	high	-	-
Blackburnian Warbler (*Setophaga fusca*)	medium	-	-
Black-capped Chickadee (*Poecile atricapillus*)	low	-	-
Bobolink (*Dolichonyx oryzivorus*)	high	Sensitive	Threatened
Boreal chickadee (*Poecile hudsonicus*)	low	-	-

	high		
Boreal Owl (*Aegolius funereus*)	low	May be at risk	-
Broad-winged hawk (*Buteo platypterus*)	low	-	-
Canada Warbler (*Wilsonia canadensis*)	high	At risk	Threatened
Cape May Warbler (*Setophaga tigrina*)	high	-	-
Chimney Swift (*Chaetura pelagica*)	high	At risk	Threatened
Common Eider (*Somateria mollissima*)	high	-	-
Common Goldeneye (*Bucephala clangula*)	low	-	-
Cooper's Hawk (*Accipiter cooperii*)	low	May be at risk	-
Eastern Wood-pewee (*Contopus virens*)	medium	-	Special concern
Evening Grosbeak (*Coccothraustes vespertinus*)	high	-	-
Golden-crowned Kinglet (*Regulus satrapa*)	medium	-	-
Gray Jay (*Perisoreus canadensis*)	high*	-	-
Great Horned Owl (*Bubo virginianus*)	low	-	-
Harlequin Duck (*Histrionicus histrionicus*)	low	At risk	Endangered (Eastern population)
Nelson's sparrow (*Ammospiza nelsoni*)	high	-	-
Northern Goshawk (*Accipiter gentilis*)	low	-	-
Northern Saw-whet Owl (*Aegolius acadicus*)	low	-	-
Olive-sided Flycatcher (*Contopus cooperi*)	low medium high	At risk	Threatened
Osprey (*Pandion haliaetus*)	low	-	-
Ovenbird (*Seiurus aurocapilla*)	low	-	-
Peregrine Falcon (*Falco peregrinus anatum*)	low	At risk	Endangered
Pied-billed grebe (*Podilymbus podiceps*)	high	-	-
Piping Plover (*Charadrius melodus*)	medium high	At risk	Endangered
Red-tailed Hawk (*Buteo jamaicensis*)	low	Sensitive	-
Rusty Blackbird (*Euphagus carolinus*)	medium	May be at risk	Special concern
Scarlet Tanager (*Piranga olivacea*)	high	-	-
Solitary Sandpiper (*Tringa solitaria*)	low	-	-
Sora (*Porzana carolina*)	high*	-	-
Spruce Grouse (*Falcipennis canadensis*)	low	-	-
Swainson's thrush (*Catharus ustulatus*)	low	-	-

Three-toed Woodpecker (*Picoides tridactylus*)	high	Sensitive	-
Winter Wren (*Troglodytes hiemalis*)	low	-	-
Wood Thrush (*Hylocichla mustelina*)	low medium	May be at risk	Threatened

*High score was questioned by experts during the workshop. A lower score was recommended.

Table A3: Freshwater fish

Species	Score	Status (COSEWIC)	Status (NB SAR Act)
American Eel (*Anguilla rostrata*)	low high	-	Threatened
Arctic Char (*Salvelinus alpinus*)	high (2)	Sensitive	-
Atlantic Salmon (*Salmo salar*)	high (7)	Sensitive	Special concern (Gaspe-Southern Gulf of St. Lawrence population), Endangered (Bay of Fundy populations)
Atlantic Sturgeon (*Acipenser oxyrhynchus*)	low	Sensitive	Threatened (Maritimes population)
Brook Trout (*Salvelinus fontinalis*)	high (3)	-	-
Brown Trout (*Salmo trutta*)	low	-	-
Lake Trout (*Salvelinus namaycush*)	high (2)	Sensitive	-
Rainbow Smelt (*Osmerus mordax*)	low	At risk	Threatened
Shortnose Sturgeon (*Acipenser brevirostrum*)	low	Sensitive	Special concern
Small-mouth Bass (*Micropterus dolomieu*)	high	-	-
Striped Bass (*Morone saxatilis*)	low high	At risk	Special concern (Southern Gulf of St. Lawrence population), Endangered (Bay of Fundy population)

Table A4: Fungi and lichens

Species	Score	Status (COSEWIC)	Status (NB SAR Act)
Blue Felt Lichen (*Degelia plumbea*)	high	N/A	Special Concern
Eastern Waterfan (*Peltigera hydrothyria*)	medium		-
	high (2)		
Lecanora insignis	high		-
Leptogium hirsutum	high		-
Vole Ears Lichen (*Erioderma mollissimum*)	medium		Endangered
	high		
Wrinkled Shingle Lichen (*Pannaria lurida*)	medium		Pending
	high (4)		

Table A5: Insects

Species	Score	Status (COSEWIC)	Status (NB SAR Act)
American Rubyspot (*Hetaerina americana*)	low (3)	Sensitive	-
Arctic Fritillary (*Boloria chariclea*)	low	-	-
Boreal Snaketail (*Ophiogomphus colubrinus*)	low (3)	May be at risk	-
	high		
Bronze Copper (*Lycaena hyllus*)	low (2)	-	-
Canada Whiteface (*Leucorrhinia patricia*)	low (2)	May be at risk	-
Clayton's (Dorcas) Copper (*Lycaena dorcas claytoni*)	medium (2)	May be at risk	-
Cobblestone Tiger Beetle (*Cicindela marginipennis*)	low	-	Endangered
	medium		
	high (3)		
Cobra Clubtail (*Gomphus vastus*)	low (2)	Sensitive	-
Delicate Emerald (*Somatochlora franklini*)	low	Sensitive	-
Early Hairstreak (*Erora laetus*)	low	-	-
	medium		
	high		
Eastern Red Damsel (*Amphiagrion saucium*)	medium	Sensitive	-
Elegant Spreadwing (*Lestes inaequalis*)	low (2)	Sensitive	-
Forcipate Emerald (*Somatochlora forcipata*)	low	Sensitive	-

Fragile Forktail (*Ischnura posita*)	low	May be at risk	-
Harpoon Clubtail (*Gomphus descriptus*)	low (2)	Sensitive	-
Henry's Elfin (*Callophrys henrici*)	low (2)	-	-
Maritime Ringlet (*Coenonympha tullia nipisiquit*)	low high (3)	-	Endangered
Monarch (*Danaus plexippus*)	low (2) high	Sensitive	Special concern
Mottled Darner (*Aeshna clepsydra*)	low	Sensitive	-
Orange Bluet (*Enallagma signatum*)	low high	May be at risk	-
Quebec Emerald (*Somatochlora brevicincta*)	medium	May be at risk	-

Table A6: Mammals

Species	Score	Status (COSEWIC)	Status (NB SAR Act)
American Marten (*Martes americana*)	medium (2) high (2)	-	-
American Mink (*Neogale vison*)	low (2)	-	-
American Red squirrel (*Tamiasciurus hudsonicus*)	low (2)	-	-
Big Brown Bat (*Eptesicus fuscus*)	low (4)	Sensitive	-
Black Bear (*Ursus americanus*)	low (3)	-	-
Black Rat (*Rattus rattus*)	low (2)	-	-
Bobcat (*Lynx rufus*)	low (6)	-	-
Canada Lynx (*Lynx canadensis*)	low (2) medium (3) high (2)	At risk	Endangered
Deer Mouse (*Peromyscus maniculatus*)	low (2)	-	-
Eastern Chipmunk (*Tamias striatus*)	low (2)	-	-
Eastern Coyote (*Canis latrans*)	low (2)	-	-
Eastern Gray Squirrel (*Sciurus carolinensis*)	low (2)	-	-
Eastern Meadow Vole (*Microtus pennsylvanicus*)	low	-	-
Fisher (*Pekania pennanti*)	low (2)	-	-
Groundhog (*Marmota monax*)	low (2)	-	-
House Mouse (*Mus musculus*)	low	-	-
Little Brown Bat (*Myotis lucifugus*)	medium	Sensitive	Endangered

Long-tailed Shrew (*Sorex dispar*)	low	May be at risk	-
Long-tailed Weasel (*Neogale frenata*)	low (2)	-	-
Meadow Jumping Mouse (*Zapus hudsonius*)	low	-	-
Moose (*Alces alces*)	low medium (2) high (5)	-	-
Muskrat (*Ondatra zibethicus*)	low (2)	-	-
North American Beaver (*Castor canadensis*)	low (3)	-	-
North American Porcupine (*Erethizon dorsatum*)	low (3) high	-	-
North American River Otter (*Lontra canadensis*)	low (2) high	-	-
Northern Flying Squirrel (*Glaucomys sabrinus*)	low high	-	-
Northern Long-eared Bat (*Myotis septentrionalis*)	medium	Sensitive	Endangered
Norway Rat (*Rattus norvegicus*)	low (2)	-	-
Raccoon (*Procyon lotor*)	low (3)	-	-
Red Fox (*Vulpes vulpes*)	low (2)	-	-
Short-tailed Weasel (*Mustela erminea*)	low (2)	-	-
Snowshoe Hare (*Lepus americanus*)	low (4)	-	-
Southern Red-backed Vole (*Myodes gapperi*)	low	-	-
Star-nosed Mole (*Condylura cristata*)	low	-	-
Striped Skunk (*Mephitis mephitis*)	low	-	-
Tricolored Bat (*Perimyotis subflavus*)	low high	-	-
White-tailed Deer (*Odocoileus virginianus*)	low (4) medium (1) high (1)	-	-
Woodland-jumping Mouse (*Napaeozapus insignis*)	low	-	-

Table A7: Molluscs

Species	Score	Status (COSEWIC)	Status (NB SAR Act)
Brook Floater (*Alasmidonta varicosa*)	low	May be at risk	-
Common marsh snail (*Melampus bidentatus*)	low	-	-
Ribbed mussels (*Geukensia demissa*)	high	-	-
Triangle Floater (*Alasmidonta undulata*)	low	Sensitive	Special concern
Yellow Lampmussel (*Lampsilis cariosa*)	high	Sensitive	Special concern

Table A8: Plants

Species	Score	Status (COSEWIC)	Status (NB SAR Act)
Balsam Fir (*Abies balsamea*)	high	-	-
Beach pinweed (*Lechea maritima*)	medium high (2)	-	Special concern
Black Ash (*Fraxinus nigra*)	medium high (3)	-	-
Bog Fern (*Thelypteris simulata*)	high	May be at risk	-
Broad-leaved Twayblade (*Listera convallarioides*)	high	Sensitive	-
Bulrush Sedge (*Carex scirpoidea*)	high	-	-
Bur Oak (*Quercus macrocarpa*)	high	-	-
Butternut (*Juglans cinerea*)	low (3) high	-	Endangered
Calypso; Fairy Slipper (*Calypso bulbosa*)	high (3)	May be at risk	-
Clinton's Wood Fern (*Dryopteris clintoniana*)	medium	-	-
Eastern White Cedar (*Thuja occidentalis*)	low medium high	-	-
Entire-Leaved Mountain-Avens (*Dryas integrifolia*)	high	-	-
Furbish's Lousewort (*Pedicularis furbishiae*)	high (2)	-	Endangered
Gulf of St. Laurence aster (*Symphyotrichum laurentianum*)	medium high	-	Endangered
Inland Bluegrass	high	-	-
Large-leaved Sandwort (*Moehringia macrophylla*)	high	-	-

Menzies' Rattlesnake-plantain (*Goodyera oblongifolia*)	high	Sensitive	-
Multi-rayed Goldenrod (*Solidago multiradiata*)	high	-	-
Northern Holly Fern (*Polystichum braunii*)	high	-	-
Northern woodsia (*Woodsia alpina*)	high	-	-
Purple Violet (*Viola Cucullate*)	low	-	-
Showy Orchis (*Galearis spectabilis*)	medium	May be at risk	-
Small Round-leaved Orchis (*Amerorchis rotundifolia*)	high	May be at risk	-
Southern Twayblade (*Listera australis*)	high	At risk	Endangered
Tubercled-orchid (*Platanthera flava*)	high	May be at risk	-
Van Brunt's Jacob's-ladder (*Polemonium vanbruntiae*)	high		Threatened
Wall-rue (*Asplenium ruta-muraria*)	high	May be at risk	-
White Adder's-mouth (*Malaxis monophylla*)	high	May be at risk	-
Yellow Lady's-slipper (*Cypripedium parviflorum var. makasin*)	high	May be at risk	-

Appendix B - Key Habitats and Vulnerability

Table B1: Distribution of Species Vulnerability Scores by Key Habitat Type

	Species Score		
Habitat	**low**	**medium**	**high**
Bog	8	1	11
Fen	10	4	14
Freshwater marsh	27	2	20
Forested wetland	24	6	29
Coastal marsh	12	1	6
Pine-dominated forest	10	1	5
Hardwood-dominated forest	38	5	10
Spruce fir-dominated forest	37	8	24

Tolerant hardwood-dominated forest	28	7	8
Mixedwood-dominated forest	48	9	18