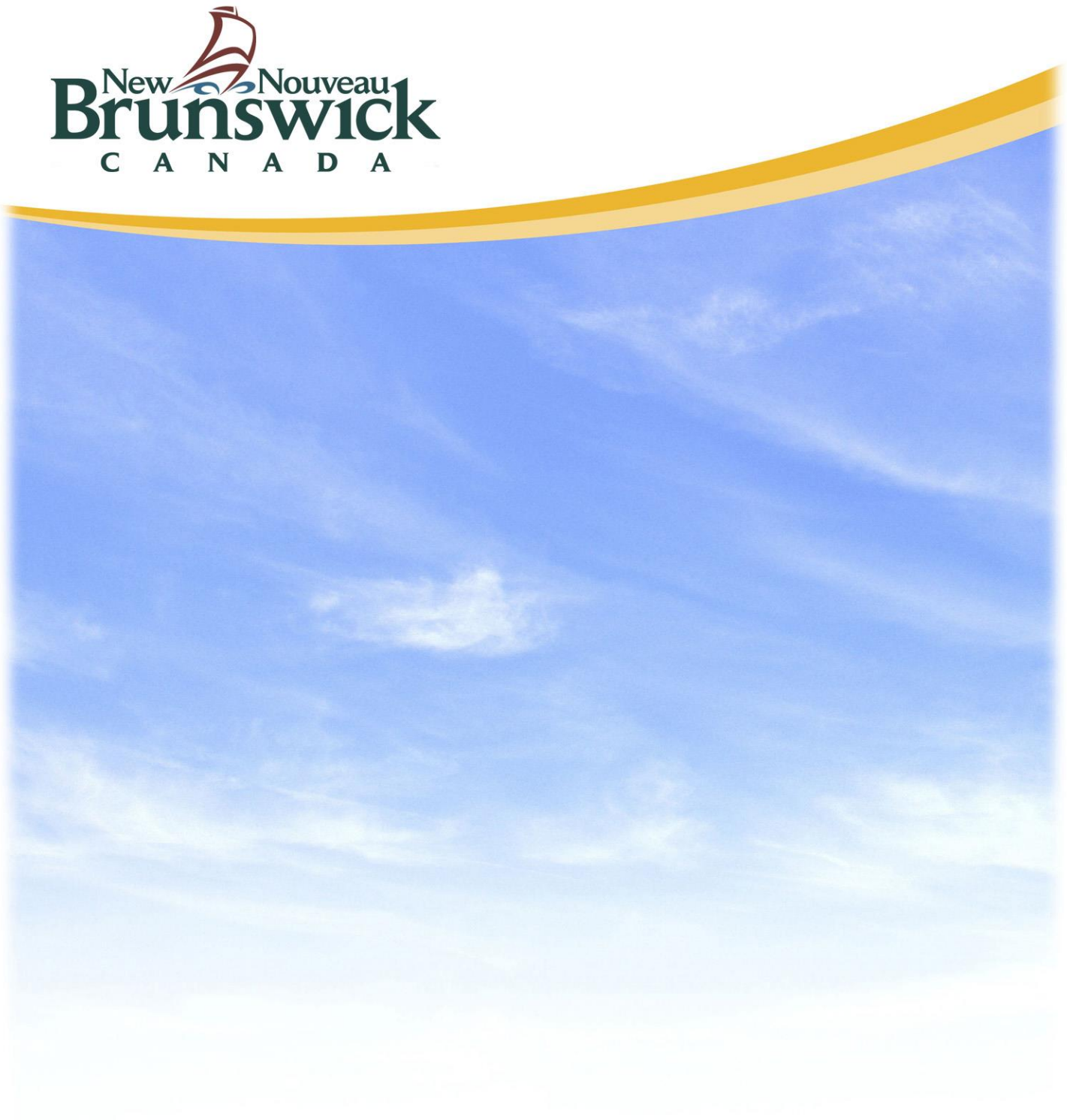

Department of Energy and Resource Development
December 2017

EXECUTIVE SUMMARY

The Eastern Habitat Joint Venture (EHJV) is a partnership of organizations from Ontario eastward dedicated to the conservation of waterfowl and other bird populations. In New Brunswick, partners engaged in program delivery are Bird Studies Canada, Ducks Unlimited Canada, Environment and Climate Change Canada (the Canadian Wildlife Service), the Nature Conservancy of Canada, the Nature Trust of New Brunswick, and the New Brunswick Department of Energy and Resource Development (NB ERD). This report documents a 2-year project undertaken under the auspices of the New Brunswick EHJV with support and funding from Environment and Climate Change Canada.

The intent of the project was to identify and describe the habitat of New Brunswick vertebrates, to assess current habitat abundance, and to identify habitat trends over the 50-year period of 1987 to 2037. The assessment area included all of Crown land (federal and provincial) and small private holdings, an area equivalent to 84% of the Province.

A species-focused land cover classification system was developed using elements of the Province's photo-interpreted inventory data. There are 329 vertebrate species (excluding fish) that breed or overwinter in New Brunswick, or for which the Province provides an important migratory pathway. Due to limitations in the resolution of photo-interpreted inventory data, the scope of the analysis was limited to forest, wetland and coastal habitats, and the 299 species they support. The distributions of uncommon species are not identified well in coarse-resolution analyses such as this one, and habitats were therefore defined based primarily on the needs of 218 relatively common species. Thirteen forest, 16 wetland and 7 coastal habitats were defined to cover the requirements of all retained species. Habitats and species assignments are described in the companion documents *Old Forest Communities and Old-forest Wildlife Habitats in New Brunswick*, *Young-forest Wildlife Habitats in New Brunswick* and *Wetland and Coastal Wildlife Habitats in New Brunswick.*

There are 130 relatively common forest vertebrates, 58 of which occupy young or mid-age conditions and 72 of which occupy old forest. Forest habitat definitions were assessed against stand growth model outputs to generate habitat-specific development patterns for all forest management strata. The patterns were used to estimate habitat abundance from past and current conditions and were incorporated into strategic planning models to estimate future abundance. The value of a habitat depends in part on its spatial configuration on the landscape. Calculated areas of forest habitats were filtered through species-specific sets of spatial criteria to remove individual stands or agglomerations that were too small, too isolated or shaped in such a way as to make them unsuitable. Minimum patch sizes ranged from 10 ha to 375 ha; 33 combinations of habitat type and patch size were assessed.

Old-forest habitats, assessed at their largest minimum patch sizes, declined by 79% (1.28M ha to 272K ha) from 1987 to 2012, and are expected to decline by 15% (to 231K ha) from 2012 to 2037, with most of the change happening by 2022. The sharp decline from 1987 to 2012 was due to harvesting of old forest over the period at a rate which precluded its replacement, due in part to a relatively low abundance of mid-age forest at the outset. The rate of decline drops considerably after 2012, which indicates a substantial reduction in the rate of harvesting of

natural old forest, due to the location of much of that forest within areas managed for conservation and a gradual shift towards the harvest of managed stands. Old-forest habitats vary in abundance and rate of change with land tenure, with private holdings containing substantially less habitat than expected based on total forest area, and non-license Crown land containing substantially more. Threshold levels for old-forest habitats exist for Crown land in license; these were updated to address the increased assessment area of this analysis. One of the 6 old-forest habitats is below its updated threshold level in 2012, and 3 are below threshold levels in 2022. Young and mid-age forest habitats at their largest minimum patch sizes increased by 40% from 1987 to 2012, are expected to increase a further 21% by 2022, and to decline slightly after that. Habitat supplies can be calculated for any species by filtering overall supplies by the relevant patch size.

There are 141 relatively common vertebrates associated with 23 wetland or coastal habitats in New Brunswick. Current habitat abundance was assessed at 6 species-based minimum patch sizes. Relative abundance of all habitats is displayed at the scale of ecodistricts. The resolution of the 1987 land cover inventory within wetlands and coastal areas was low, and it was therefore not possible to reliably identify past habitat conditions. Models were not available for projecting wetland and coastal conditions into the future, and future anthropogenic changes were not known. Many wetland and coastal species use more than one habitat type, and habitat supplies for individual species cannot therefore be readily determined from data presented. Examples of the process of calculating supplies for individual species are given.

The analyses and processes described in this and supporting documents were the most robust available that could be applied at landscape scales; the results are therefore presented as reasonable and defensible estimates of past, present and future habitat supplies. Nonetheless, there were numerous points in the process where different assumptions could have led to somewhat different results. These are discussed at length.

Résumé

Le Plan conjoint des habitats de l'Est (PCHE) est un partenariat d'organismes implantés depuis l'Ontario vers l'Est qui se consacre à la conservation de la sauvagine et d'autres populations d'oiseaux. Au Nouveau-Brunswick, les partenaires qui participent à la prestation des programmes sont Études d'Oiseaux Canada, Canards Illimités Canada, Environnement et Changement climatique Canada (le Service canadien de la faune), Conservation de la nature Canada, La Fondation pour la protection des sites naturels du Nouveau-Brunswick Inc. et le ministère des Ressources naturelles et du Développement de l'énergie (MRNDE). Le présent rapport fait le point sur un projet de deux ans entrepris sous l'égide du PCHE du Nouveau-Brunswick avec le soutien et le financement d'Environnement et Changement climatique Canada.

Le projet visait à déterminer et décrire l'habitat des vertébrés du Nouveau-Brunswick, à évaluer l'abondance de l'habitat actuel et à dégager les tendances de l'habitat sur la période de 50 ans de 1987 à 2037. L'aire d'évaluation comprenait l'ensemble des terres de la Couronne (fédérales et provinciales) ainsi que de petites propriétés privées, pour une superficie équivalant à 84 % de la superficie de la province.

Un système de classification des couvertures terrestres axé sur les espèces a été élaboré à l'aide d'éléments des données d'inventaire photo-interprétées de la province. Il y a 329 espèces de vertébrés (à l'exclusion des poissons) qui se reproduisent ou hivernent au Nouveau-Brunswick, ou pour lesquelles la province fournit une voie migratoire importante. En raison des limites de la résolution des données d'inventaire photo-interprétées, la portée de l'analyse a été limitée à la forêt, aux zones humides et côtières, et aux 299 espèces qu'elles soutiennent. La distribution des espèces rares n'est pas bien délimitée dans des analyses à résolution grossière comme la présente, et les habitats ont donc été définis en fonction principalement des besoins de 218 espèces relativement communes. Treize habitats forestiers, seize habitats de terres humides et sept habitats côtiers ont été définis pour couvrir les besoins de toutes les espèces retenues. Les habitats et l'assignation des espèces sont décrits dans les documents complémentaires *Les communautés de forêt âgée et les habitats fauniques de forêt âgée du Nouveau-Brunswick*, *Young-forest Wildlife Habitats in New Brunswick and Wetland* (en anglais seulement) *et Wetland and Coastal Wildlife Habitats in New Brunswick* (en anglais seulement).

La province compte 130 espèces de vertébrés forestières relativement communes, dont 58 occupent des forêts jeunes ou matures et 72 occupent des forêts anciennes. Nous avons évalué les définitions d'habitat forestier par rapport aux résultats du modèle de croissance des peuplements afin de générer des modèles de développement propres aux habitats pour toutes les strates de gestion forestière. Les modèles ont servi à estimer l'abondance de l'habitat par rapport aux conditions passées et actuelles, et ont été intégrés aux modèles de planification stratégique en vue de l'estimation de l'abondance future.

La valeur d'un habitat dépend en partie de sa configuration spatiale par rapport au paysage. Des ensembles de critères spatiaux propres aux espèces ont été appliqués aux superficies calculées des habitats forestiers pour éliminer les peuplements individuels ou les agglomérations trop petites, trop isolées ou façonnées d'une manière les rendant inaptes. La taille minimale des parcelles variait de 10 ha à 375 ha; 33 combinaisons de type d'habitat et de taille de parcelle ont été évaluées.

Les habitats de forêt ancienne, évalués à leur plus grande taille minimale de parcelle, ont diminué de 79 % (soit de 1,28 million d'hectares à 272 000 hectares) de 1987 à 2012, et devraient diminuer de 15 % (à 231 000 ha) de 2012 à 2037, la majeure partie du changement ayant lieu d'ici 2022. La chute marquée de 1987 à 2012 est attribuable à la récolte de la forêt ancienne au cours de la période à une vitesse qui en a empêché le remplacement, en partie en raison d'une abondance relativement faible de forêts matures au début du processus. La vitesse de déclin diminue considérablement après 2012, ce qui indique une réduction substantielle du taux de récolte de la forêt ancienne naturelle en raison de l'emplacement d'une grande partie de cette forêt dans les zones gérées pour la conservation et d'un changement graduel vers la récolte de peuplements gérés. Les habitats de forêt ancienne varient en

abondance et en vitesse de changement en fonction de la méthode de tenure, les propriétés privées renfermant un nombre sensiblement moins élevé d'habitats que prévu compte tenu de la superficie totale des forêts, et les terres de la Couronne qui ne sont pas visées par des permis en renfermant beaucoup plus. Il existe des niveaux de seuil pour les habitats de forêt ancienne des terres de la Couronne visées par des permis; ils ont été mis à jour pour tenir compte de l'aire d'évaluation accrue de la présente analyse. L'un des six habitats de forêt ancienne est inférieur à son seuil révisé en 2012 et trois sont inférieurs aux niveaux de seuil pour 2022. Les habitats de forêt jeune et de forêt mature à leur plus grande taille minimale de parcelle ont connu de 1987 à 2012 une hausse de 40 %, et devraient augmenter de 21 % d'ici 2022 pour diminuer légèrement par la suite. La disponibilité des habitats peut être calculée pour toute espèce en divisant la superficie totale des habitats par la taille de parcelle pertinente.

Au Nouveau-Brunswick, 141 espèces de vertébrés relativement communes sont associées à 23 habitats de zone humide ou côtière. L'abondance actuelle d'habitats a été évaluée pour six tailles minimales de parcelles basées sur les espèces. L'abondance relative de l'ensemble des habitats est affichée à l'échelle des écodistricts. La résolution de l'inventaire des couvertures terrestres de 1987 dans les zones humides et côtières était faible, et il n'était donc pas possible de déterminer de façon fiable les conditions d'habitat antérieures. Des modèles n'étaient pas disponibles pour faire des projections des conditions des milieux humides et côtiers, et les changements anthropiques futurs n'étaient pas connus. Beaucoup d'espèces de zones humides et côtières utilisent plus d'un type d'habitat, et la disponibilité d'habitats pour chaque espèce ne peut donc pas être facilement déterminée à partir des données présentées. Des exemples du processus de calcul de la disponibilité des habitats pour chaque espèce sont fournis.

Les analyses et les processus décrits dans le présent document et dans les documents à l'appui étaient les plus robustes pouvant être appliqués aux échelles d'aménagement; les résultats sont donc présentés comme des estimations raisonnables et défendables de la disponibilité antérieure, actuelle et future. Néanmoins, pour de nombreux points dans le processus, différentes hypothèses auraient pu donner des résultats quelque peu différents. Ces questions sont étudiées en profondeur.

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INTRODUCTION

The Eastern Habitat Joint Venture (EHJV) is a partnership of organizations from Ontario eastward dedicated to the conservation of waterfowl and other bird populations. In New Brunswick, partners engaged in program delivery are Bird Studies Canada, Ducks Unlimited Canada, Environment and Climate Change Canada (the Canadian Wildlife Service), the Nature Conservancy of Canada, the Nature Trust of New Brunswick, and the New Brunswick Department of Energy and Resource Development (ERD) .

The New Brunswick EHJV Habitat Supply Analysis was a 2-year project undertaken by ERD with support and funding from Environment and Climate Change Canada (ECCC). The intent of the project was to identify and describe the habitat of New Brunswick vertebrates, to assess habitat abundance, and to identify trends. This report is submitted in partial fulfillment of the requirements of Regional Project 1300057, and describes progress made during the term of the ECCC funding (2013-2015) and beyond.

This report is distributed with 3 other documents that provide key information that is not repeated here. They are *Old Forest Communities and Old-forest Wildlife Habitats in New Brunswick, Young-forest Wildlife Habitats in New Brunswick, Wetland and Coastal Wildlife Habitats in New Brunswick,* and *Old-Forest Thresholds for New Brunswick's Crown Forest* (NB ERD 2017a, 2017b, 2017c). Of those, the first 3 present our working classification of forest, wetland and coastal ecosystems and our current understanding of the habitat relationships of the vertebrate species that occupy them. The latter document presents the process used to determine the abundance and distribution of habitat required to maintain viable populations of species across the ranges in which they normally occur. A bibliography of suggested reading on these topics is presented in Appendix 6.

PROJECT RATIONALE

The vision for the EHJV is that landscapes sustain bird populations while providing ecological, social and economic benefits to society (Eastern Habitat Joint Venture 2014). Goals for the North American Waterfowl Management Plan (NAWMP) include maintaining abundant and resilient waterfowl populations and sufficient wetlands and related habitats to sustain waterfowl populations at desired levels (NAWMP 2014). The North American Bird Conservation Initiative (NABCI), itself a partnership that includes EHJV, aims to ensure that populations and habitats of North America's birds are protected, restored and enhanced through coordinated efforts at international, national, regional and local levels (NABCI undated).

The New Brunswick Biodiversity Strategy identifies healthy and resilient native ecosystems and viable populations of native species among its conservation outcomes (PNB 2009). The New Brunswick Crown Lands and Forests Act (1980) provides for the integrated management of the resources of Crown land, which includes habitat for the maintenance of fish and wildlife populations. Goals for the management of New Brunswick Crown land include providing the habitat necessary to support populations of native wildlife at desired levels. The Coastal Areas Protection Policy for New Brunswick and the New Brunswick Wetlands Conservation Policy identify coastal areas and wetlands as unique and valuable habitat for wildlife (NB DELG 2002, NB DNRE / NB DELG 2002).

The *Migratory Birds Convention Act* (MBCA) provides regulations relating to killing or disturbing migratory birds and destroying or disturbing their nests (Canada 1994); the *Bird Conservation Strategy* for Bird Conservation Region 14 in New Brunswick provides conservation objectives and recommended actions intended to support compliance under the MBCA (Environment Canada 2013). The Strategy provides conservation goals and recommended actions intended to support compliance under the MBCA (Environment Canada 2013). The Strategy identifies bird species of conservation priority, including those that are vulnerable due to population size, trend or distribution, those considered typical of the regional avifauna, and those with a large proportion of their continental range in New Brunswick. The most frequent conservation goal for priority species is provision of adequate habitat.

Wildlife habitats are important, measurable and manageable elements of biodiversity. Maintaining adequate amounts of these across the landscape through time is necessary for achieving the Province's vision for biodiversity and for providing benefits to future generations of New Brunswickers. Although habitat abundance and character vary naturally through disturbance and successional processes, much of the recent and current changes are the result of anthropogenic activities. Knowledge of trends in habitat abundance can help to discern other influences on populations, can inform the processes of setting population and habitat objectives, and can be used to develop legislation, regulations, strategies and policies related to wildlife habitat and other conservation priorities.

The intent of this analysis is to:

- Identify the habitat requirements of vertebrate species in New Brunswick
- Define habitat requirements using elements of the Province's photo-interpreted land cover inventory data
- Determine current (2012) abundance of habitat types and hence of available habitat for individual species, and
- Estimate past and future abundance of forest habitats in the Province.
- Discuss the modelling approaches and assumptions used with a view to identifying key areas for research and development

PROJECT RESOURCES

This project built on existing wildlife habitat definitions and modelling work in use by ERD and made extensive use of the Province's photo-interpreted land cover inventory data. Four permanent staff members of the Habitat Section of ERD contributed to the project, and 2 project biologists were hired on contract for total of 104 weeks.

In-kind support was provided by organizations and individuals in the form of scientific expertise delivered through meetings, correspondence, and participation in a 2-day workshop. Supporters included Environment and Climate Change Canada (Atlantic and National), the Nature Conservancy of Canada, the Nature Trust of New Brunswick, Ducks Unlimited Canada, Bird Studies Canada, the University of New Brunswick, Mount Allison University, Université de Moncton and Dalhousie University.

The total value of monetary and in-kind support to the project during 2013 to 2015 is conservatively estimated to be $208,000, with direct funding from Environment and Climate Change Canada of $75,000.

The New Brunswick Department of Energy and Resource Development staff most involved with the project were Daniel Beaudette, Kevin Connor, Scott Makepeace and Leon Vietinghoff. The project would not have been possible without the diligence and thoroughness of our contract staff, A. DeMerchant and C. Melrose. We wish to express our gratitude for the financial and in-kind support of Environment and Climate Change Canada.

PROJECT SCOPE

Habitat abundance was assessed exclusively from the Province's land cover inventory data, with calibration from existing ground plot data where available. Inventory data are based on interpretation of true-colour images at a scale of 1:12,500. The imagery was captured between 2002 and 2011; timber harvesting, silviculture and road building were updated annually for Crown land only. Inventory data reside in the Province's geographic information system (GIS) and are organized into discrete database schemas for forest, wetland and coastal, non-forest upland, water body, stream and road attributes.

There are 329 vertebrate species (excluding fish) that breed or overwinter in New Brunswick, or for which the Province provides an important migratory pathway. They are distributed among the Province's forest, non-forested upland, wetland, freshwater, coastal and marine ecosystems. Marine habitats were considered beyond the scope of this exercise. Species assigned exclusively to marine habitats (13) were therefore excluded, whereas those assigned to both marine and non-marine habitats were retained. Land cover inventory data for non-forested upland and freshwater conditions proved to not be of sufficient resolution for adequate identification of habitats; hence, species assigned exclusively to those classes (15) or cross-assigned between them (2) were excluded. Ultimately, three habitat classes (Forest, Wetland and Coastal), 37 habitat types and 299 species were retained. The links between retained species and excluded habitat classes were retained so that the full breadth of habitat use would be evident for all species.

New Brunswick encompasses 7.1M ha, excluding open water and submerged coastal lands. Forty-eight percent of the land is provincial Crown, 2.5% is federal Crown, 33% is in small private ownership (residences, farms and woodlots), and 16% is classed as industrial forest freehold. Land cover inventory data were not available for industrial freehold land. Analyses were conducted for all Crown land (provincial and federal) and all small private holdings, which together encompass 6.0M ha, or 84% of the Province. For the purposes of these analyses, the assessment area was divided based on management scheme into 3 land tenures: provincial Crown land in timber license (60%), federal land and provincial Crown land not in license (4.0%), and small private holdings (36%). Analyses of past and current conditions were similar across tenures; analyses of future conditions differed due to differences in the availability of models predicting natural forest development and interventions.

LANDSCAPE UNITS

Eighty-four percent of the Province is forested. Forest composition varies considerably from rich, well-drained, northern hardwood, to moderately rich and moist mixtures of balsam fir and red spruce, to nutrient-poor and dry stands of jack, red or white pine, and to poor and wet stands of black spruce and tamarack. Wetlands occupy 5.1% of the province. The most abundant types are shrub wetlands, bogs and fens, although substantial areas of freshwater and coastal marshes, aquatic beds, tidal flats and forested wetlands also occur. The remaining area is water (2.4%), agriculture (3.9%) and development or roads (4.8%).

Biodiversity management units were described in the New Brunswick Biodiversity Strategy as the geographic areas in which biodiversity elements would be assessed, and for which biodiversity thresholds and targets could be set (PNB 2009). The management units proposed in the Strategy for terrestrial and coastal features were based on the Province's Ecological Land Classification (ELC). The ELC describes the provincial landscape as a function of its variation in landform, geology and climate (Figure 1) (NB DNR 2007); these features strongly influence the abundance and distribution of forest, wetland and coastal ecosystems and their associated fauna. ELC units were therefore chosen as the landscape units for which habitat abundance is reported in this project.

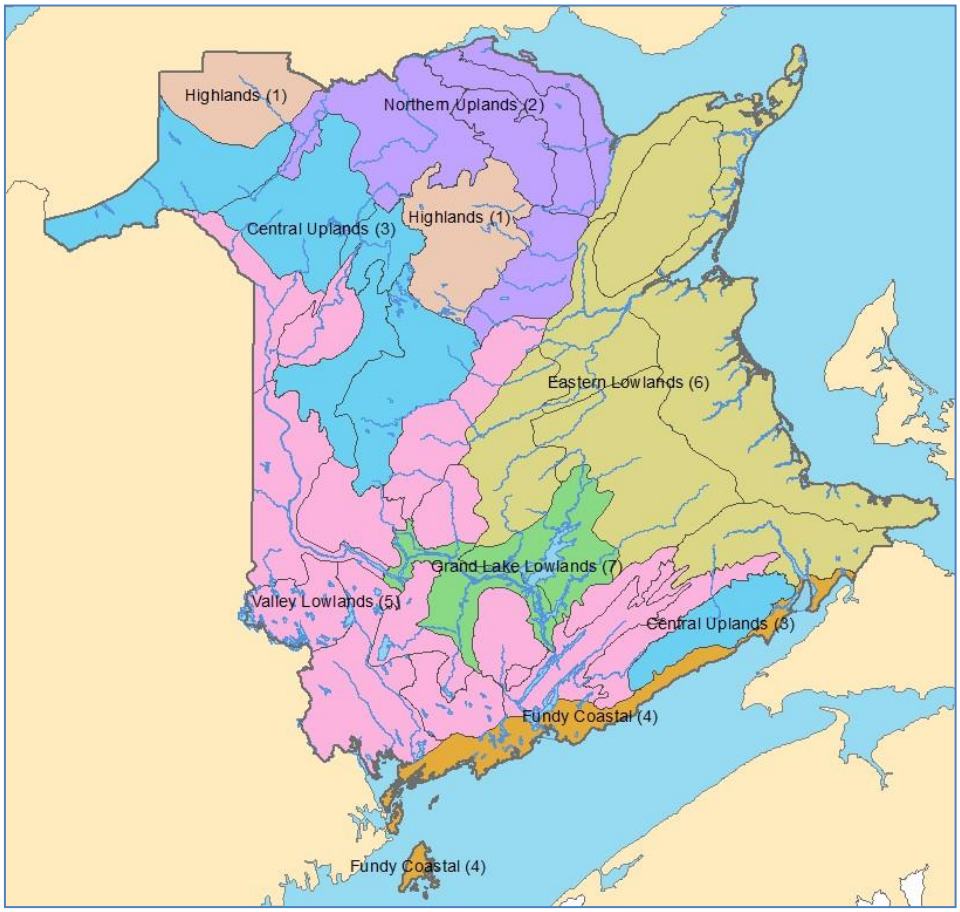

Figure 1. New Brunswick Ecological Land Classification. Units are ecoregions (background colours) and ecodistricts (grey lines).

HABITAT DESCRIPTIONS AND DEFINITIONS

General Status of Wild Species assessments for New Brunswick were used to assign species to breeding, non-breeding and migrating populations; 40 species have more than one population in the Province (NB DNR 2016). Habitat was described for each combination of species and population (345 combinations for 299 species) based on a review of the literature and on expert opinion. For forest species, information utilized included forest type (species mix), successional stage, and densities and diameters of both live and dead trees. For wetland and coastal species, information included wetland type, vegetation type and extent of vegetation cover. To address landscape configuration, attempts were made to collect information on range, density, breeding system, home range size, dispersal distance and habitat patch size for all species.

The distributions of uncommon species are not identified well in coarse-resolution analyses such as this one. Much of what would be labelled as habitat is likely to be unoccupied because fine-scale habitat requirements are not well understood or cannot be assessed, because species may be at the extremities of their ranges and not using all suitable habitat, or because population constraints may be occurring outside the province. Species were therefore classified as either common (218) or uncommon (81) in the Province, and habitats were defined primarily on the basis of common species.

A species-focused land cover classification system was developed to capture the habitat requirements of common species. The habitats generated from this process therefore reflect how species separate out along ecological gradients rather than being the result of combining discrete units of existing classifications. Habitats can be discrete, can overlap, or can be nested one within the other, reflecting the different ways in which species use their environments and the different locations they occupy along the gradient of generalist to specialist. Throughout the process of assigning species to habitats, reviews were conducted by examining aerial imagery of a sample of polygons identified by their inventory attributes as being habitat.

This report is primarily about habitat abundance, and yet that information is underpinned by the accuracy and resolution with which habitats were defined. Information on habitat use by vertebrates abounds, and yet its value to this process was highly variable and rather low overall. Habitat descriptions were frequently vague, in that they encompassed a wide range of conditions, and were often not stated in relation to contrasting conditions. Many species found locally have broad continental ranges and habitat descriptions were often from locations with disparate conditions. Overall, the process of describing habitats in an explicit fashion was a daunting one.

Habitat definitions for all retained species are available in the documents *Old Forest Communities and Old-forest Wildlife Habitats in New Brunswick*, *Young-forest Wildlife Habitats in New Brunswick* and *Wetland and Coastal Wildlife Habitats in New Brunswick* (NB ERD 2017a, 2017b, 2017c). The documents present a working classification of New Brunswick's ecosystems and our current understanding of the habitat relationships of its vertebrates. Definitions were coded and stored in the Microsoft® Access database *NBERD Species Matrix 2017*, which is available upon request. The database identifies all habitat types associated with individual species and allows the assemblage of communities based on shared habitat requirements.

Forest Habitat Definitions

There are 159 vertebrate species that use New Brunswick's forest for some or all of their breeding, overwintering or migration requirements, of which 130 were considered sufficiently common for inclusion in the process of defining habitats.

Eighteen forest communities provide a low-resolution classification of the forest based on overstorey composition (NB ERD 2017a). Forest vertebrates were cross-assigned to forest communities and to 1 or more of 3 successional stages based on the expected occurrence of required habitat features. Forest communities were grouped together into habitat types when a suite of species occupied a set of forest communities with similar vegetative composition and structure. Not all forest conditions were retained as habitats. Those without assigned species were removed from the analysis, and those with ecologically similar conditions and identical species assignments were merged. Ultimately, 5 young, 2 mid-age and 6 old forest habitats were defined (Table 1).

Table 1. Forest conditions generated from 8 forest composition types and 3 successional stages. Those retained as habitat types are indicated with a check mark. Habitats spanning Young and Mid-age successional stages were labelled as Young.

Composition	Successional Stage		
	Young	Mid-age	Old
Spruce-fir	✔		✔
Black Spruce	✔		
Jack Pine		✔	
Pine (red, white)			✔
Hardwood	✔	✔	✔
Tolerant hardwood			✔
Mixedwood	✔		✔
Any Forest	✔		✔

Fifty-eight vertebrate species make use of young and mid-age forest of various types. Habitats were identified and defined based on the requirements of those species; however, priority was given to the 32 species that meet the criteria of being relatively common, of not also having their needs met in old forest, and of not requiring that forest be in close proximity to other non-forest habitat conditions. Habitats were defined using tree species composition (forest community), mean stem diameter, stem density and the maximum basal area of large residual stems. Details on habitat definitions and species assignments are available in the document *Young-forest Wildlife Habitats in New Brunswick* (NB ERD 2017b).

Seventy-two vertebrates make use of some aspect of old-forest structure. Old-forest habitats were identified primarily on the requirements of the 38 relatively common species whose needs are not also met in young or mid-age forest and who do not require non-forest conditions in close proximity. Old-forest habitats were defined using species composition, crown closure, basal area and densities of live and dead stems of various size classes. Details on

old-forest habitats and how species are assigned to them are available in the document *Old Forest Communities and Old-forest Wildlife Habitats in New Brunswick* (NB ERD 2017a).

Wetland and Coastal Habitat Definitions

There are 198 vertebrates associated with wetland or coastal habitats in New Brunswick, of which 141 were considered common. Twenty-one habitats were identified to describe the range of necessary conditions (Table 2). They were defined using combinations of wetland inventory attributes *wetland class* (11), *vegetation type* (9), *vegetation cover* (5) and distance to open water. In addition, a number of habitats were identified based on forest attributes related to stand composition, site character and moisture regime. In these cases, identified stands may also contribute to forest habitats. Details on wetland and coastal habitats and how species were assigned to them are provided in the document *Wetland and Coastal Wildlife Habitats in New Brunswick* (NB ERD 2017c).

Table 2. Wetland and coastal habitat types. Habitats are not mutually exclusive.

Habitat Class	Habitat Type
Wetland	Wet meadow / Tidal marsh
	Emergent shallow marsh
	Deep marsh / Aquatic bed
	Bog (Open, Pond, Shrub, Partly or Fully[1] treed or Coastal)
	Fen
	Alder or shrub swamp[1]
	Floodplain forest[1]
	Marsh complex (Water near or Water far)
	Wet shrub complex (Water near or Water far)
	Vernal pool
	Wetland margin[1]
	Cedar swamp[1]
	Wet forest[1]
	Beaver pond
Coastal	Salt marsh
	Coastal island
	Estuary
	Beach
	Dune
	Mud flat
	Rocky shore

[1] Stands that contribute to these habitats may also contribute to forest habitats.

ASSESSMENT OF HABITAT ABUNDANCE

The processes described herein were intended to assess changes in habitat abundance over a period of 50 years, extending from 25 years ago to 25 years into the future. The start time was set at 1987, the final year of data compilation for the Province's first digitized land cover inventory. The present was set at 2012, the starting year of current forest management plans for Crown land. The future is a number of points in time extending to 2037.

Habitat abundance is reported by habitat type, and can also be reported for individual species. Abundance of a habitat type is based on the area reported from the land cover inventory that appears to meet stand-level criteria. For forest habitats, the area is then reduced using estimates of the probabilities that required structural features are present, and then by excluding the areas that do not meet spatial criteria. Probability estimates could not be derived for wetland or coastal habitats. Wetland and coastal habitats are reported by patch size categories, and habitat reported for individual wetland or coastal species is reduced by excluding areas that do not meet minimum patch size requirements.

Forest Habitat Assessment

The processes used for planning forest management activities on Crown land have significantly informed the assessment of forest habitats, and so are discussed here. Forest planning is the design of management strategies that enable forest-level objectives to be met. The resulting strategies are assemblages of stand-level interventions over space and time that cause predictable changes to the development of the forest and to the flow of management values. Although forest development is the cumulative impact of changes to constituent stands, stand-level inventory data are not of sufficient resolution to forecast it as such. Stands are therefore grouped into forest strata based on ecological classification (ecodistrict, see Figure 1), site quality and similarity of photo-interpreted attributes relating to species composition, successional stage and crown closure. Strata are sampled on the ground in a series of temporary sample plots, which are used to initialize the modelled forest, and in a series of permanent plots, which are used to generate change functions.

Forest management strategies are developed using the Woodstock modelling platform (Walters et al. 1999). Woodstock is linear programming software that generates the optimum schedule of harvesting and silvicultural treatments in order to meet stated management objectives. Model parameters are expected development patterns of forest strata, treatment options and an array of possible management constraints related to flows of volume, products and biodiversity elements.

Aspatial Current and Future Habitat

Aspatial habitat abundance is the area reported from strategic forest models before spatial criteria are incorporated into the assessments. The process assigns habitat probabilities to all forest polygons for all time periods of interest.

There are approximately 16,000 sample plots distributed among 927 forest strata on Crown land. Plot data provide stem densities by species and diameter class for both live and dead stems at the time of collection. Stand development patterns are generated from plot data using the STAMAN stand growth model (Vanguard Forest Management Services 1993, Erdle and

MacLean 1999); this allows all temporary plots older than the current management period to be brought forward to 2012. The model produces stand tables for each plot at every 5-year iteration against which habitat criteria can be assessed. The probability of a stratum being a particular habitat was calculated as the ratio of the number of plots meeting habitat criteria to the total number of plots. Sample plots were sufficiently abundant in mid-age and old forest to calculate yields for every stratum; yields ranged from 0.0 to 1.0.

Far fewer plots were available for young forest (naturally regenerated and planted) and they were generally not established early enough to cover the very early stages of young-forest habitats. The paucity of plots was addressed by grouping strata together based on species composition and occasionally grouping plots with different stand-establishment techniques. The lack of data from very early ages was addressed by manually extrapolating the yields from known points. Though this was recognized as being a crude process, it was preferable to not reporting habitat at all from very young stands.

Ultimately, all strata were assigned time-dependant probability functions for all habitats. Abundance of a given habitat type at a given time, then, was the sum of the areas of all strata that contribute to the type multiplied through by their respective yields for that type at that time.

Forest management strategies exist for each of the Crown land licenses (e.g., J. D. Irving, Limited 2014) and for the area that encompasses small private holdings (C. Norfolk, New Brunswick Department of Energy and Resource Development, personal communication). For Crown land in license, a harvest schedule provides detail on where harvesting will occur over the next 10 years; beyond that time, only the area treated by stratum is known. Most of the area of non-license Crown land is used for conservation and is not harvested. Predicted treatment levels for small private holdings were based on current levels; they are admittedly speculative and are likely lower than actual levels. Future harvest rates within the 5th Canadian Division Support Base Gagetown were unknown. However, because the base accounts for only 1.3% of the Province's forest and the difference in overall future habitat levels between low and high harvest rates would be minimal, future harvesting was assumed to not occur. Most of the remainder of federal land is used for conservation and would not normally be harvested. All habitats were tracked on all forest lands.

Aspatial Habitat in 1987

Modelling past forest conditions was an exercise in converting old inventory data to a form where they were comparable to current data. As the current data were far superior, in terms of both quality and resolution, the exercise most often entailed "backcasting" the current inventory rather than attempting to identify habitat value from the old data.

The land cover inventory from 1987 was overlaid on the current one to provide assessment of the past and current status of stands simultaneously. Forest stands were classified based on a combination of past and current conditions, respectively, as Old-Old, Old-Young, Young-Old or Young-Young.

Old-Old Forest was mid-age to old (mature) in 1987, and has not been subjected to significant natural disturbance or harvesting since that time. It's likely that old-forest habitat yields have

increased in undisturbed stands over time. However, because current yields are quite low, 1987 stands were assigned the same old-forest habitat yields as they currently have.

Old-Young Forest was mature in 1987 and has since been harvested or been subjected to a significant natural disturbance. Harvesting has tended to favour stands with high volume and large trees and so it is likely that habitat yields were higher in 1987 than they are in current similar strata. Old-forest habitat yields for 1987 were therefore set to 1.0, except those for poor or wet sites, which received yields of zero.

Young-Old Forest was in a regenerating condition in 1987 and has since grown into a mature condition. Past stand composition was identified using the current inventory and the appropriate young-forest habitat yields were assigned to the past condition with ages decreased by 25 years.

Young-Young Forest was in a regenerating condition in the 1987 and still has young-forest attributes in the current inventory. Current young-forest habitat yields were used with ages decreased by 25 years.

Application of Spatial Criteria

Spatial criteria have particular application to forest habitats, as landscape structure is often far from what would be expected in the absence of harvesting and other silvicultural activities. In contrast, wetland and coastal habitats are slow to change and relatively fixed in space. The intent was to filter the forest area that met stand-level habitat criteria through species-specific sets of spatial criteria to remove individual stands or agglomerations that were too small, too isolated or shaped in such a way as to make them unsuitable. By definition, the remainder was suitably arranged on the landscape and therefore yielded the best approximation of actual habitat abundance. Spatial criteria for individual forest species are identified in the documents *Old Forest Communities and Old-forest Wildlife Habitats in New Brunswick* and *Young-forest Wildlife Habitats in New Brunswick* (NB ERD 2017a, NB ERD 2017b) and are summarized in Table 3.

Land cover inventory data are stored as a polygonal cover; polygon edges follow stand boundaries and hence polygons vary considerably in size (mean = 5.1 ha) and shape. The spatial analysis process entailed converting the polygon layer into a 25 m by 25 m (0.0625 ha) raster layer; resulting cells were given the habitat attributes of the polygon they overlapped with most. The process allowed each cell to be carried forward as a homogeneous unit, thereby reducing the fragmentation influence of narrow or small areas that were of different composition or age, or that were not forested.

The analysis tool was an in-house modification of open-source software (Majka et al. 2007). It uses a moving-window approach to assign a habitat yield to each raster cell equal to the average of the yields of all cells within a given assessment distance. Cells with average habitat yields above a user-defined threshold are retained, and the remainder are discarded. The boundaries of retained cells are dissolved to create the largest patches possible.

Table 3. Species-specific minimum patch sizes assigned to forest habitats.

Habitat Type	Minimum Patch Sizes (ha)							
	10	15	20	30	40	50	100	375
Old Forest (OFH)	✔		✔	✔				✔
Old Spruce-Fir (OSFH)	✔		✔	✔	✔	✔		✔
Old Mixedwood (OMWH)			✔			✔		
Old Hardwood (OHWH)	✔		✔	✔				
Old Tolerant Hardwood (OTHH)	✔		✔		✔		✔	
Old Pine (OPIH)	✔							
Mid-age Hardwood (MHWH)	✔		✔			✔		
Mid-age Jack Pine (MJPH)	✔					✔		
Young Forest (YFH)	✔		✔				✔	
Young Spruce-Fir (YSFH)	✔							
Young Black Spruce (YBSH)		✔						
Young Mixedwood (YMWH)			✔			✔		
Young Hardwood (YHWH)	✔							

The impact on spatial habitat supply of varying the assessment distance (circle radius for calculating average habitat yield) and the yield threshold (minimum average yield of a patch) were initially evaluated using Old Spruce-fir Habitat (OSFH) for patches of at least 375 ha, which is the largest patch identified for the type (NB ERD 2017a). The effects of changing the assessment distance varied with the patchiness of the landscape but, overall, decreases in distance tended to increase habitat levels, decrease patch sizes, and induce more dendritic patch shapes.

As discussed above in the section *Aspatial Current and Future Habitat*, aspatial habitat supply was known for any point in time via accumulating the areas of forest strata and multiplying them by applicable yields. The objective of this exercise was to spatially reference an area equal to the aspatial level using the most suitable patches available on the landscape. This was achieved via an iterative process of modifying both the assessment distance and the minimum yield threshold until the resulting habitat area across all patch sizes was approximately equal to the aspatial level. Ultimately, the assessment distance was set at 300 m (~28 ha circle) for all habitats and threshold yields varied among types from 0.10 to 0.29. The results for each habitat were filtered on relevant minimum patch sizes (Table 3), which yielded abundance estimates and spatial layers of each type at each patch size.

There was no reference landscape against which to test results; however, the Province's Conservation Forest provided a reasonable alternative. The Conservation Forest is the area on Crown land designated to meet conservation goals, and includes target levels of old forest communities and old-forest wildlife habitats. The areas were originally identified by a process of assigning community and habitat value to individual stands based on their stratum assignments, agglomerating stands manually to meet spatial criteria, and adjusting the results through aerial survey and assessment of aerial imagery. Overlap between patches selected by the 2 processes always occurred; however, the proportion of manually-selected area that was captured by the automated process was relatively low, varying among habitats from 0.32 to

0.53. Recall that yields were calculated for entire forest strata, and that the strata were assembled from mostly photo-interpreted attributes. The variability among stands within a stratum is therefore quite high, and it is to be expected that some stands that appeared highly suitable from the air were assigned low yields and vice versa.

Wetland and Coastal Habitat Assessment

The original 1987 land cover inventory was primarily intended to capture forest conditions. The resolution applied within wetlands and other non-forest conditions was very low, and it was therefore not possible to reliably identify past habitat conditions. Though it may be possible to assess changes to the overall area of wetlands, real change is expected to be small in most habitats and most identified changes are just as likely to be due to inconsistencies in interpretation as they are to real change. Models were not available for projecting wetland and coastal conditions into the future, and future anthropogenic changes were not known.

There were no ground data with which wetland and coastal habitat assignments could be validated, which would have allowed for habitat probabilities to be calculated. Abundance was therefore calculated as the simple sum of the areas in each habitat type. Internal polygon boundaries were removed for each habitat type to calculate patch size distribution. For assessments of habitat abundance for individual species, polygon boundaries were dissolved around all habitat types associated with the species.

HABITAT SUPPLIES AND TRENDS

Forest Habitat Supplies and Trends

The intent is to report trends in abundance for 13 forest habitats for the period 1987-2037 across federal and provincial Crown land and small private holdings combined. Although full assessments were possible for past and current conditions, assessments of future conditions were variously limited across land tenures and time periods by availability of spatially-referenced data.

Known changes to reported habitat due to the addition of spatial criteria (spatial netdown) were used to estimate the changes for land tenures and time periods for which netdown values were not available. For Crown land in license, spatial netdowns from 2022 were applied to 2037. For other land tenures, netdowns for 2012 were transferred to both 2022 and 2037. Estimated net-downs are considered conservative, and so are more likely to overestimate habitat abundance than they are to underestimate it. Average known and estimated spatial netdown values are provided in Table 4. Netdowns vary by land tenure, and are most discrepant for large patch sizes. For example, spatial netdown in 2012 for 375-ha OSFH patches is 0.40 on Crown timber licenses, 0.58 on Crown land not in license, and 0.04 on small private holdings. The high value for Crown not in license reflects the absence of fragmentation caused by harvesting, and the low value on private land reflects moderately high harvesting pressure distributed across small parcel sizes.

Abundance data are reported for old forest habitats in Appendix 1 and for young and mid-age habitats in Appendix 2. Reporting unit is ecoregion for 1987 and 2012, and all land combined for 2022 and 2037. Provincial summaries for old forest habitats at their smallest and largest patch sizes (see Table 3) are presented in Figure 2 and Figure 3, respectively.

Habitat abundance for individual species can be determined by filtering on patch size. For example, Figure 2 represents Old Forest Habitat (OFH) for northern parula warbler, Old Spruce-fir Habitat (OSFH) for Cape May warbler, Old Mixedwood Habitat (OMWH) for blackburnian warbler and Old Tolerant Hardwood Habitat (OTHH) for black-throated blue warbler, whereas Figure 3 represents abundance of the same habitat types for American marten, black-backed woodpecker, northern flying squirrel, hairy woodpecker and barred owl, respectively. Old Pine Habitat (OPIH) has only one patch size, which was intended for pine warbler.

Provincial summaries for young and mid-age habitats are presented in Figure 4 and Figure 5. Figure 4 represents Young Forest Habitat (YFH) for white-throated sparrow, Young Mixedwood Habitat (YMWH) for Philadelphia vireo, Mid-aged Hardwood Habitat (MHWH) for American redstart and Mid-aged Jack Pine Habitat (MJPH) for red squirrel, whereas Figure 5 represents the same types for ermine, American woodcock, ruffed grouse and spruce grouse, respectively. Young Spruce-fir Habitat (YSFH), Young Black Spruce Habitat (YBSH) and Young Hardwood Habitat (YHWH) have only 1 patch size; values are therefore the same in both figures. They represent habitat supplies for magnolia warbler, palm warbler and chestnut-sided warbler, respectively.

Table 4. Provincial spatial netdowns for forest habitats at the largest patch size assessed for each habitat. Values are percentages of aspatial assessment amounts that remain once spatial criteria are applied. Values in black were calculated from spatial assessments; those in blue italics were estimated from known values. Patch sizes assessed (ha) are attached to habitat names.

	Spatial Netdown (%)			
Habitat	1987	2012	2022[1]	2037
Old Forest (375)	0.77	0.47	0.47	*0.47*
Old Spruce-Fir (375)	0.67	0.32	0.32	*0.32*
Old Mixedwood (50)	0.71	0.50	0.50	*0.50*
Old Hardwood (30)	0.84	0.84	0.84	*0.84*
Old Tolerant Hardwood (100)	0.58	0.63	0.63	*0.63*
Old Pine (10)	0.91	0.86	0.86	*0.86*
Mid-age Hardwood (50)	0.51	0.48	*0.48*	*0.48*
Mid-age Jack Pine (50)	0.70	0.47	*0.47*	*0.47*
Young Forest (100)	0.53	0.59	*0.59*	*0.59*
Young Spruce-Fir (10)	0.92	0.96	*0.96*	*0.96*
Young Black Spruce (15)	0.83	0.92	*0.92*	*0.92*
Young Mixedwood (50)	0.40	0.51	*0.51*	*0.51*
Young Hardwood (10)	0.87	0.92	*0.92*	*0.92*

[1] Spatial netdowns in 2022 are known for old-forest habitats on Crown land in license and estimated elsewhere.

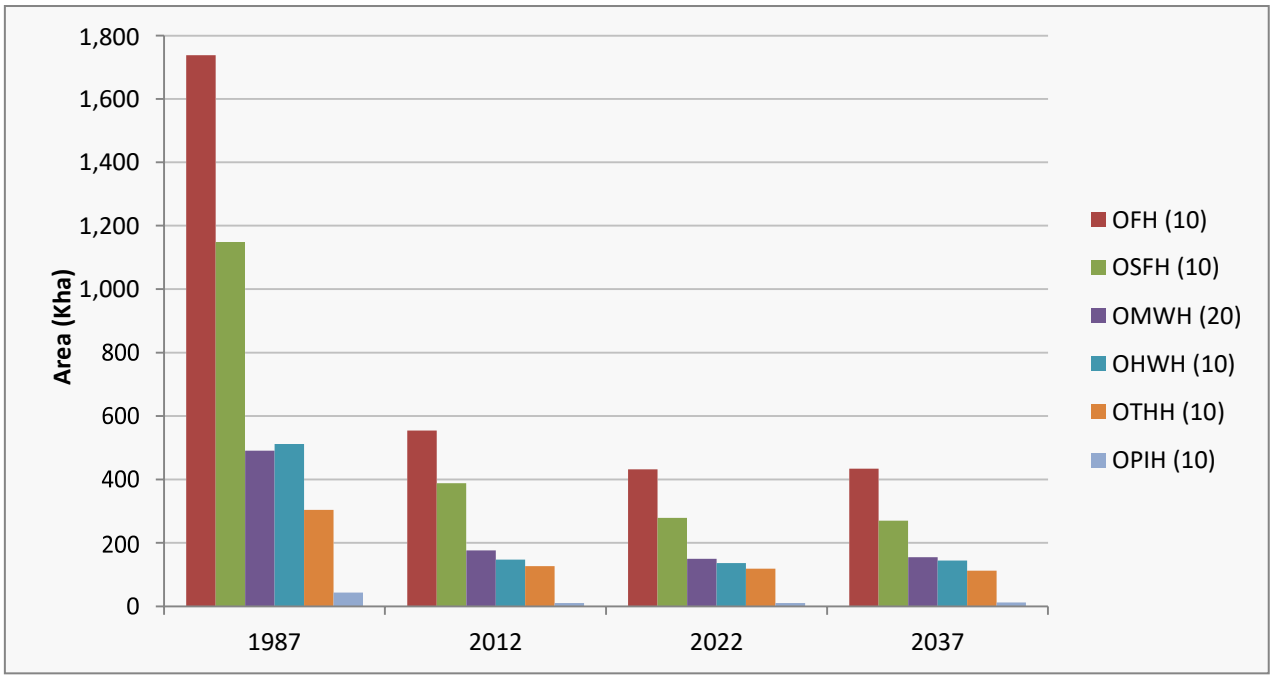

Figure 2. Old-forest habitat abundance in New Brunswick at the smallest habitat-specific patch size for provincial and federal Crown land and small private holdings combined, 1987-2037. Habitat acronyms are given in Table 3; patch sizes (ha) are attached to habitat labels.

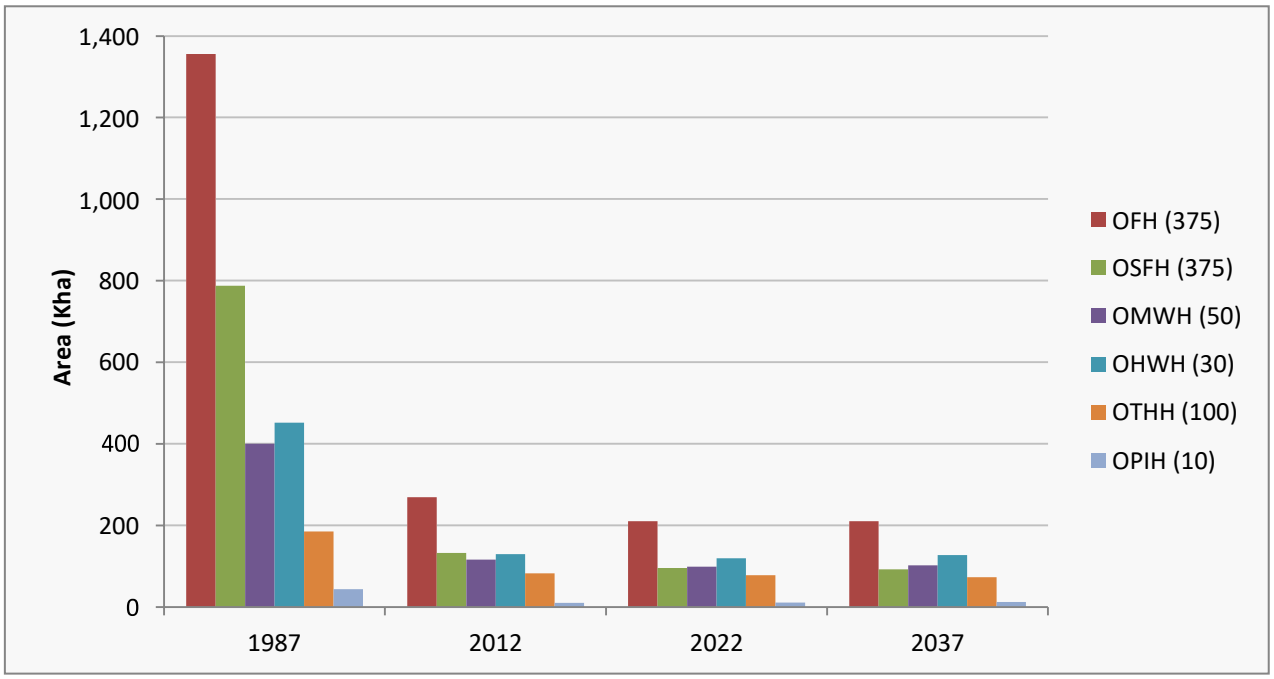

Figure 3. Old-forest habitat abundance in New Brunswick at the largest habitat-specific patch size for provincial and federal Crown land and small private holdings combined, 1987-2037. Habitat acronyms are given in Table 3; patch sizes (ha) are attached to habitat labels. OPIH has only one patch size and hence values are repeated from Figure 2.

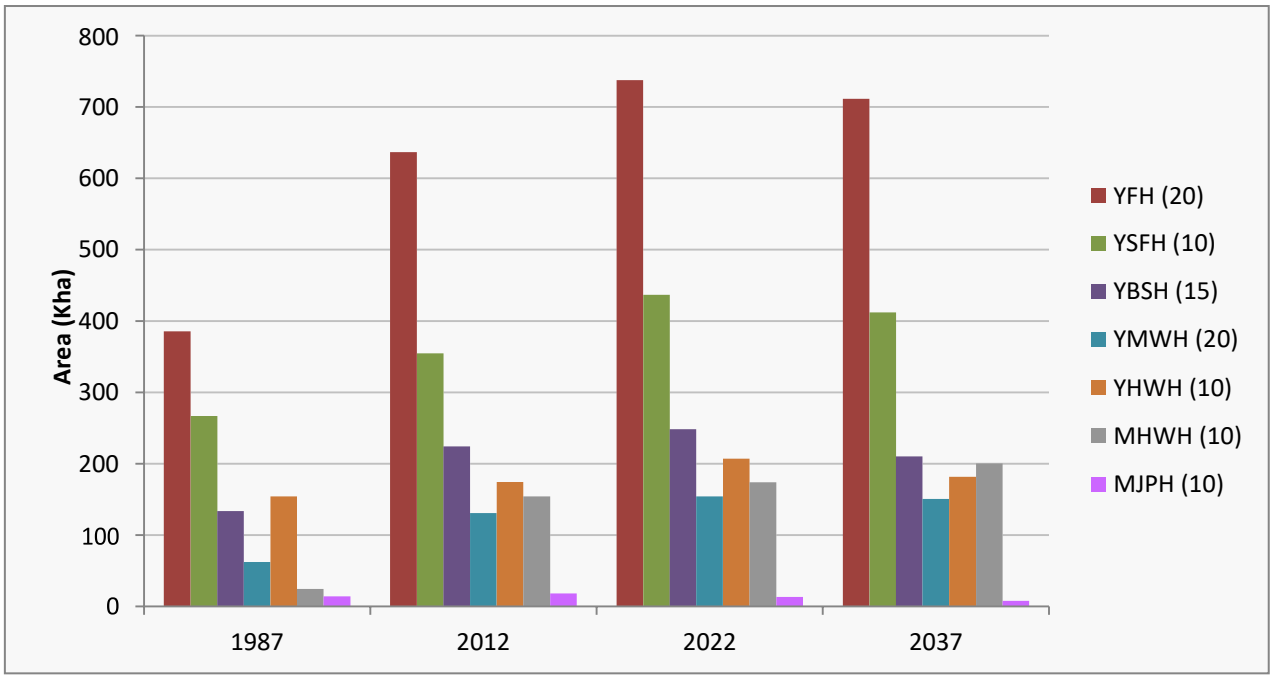

Figure 4. Young and mid-age forest habitat abundance in New Brunswick at the smallest habitat-specific patch size for provincial and federal Crown land and small private holdings combined, 1987-2037. Habitat acronyms are given in Table 3; patch sizes (ha) are attached to habitat labels.

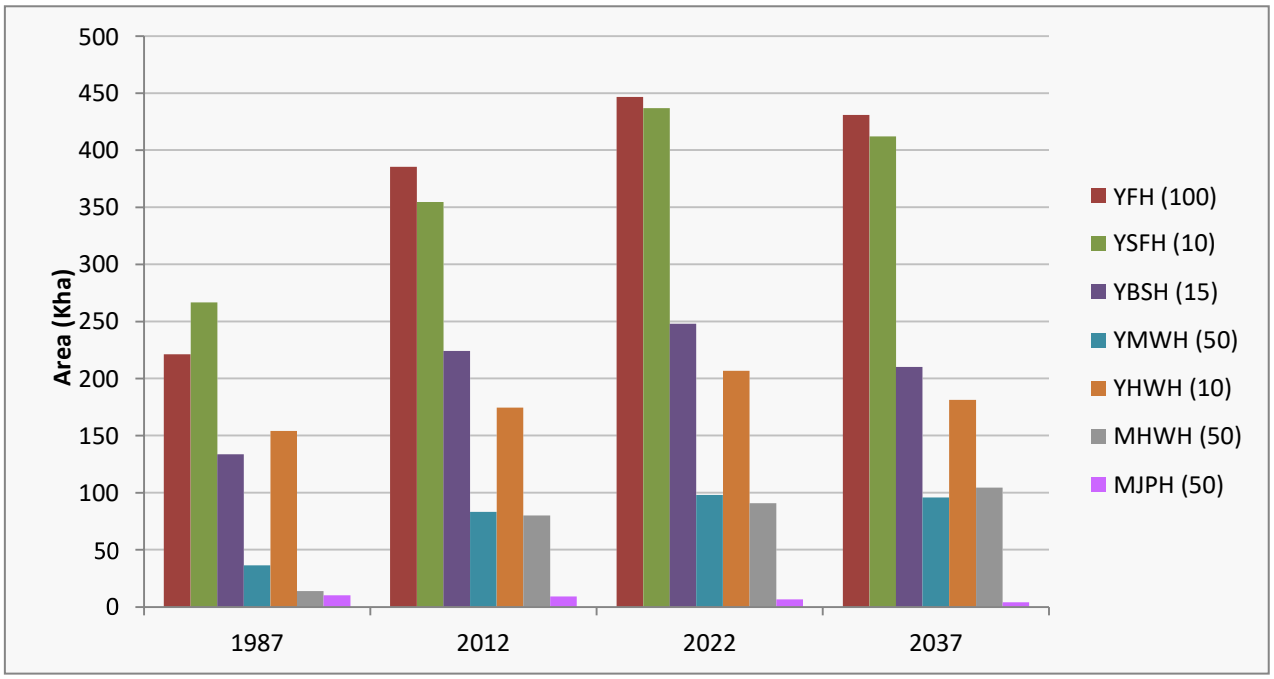

Figure 5. Young and mid-age forest habitat abundance in New Brunswick at the largest habitat-specific patch size for provincial and federal Crown land and small private holdings combined, 1987-2037. Habitat acronyms are given in Table 3; patch sizes (ha) are attached to habitat labels. YHWH, YBSH and YSFH Have only one patch size and hence values are repeated from Figure 4.

Single expressions of overall temporal changes to forest habitat abundance are difficult to generate as habitat definitions overlap. The single best expression for old-forest habitats is the combined value of Old Spruce-fir Habitat, Old Hardwood Habitat and Old Pine Habitat, which are mutually exclusive, at their respective largest minimum patch sizes. This measure of old-forest habitat abundance declined by 79% (1.28M ha to 272K ha) from 1987 to 2012 (range 56-83% among individual habitats), and is expected to decline by 15% (to 231K ha) from 2012 to 2037 (range 30% decrease to 20% increase), with most of the change happening by 2022.

The sharp decline in old-forest habitat from 1987 to 2012 was due to harvesting of old forest over the period at a rate which precluded its replacement, due in part to a relatively low abundance of mid-age forest at the outset. The rate of decline drops considerably after 2012, which indicates a substantial reduction in the rate of harvesting of natural old forest, due to the location of much of that forest within areas managed for conservation and a gradual shift towards the harvest of managed stands.

Old-forest habitats vary in abundance and rate of change with land tenure. Private holdings contained 35% of the forest area assessed and yet supported only 11% of the old-forest habitat area reported for 2012 when assessed at the largest habitat-specific patch sizes. In contrast, Crown land in license supported 82% of reported habitat on 61% of the total forest area, and Crown land not in license supported 7% on only 4% of the forest. On Crown land not in license, old-forest habitats declined by 17% over the period 1987-2012, and are expected to increase to close to 1987 levels by 2037. This indicates that some harvesting or other disturbance occurred prior to 2012 and reflects the assumption that no further harvesting will occur. On Crown land in license, old-forest habitats declined by 78% from 1987 to 2012, and are expected to decline 33% from 2012 to 2037. The reduced rate of decline post-2012 reflects a reduced harvest of existing old forest and a maturing of mid-age forest into habitat condition. Early declines were even sharper on private land (88% from 1987 to 2012), where habitat fragmentation was likely enhanced by the distribution of harvesting across small parcel sizes. Levels are predicted to increase by 31% over the period of 2012 to 2037, though this may be largely the result of an underestimation of the future rate of harvest. For this exercise, future harvest rates on private land were set to 2012 rates in the absence of information to indicate otherwise; however, rates may increase if market conditions improve. In addition, fuelwood harvest is largely unreported on private land and is likely to have led to an underestimate of current harvest rates in hardwood-dominated conditions.

The best single measure of the combined abundance of young-forest habitats is the sum of Young Hardwood Habitat, Mid-age Hardwood Habitat, Young Spruce-fir Habitat and Mid-age Jack Pine Habitat at their largest habitat-specific minimum patch sizes. By this measure, young-forest habitats increased 40% from 1987 to 2012, are expected to increase 21% from 2012 to 2022, and to decline slightly (5%) after that. As with old-forest habitats, abundance and rates of change of young-forest habitats varied among land tenures. Crown land not in license supported very little young-forest habitat due to the absence of harvesting, and Crown licenses supported 2.5 times more young forest than did private holdings in 2012, when expressed as a function of total forest area. The latter result is perhaps counterintuitive, given that the abundance of old-forest habitat was also low on private holdings. However, young-forest habitat definitions limit overstory stems (≥ 10 or ≥15 cm in diameter) to basal areas of between 2 and 10 m^2/ha (NB ERD 2017b), and many structurally complex young and mid-age stands

resulting from partial harvesting may therefore have been excluded. On Crown land not in license, all young-forest habitats declined gradually over time in the absence of harvesting and as existing young forest grew out of suitability. On Crown land in license, young-forest habitats increased markedly from 1987 to 2022 and were relatively stable after that. On private land, young-forest habitats declined gradually over the entire assessment period. This is likely the result of increased fragmentation, though may also be affected by an underestimation of future harvest levels.

The ongoing impacts of harvesting on fragmentation of old forest is illustrated by the general decrease in the proportion of small-patch habitat that meets large-patch criteria between 1987 and 2012 (73% to 48% for old-forest habitats). Rates of decrease differ by land ownership, with the greatest change found on small private holdings (51% to 16%), where parcels are smaller, and the least change found on non-license Crown (75% to 68%), where harvesting is minimal.

Spatial distributions of habitats can only be mapped for periods and locations for which spatially-referenced treatments are known or predicted, and so are limited for entire-province views to 1987 and 2012. Graphical analyses of abundance are presented for 3 forest habitats chosen to illustrate a range of conditions: Old Tolerant Hardwood Habitat, Old Spruce-fir Habitat and Young Forest Habitat. Details on habitat composition, structure and associated species are provided elsewhere for these and other forest habitats (NB ERD 2017a, NB ERD 2017b).

Old Tolerant Hardwood Habitat

Old Tolerant Hardwood Habitat (OTHH) is composed primarily of a mix of sugar maple, yellow birch and American beech, and can contain non-dominant quantities of red and white spruce, balsam fir, white birch and poplar. It contains many live and dead stems of at least 30 cm in diameter and at least of few of 45 cm. OTHH provides habitat for 25 vertebrate species, of which 5 are dependent on its occurrence: black-throated blue warbler (minimum patch 10 ha), scarlet tanager (20 ha), barred owl (20 ha), eastern wood pewee (40 ha) and white-breasted nuthatch (100 ha).

Abundance of OTHH at its largest patch size (100 ha) declined from 185K ha to 82K ha (56%) from 1987 to 2012 and is expected to decrease to 73K ha by 2037, with the decline being relatively constant over that period. At its smallest patch size (10 ha), the decline is from 304K ha to 127K ha (63%) by 2012, with a subsequent decrease to 113K ha by 2037. The distribution of OTHH area by relevant patch size in 1987 and 2012 is given in Figure 6. The spatial distribution of OTHH is illustrated in Figure 7.

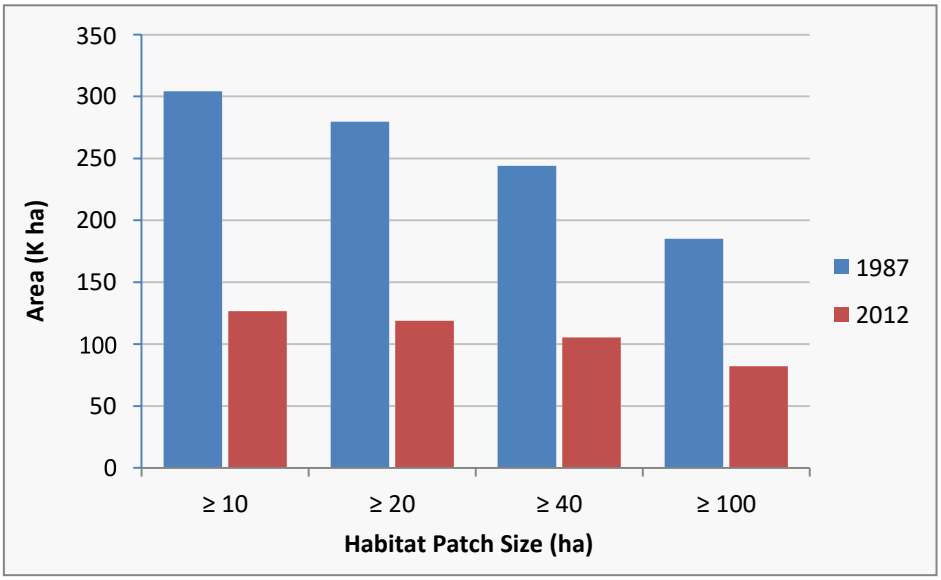

Figure 6. Distribution of area by patch size for Old Tolerant Hardwood Habitat for provincial and federal Crown land and small private holdings combined, 1987 and 2012.

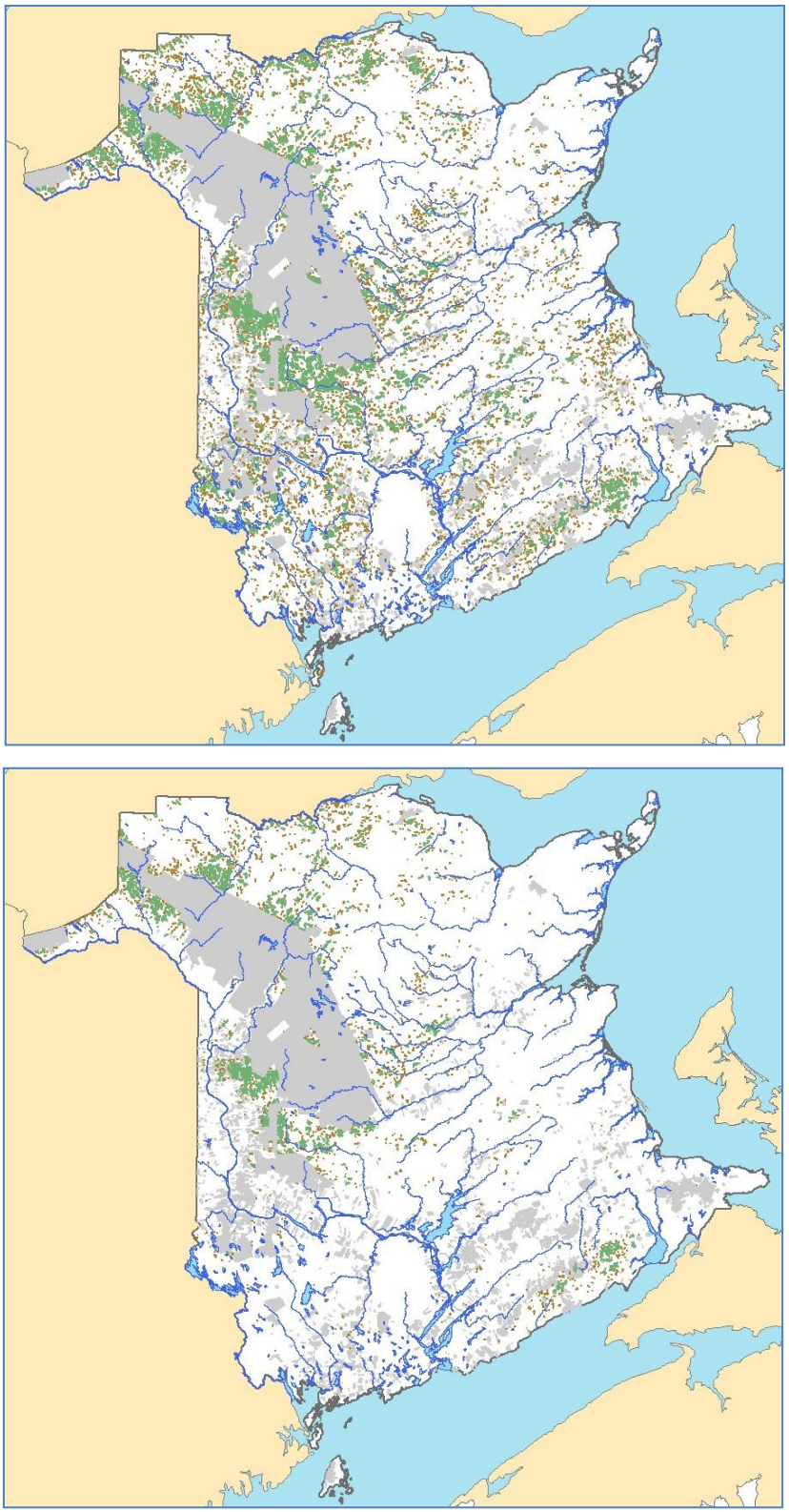

Figure 7. Spatial distributions of Old Tolerant Hardwood Habitat at 100-ha (green) and 10-ha (brown and green combined) minimum patch sizes in 1987 (top) and 2012. Grey areas are industrial freehold and were not evaluated. Due to the interaction of scale and resolution, small mapped areas may appear to occupy more area than they actually do.

Old Spruce-fir Habitat

Old Spruce-fir Habitat (OSFH) is a softwood-dominated condition composed primarily of red, white and black spruce and balsam fir on moderate or better sites. It contains a moderate amount of both live and dead stems of at least 30 cm in diameter. OSFH provides habitat for up to 22 vertebrate species, of which 10 are specialists: Cape May warbler (minimum patch 10 ha), sharp-shinned hawk (10 ha), winter wren (20 ha), pine siskin (20 ha), evening grosbeak (20 ha), red-breasted nuthatch (30 ha), red crossbill (40 ha), boreal chickadee (50 ha) and black-backed woodpecker (375 ha).

Abundance of OSFH at its largest patch size (375 ha) declined from 788K ha to 132K ha (83%) from 1987 to 2012 and is expected to decrease to 95K ha by 2022 and remain relatively constant through to 2037. At its smallest patch size (10 ha), the decline is from 1.15M ha to 389K ha (66%) by 2012, with a subsequent decrease to 270K ha by 2037. The distribution of area by relevant patch size is given for 1987 and 2012 in Figure 8. The spatial distribution of OSFH is illustrated in Figure 9.

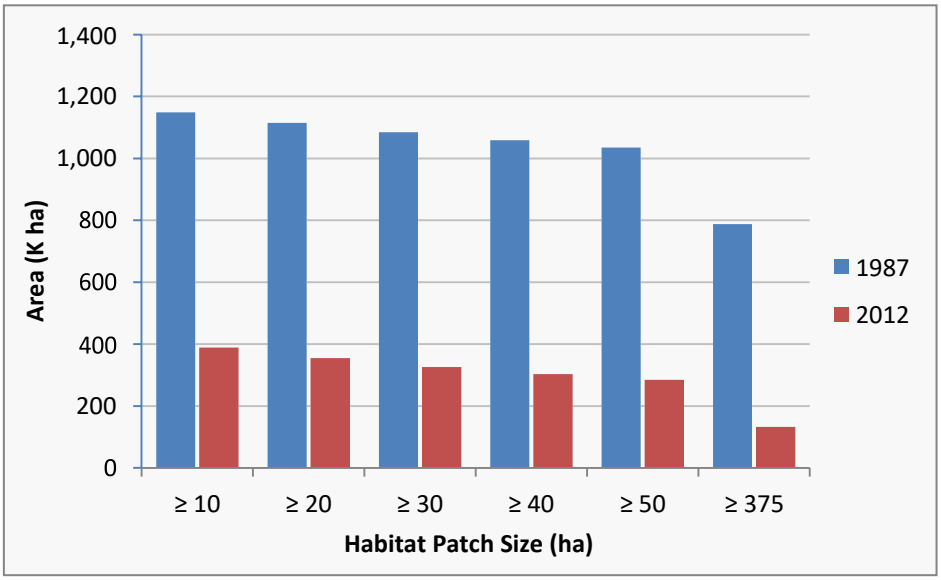

Figure 8. Distribution of area by patch size for Old Spruce-fir Habitat for provincial and federal Crown land and small private holdings combined, 1987 and 2012.

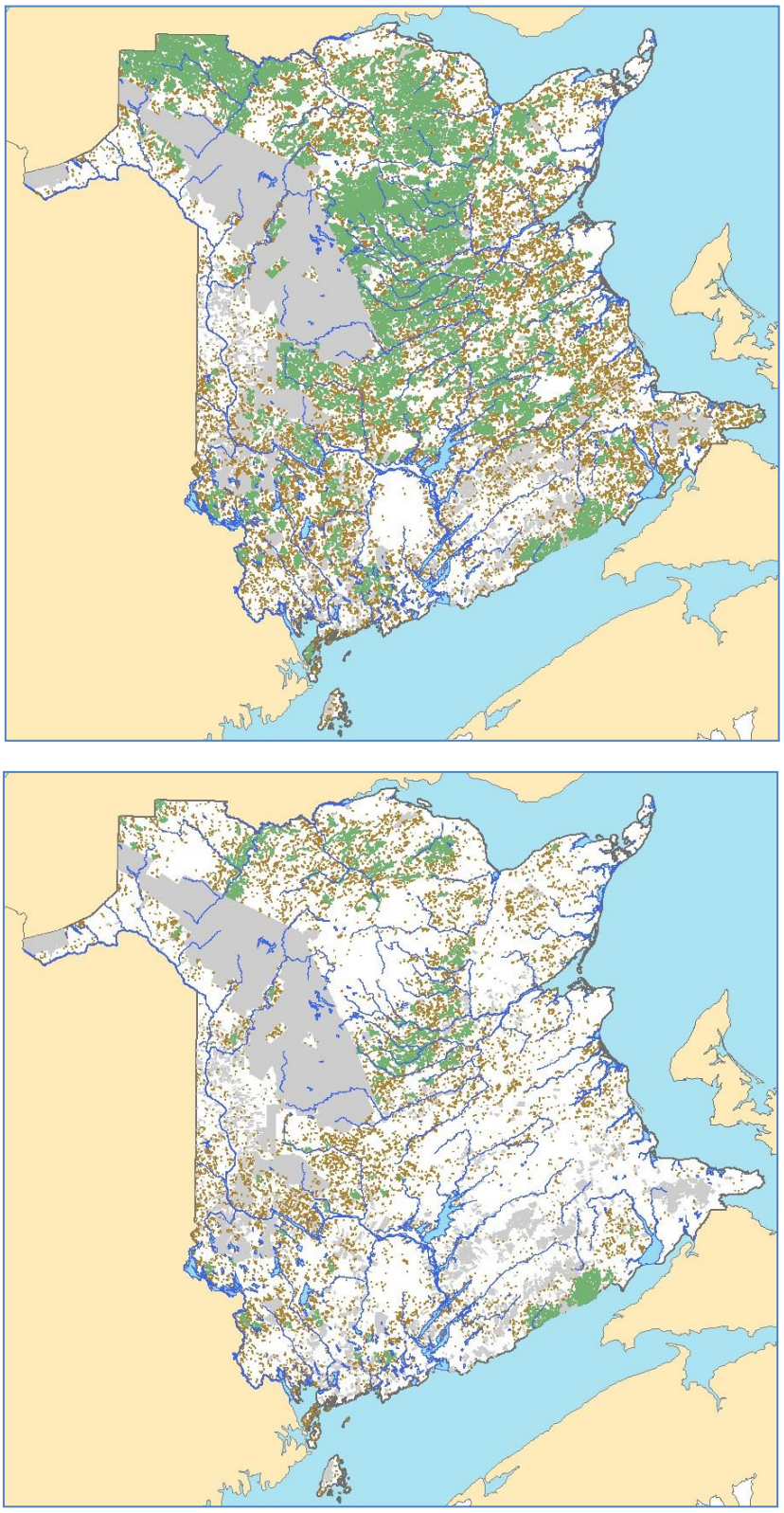

Figure 9. Spatial distributions of Old Spruce-fir Habitat at 375-ha (green) and 10-ha (brown and green combined) minimum patch sizes in 1987 (top) and 2012. Grey areas are industrial freehold and were not evaluated. Due to the interaction of scale and resolution, small mapped areas may appear to occupy more area than they actually do.

Young Forest Habitat

Young Forest Habitat (YFH) is a broadly defined regenerating to mid-age condition that encompasses the range of compositions and structures found in all other young and mid-aged forest habitats. Stem diameters vary with composition from 3 to 15 cm and the overstorey generally occupies no more than 2 m^2/ha. YFH provides important habitat for 8 young-forest species that do not require a particular composition, i.e., that are not strongly associated with any one of the other young or mid-age habitats: cedar waxwing (minimum patch < 1 ha), snowshoe hare (10 ha), Nashville warbler (10 ha), mourning warbler (10 ha), white-throated sparrow (10 ha), common yellowthroat (20 ha), Wilson's warbler (20 ha) and ermine (100 ha).

Abundance of YFH at its largest patch size (100 ha) increased from 221K ha to 385K ha (74%) from 1987 to 2012, is expected to increase to 447K ha by 2022 and to decline to 431K ha by 2037. At its smallest patch size (10 ha), the increase to 2012 is from 385K ha to 637K ha, followed by an increase to 737K ha by 2022 and a decline to 711K ha by 2037. The distribution of area across patch sizes is given for 1987 and 2012 in Figure 10. The spatial distribution of YFH is illustrated in Figure 11.

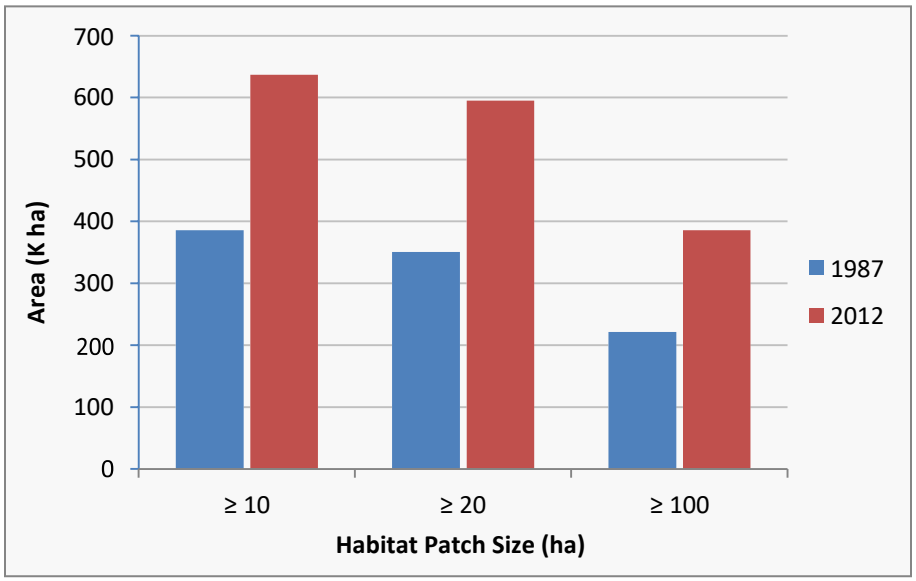

Figure 10. Distribution of area by patch size for Young Forest Habitat for provincial and federal Crown land and small private holdings combined, 1987 and 2012.

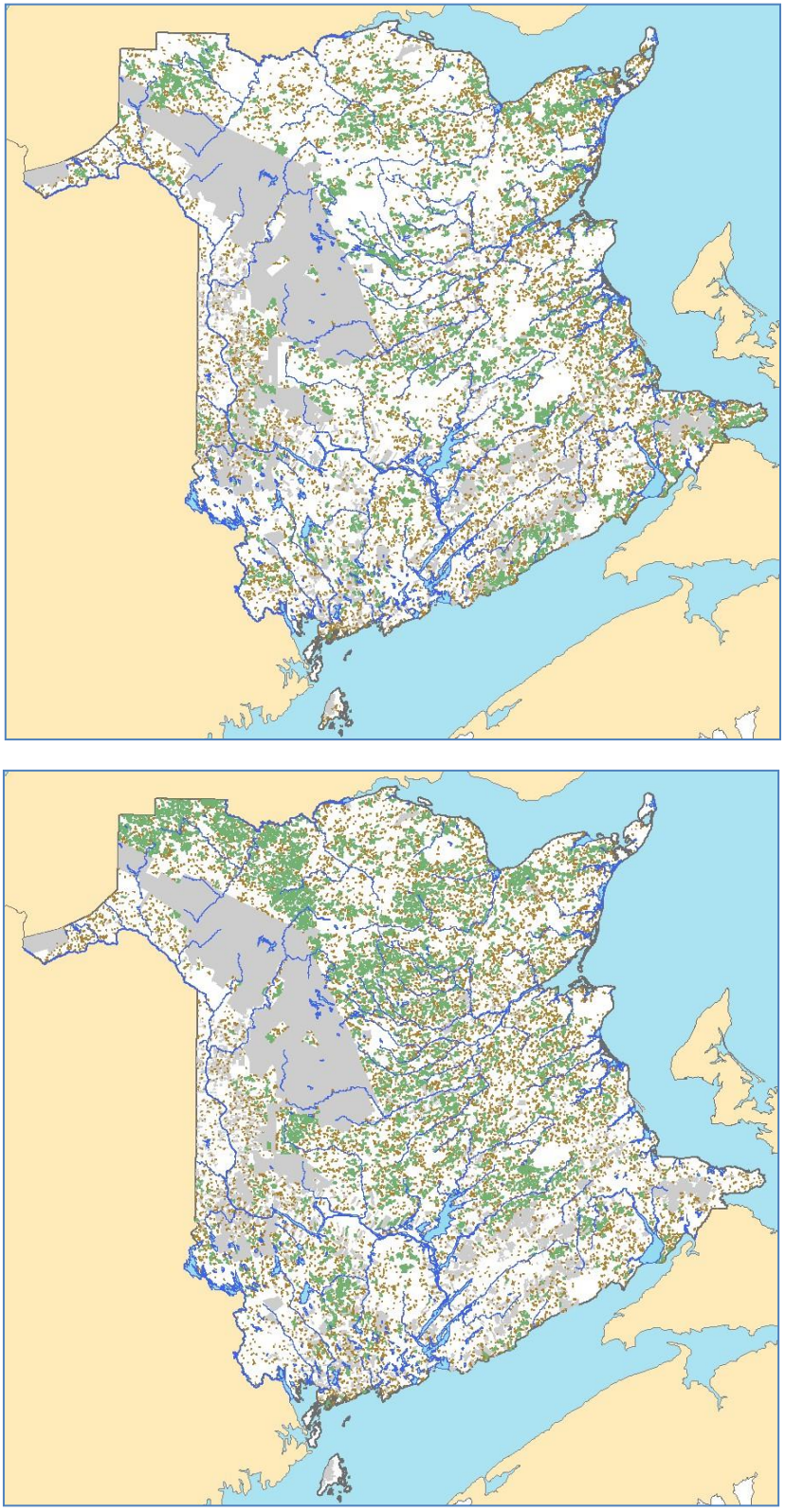

Figure 11. Spatial distributions of Young Forest Habitat (YFH) at 100-ha (green) and 10-ha (brown and green combined) minimum patch sizes in 1987 (top) and 2012. Grey areas are industrial freehold and were not evaluated. Due to the interaction of scale and resolution, small mapped areas may appear to occupy more area than they actually do.

Old-forest Habitat Thresholds

A *Biodiversity threshold* is the minimum amount or area of an element of biodiversity that is considered necessary to maintain its viability. In the context of managing the supply of old-forest habitats, a threshold is the abundance and distribution of a habitat type required to maintain, with low to moderate risk, viable populations of the species associated with it across the ranges in which they normally occur. In order for habitat thresholds to be useful for determining management targets, they are calculated for the largest minimum patch size required for each habitat type. The document *Old-forest Thresholds for New Brunswick's Crown Forest* describes the identification of threshold levels on Crown land for the 6 old-forest habitats (NB ERD 2017d). In order to provide an equivalent reference point for the area assessed in this project, thresholds were recalculated using the same processes.

For most old-forest species (32 of 44), the original intent for Crown land was to provide viable populations on each of the 29 ecodistricts with significant overlap with the Crown forest. The assessment area of this project was expanded to all of the province's 35 ecodistricts, and hence population and habitat thresholds were increased by an equivalent proportion (21%). Four species were managed on Crown land to provide populations in each of the province's 7 ecoregions. As the number of ecoregions remained the same in the larger assessment area, threshold levels for those species did not change. The remaining 8 species were managed across Crown land in its entirety. Seven of these have ranges that include the entire province; for these, thresholds were increased by a proportion equivalent to the increase in forest area assessed (63%). The threshold for American marten, which does not occur in a number of southern ecodistricts, was increased relative to the increase in assessed forest area within its range (41.7%). Threshold levels calculated for this project are given in Table 5.

Table 5. Threshold levels for old-forest habitats calculated for the assessment area of this project. Patch sizes to which thresholds apply (ha) are attached to habitat names.

Habitat	Threshold
Old Forest (375)	283,480
Old Spruce-fir (375)	131,250
Old Mixedwood (50)	97,000
Old Hardwood (30)	89,250
Old Tolerant Hardwood (100)	108,880
Old Pine (10)	6,150

In 2012, Old Tolerant Hardwood Habitat (OTHH) abundance is 25% below its threshold level and Old Forest Habitat (OFH) is slightly below. In 2022, abundance is below threshold for OTHH, OFH and Old Spruce-fir Habitat (OSFH) (29%, 26% and 27%, respectively) (Figure 12).

Thresholds were calculated from the requirements of the most area-demanding species assigned to each habitat type; most species in below-threshold habitats are above their individual threshold levels in 2012 and 2022. The single species that is below its threshold in 2012 is white-breasted nuthatch in OTHH (8%). In 2022, those below threshold are white-breasted nuthatch in OTHH (14%), black-backed woodpecker in OSFH (27%) and American marten in OFH (20%).

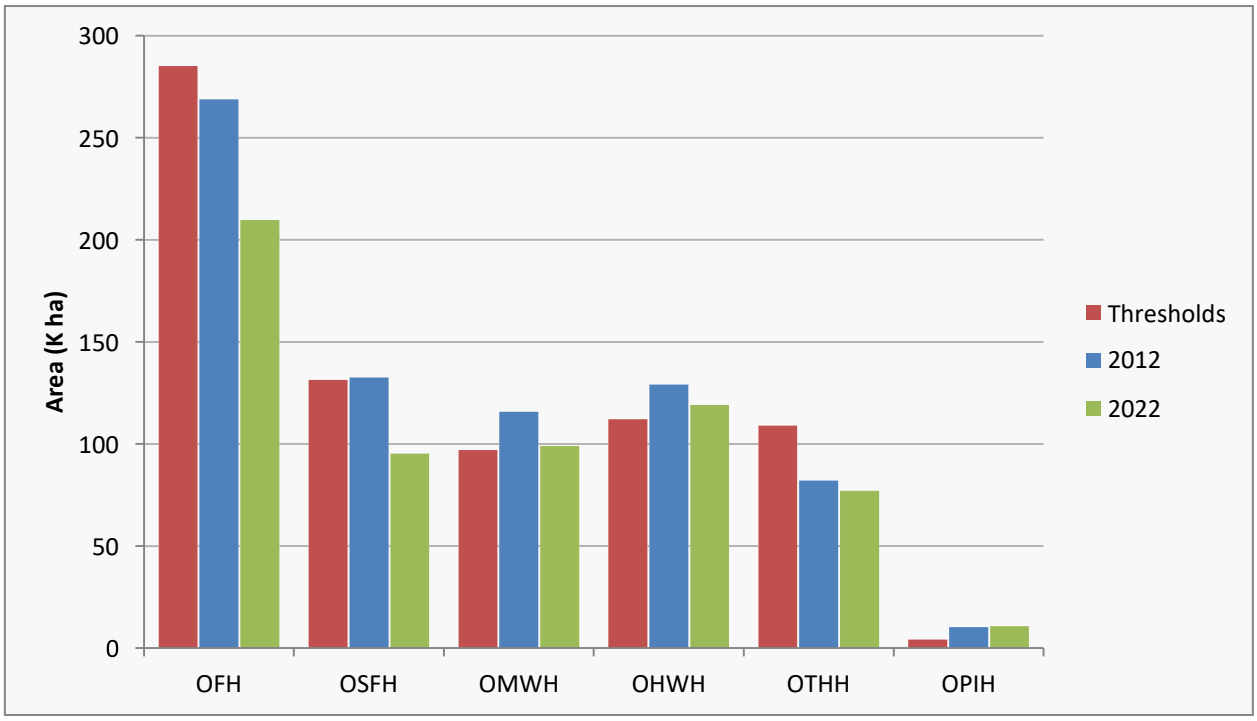

Figure 12. Threshold levels and old-forest habitat abundance in New Brunswick at the largest habitat-specific patch size for provincial and federal Crown land and small private holdings combined in 2012 and 2022. Habitat acronyms are given in Table 3.

Wetland and Coastal Habitat Supplies

There are 14 wetland and 7 coastal habitat types (see Table 2). Of these, Vernal Pool Habitat could not be identified and Coastal Island and Estuary Habitats could not reliably be delineated and hence are not presented here. Metrics available for the remaining 18 habitat types are provincial abundance estimates (Table 6), distribution by patch size (Appendix 3) and by ecodistrict (Appendix 4). Distribution maps for most habitats are presented in Appendix 5.

Area of habitat available to individual species is a function of both abundance and patch size distribution; species with small per-individual area needs are better able to use small patches than are species that require large areas. Graphical analyses of abundance and patch-size distribution are presented for 7 habitats chosen to illustrate a variety of conditions and distribution patterns: Wet Meadow / Tidal Marsh, Emergent Shallow Marsh, Fen, Alder or Shrub Swamp, Floodplain Forest, Cedar Swamp and Salt Marsh. Full descriptions of all wetland and coastal habitat types are presented elsewhere (NB ERD 2017c).

Table 6. Abundance of wetland and coastal habitat types in New Brunswick in 2012.

Habitat Class	Habitat Type[1]	Sub-type	Area
Wetland	Wet meadow / Tidal marsh		45,147
	Emergent shallow marsh		21,171
	Deep marsh / Aquatic bed		8,138
	Bog	Open	8,265
		Shrub	92,945
		Partially treed	1,255
		Fully treed	176,316
		Coastal	24,141
	Fen		61,274
	Alder or shrub wetland		149,079
	Floodplain forest		11,181
	Marsh complex	Water near	1,930
		Water far	7,859
	Wet Shrub Complex	Water near	2,916
		Water far	12,464
	Vernal pool		n/a
	Wetland margin		35,298
	Cedar swamp		67,349
	Wet forest[2]		398,036
	Beaver pond		37,525
Coastal	Salt marsh		13,969
	Coastal island		n/a
	Estuary		n/a
	Beach		2,859
	Dune		2,173
	Mud flat		7,280
	Rocky shore		509

[1] Habitat types are not mutually exclusive; areas therefore cannot be summed.

Wet Meadow / Tidal Marsh

Wet Meadow / Tidal Marsh Habitat includes high coastal marsh and emergent (seasonally flooded) floodplain wetlands dominated by cordgrass (Spartina) and adjacent idle fields and pasture. It is most abundant on the coast and in the lower Saint John River floodplain. Species of high conservation concern found in this habitat type include yellow rail, short-eared owl and bobolink. Forty-two species are strongly associated with this habitat, of which 31 are considered common (NB ERD 2017c).

There are 45K ha of Wet Meadow / Tidal Marsh Habitat in the Province, distributed across 12 ecodistricts (Figure 13). Habitat patches range in size from less than 1 ha to 960 ha, with most of the patches (83%) being small and most of the area (59%) being in large patches (>20 ha) (Figure 14, Figure 15).

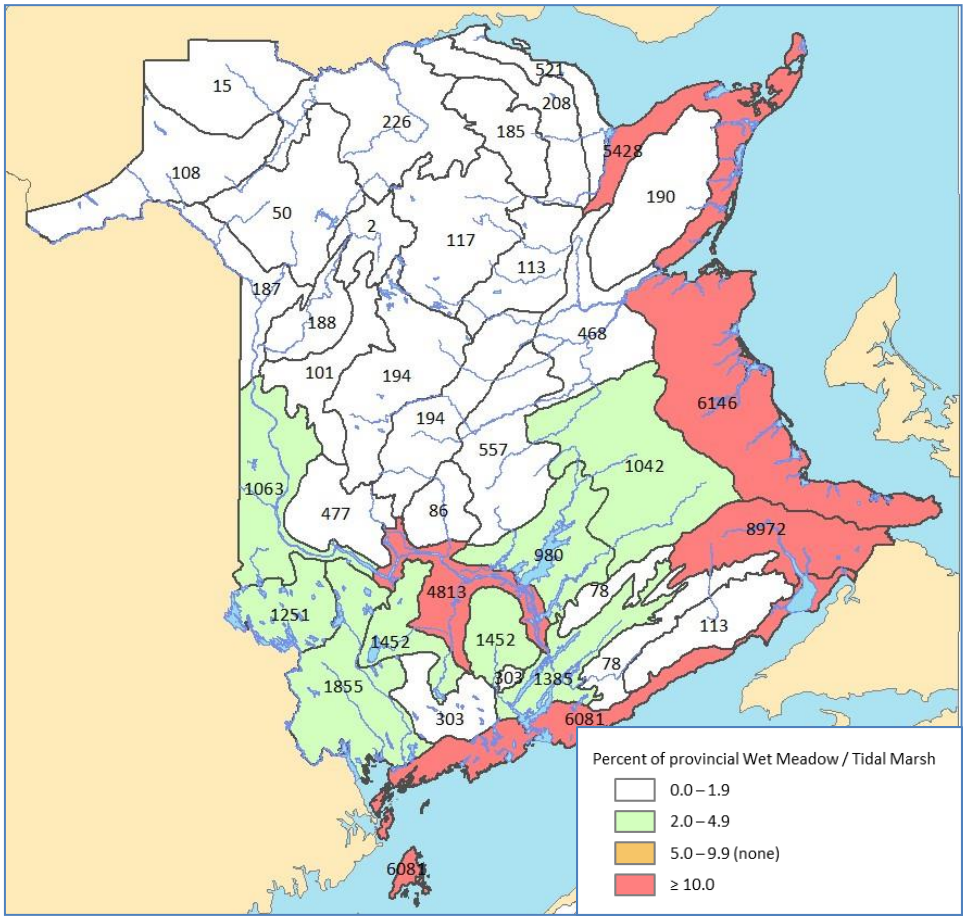

Figure 13. Distribution of Wet Meadow / Tidal Marsh across New Brunswick ecodistricts. Fill colours represent proportions of the total provincial area of the habitat; within-polygon values are the absolute area of habitat in hectares.

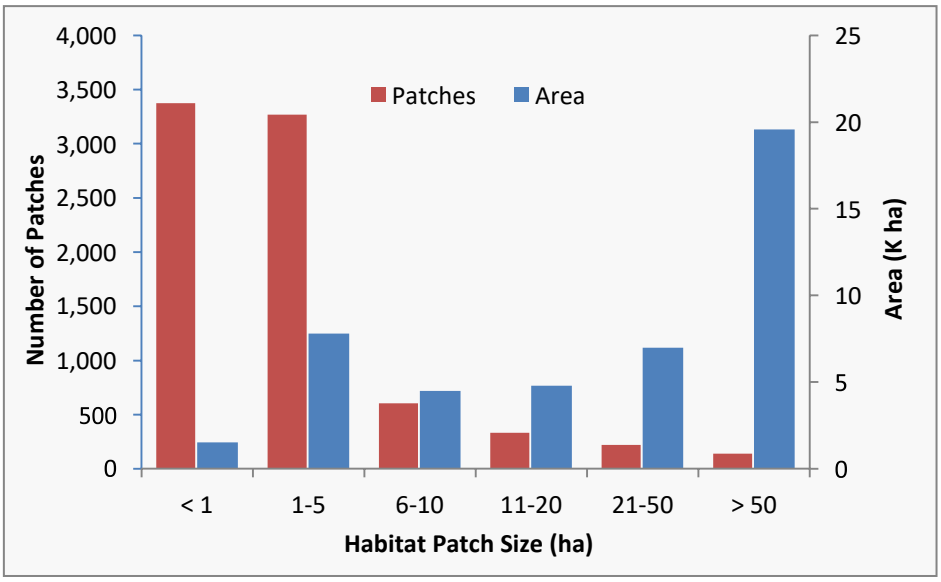

Figure 14. Patch size distribution for Wet Meadow / Tidal Marsh Habitat in New Brunswick.

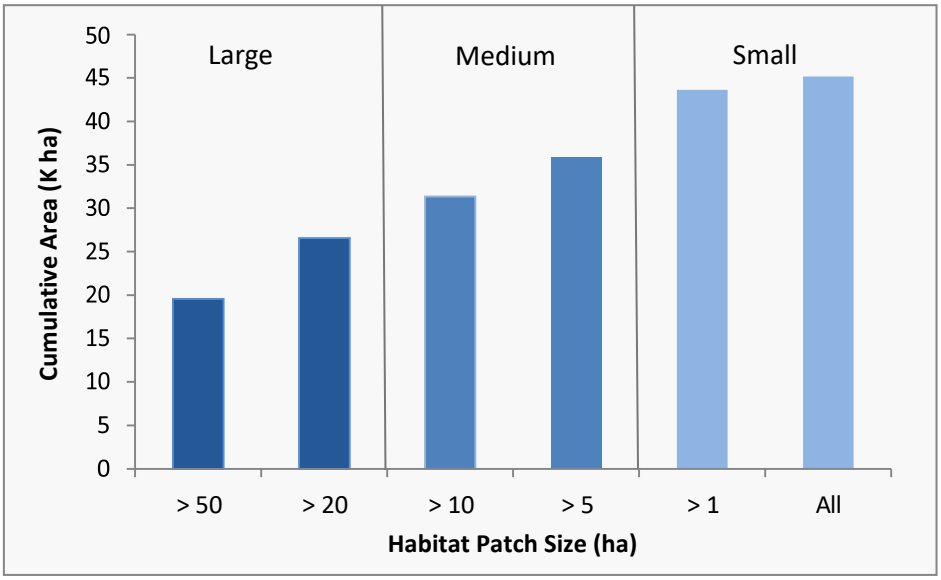

Figure 15. Cumulative area by decreasing patch size for Wet Meadow / Tidal Marsh Habitat in New Brunswick.

Emergent Shallow Marsh

Emergent Shallow Marsh Habitat maintains water during the growing season and is dominated by rooted emergent vegetation such as cattails, freshwater cordgrass, bulrush, sedges and reeds. Emergent shallow marshes are intermediate in flood duration and water depth between seasonally flooded meadows and shallow open-water environments. The large wetland complexes along the lower Saint John River include a significant component of emergent shallow marsh, much of which is impounded (NB ERD 2017c). Fifty-three species are strongly associated with this habitat, of which 37 are considered common (NB ERD 2017c).

There are 21K ha of Emergent Shallow Marsh Habitat in the Province, distributed across 17 ecodistricts (Figure 16). Habitat patches range in size from less than 1 ha to 368 ha, with most of the patches (88%) being small, and almost half the area (45%) being in small patches (Figure 17, Figure 18).

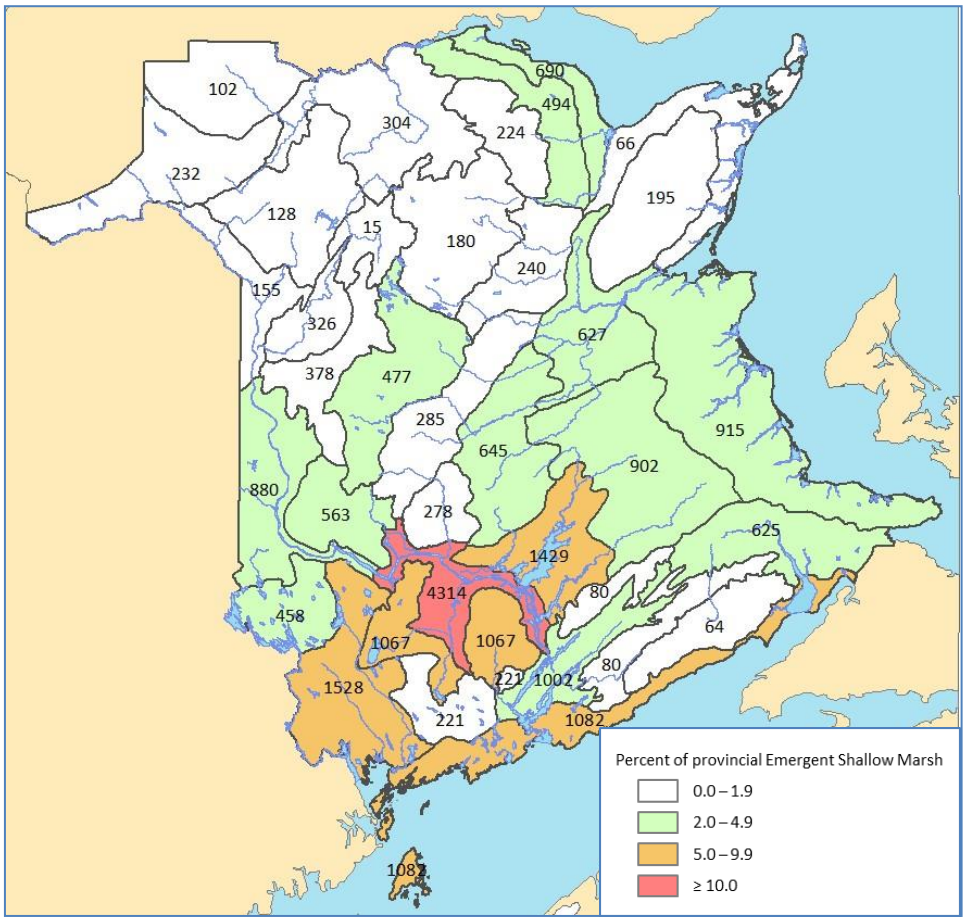

Figure 16. Distribution of Emergent Shallow Marsh Habitat across New Brunswick ecodistricts. Fill colours represent proportions of the total provincial area of the habitat; within-polygon values are the absolute area of habitat in hectares.

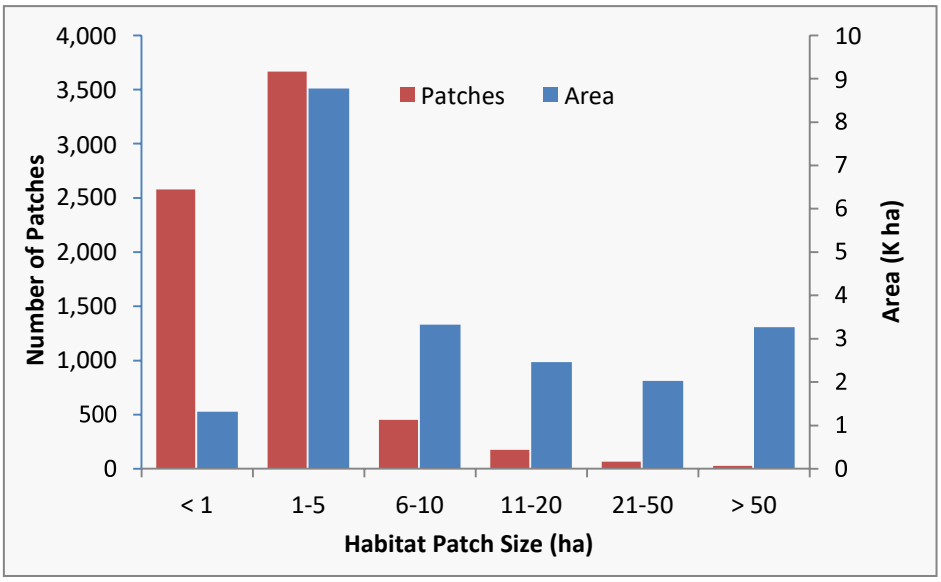

Figure 17. Patch size distribution for Emergent Shallow Marsh Habitat in New Brunswick.

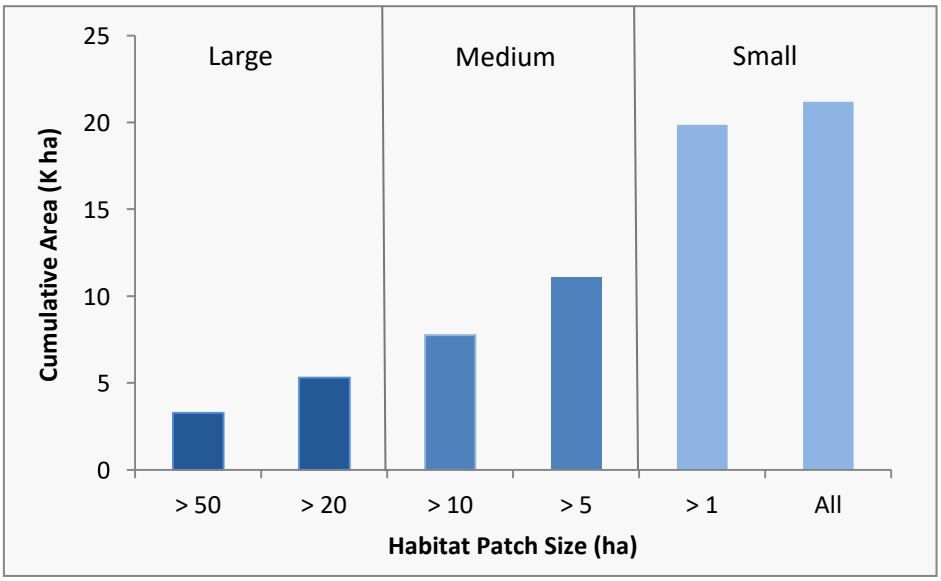

Figure 18. Cumulative area by decreasing patch size for Emergent Shallow Marsh Habitat in New Brunswick.

Fen Habitat

Fen Habitat has a saturated but open drainage system with varying depths of decaying organic matter (peat). Fens may be associated with bogs, but not necessarily so. They have contact with flowing water with a mineral substrate, and the lateral flow tends to reduce their acidity relative to that of bogs. Typical vegetation is sphagnum moss, sedges, ericaceous shrubs and black spruce. However, fens can be associated with a wide range of nutrient conditions and vegetation patterns vary accordingly. On sites with rich ground water inputs, unique plant assemblages can occur. Although many of the species associated with Bog Habitats will also use fens, there are 3 species associated with Fen Habitat that do not use bogs: muskrat, river otter and greater yellowlegs (NB ERD 2017c).

There are 61K ha of Fen Habitat in the Province, distributed primarily in 17 ecodistricts (Figure 19). Habitat patches range in size from less than 1 ha to 704 ha, with most of the patches (73%) being small, and most of the area (78%) being in intermediate and large patches (Figure 20, Figure 21).

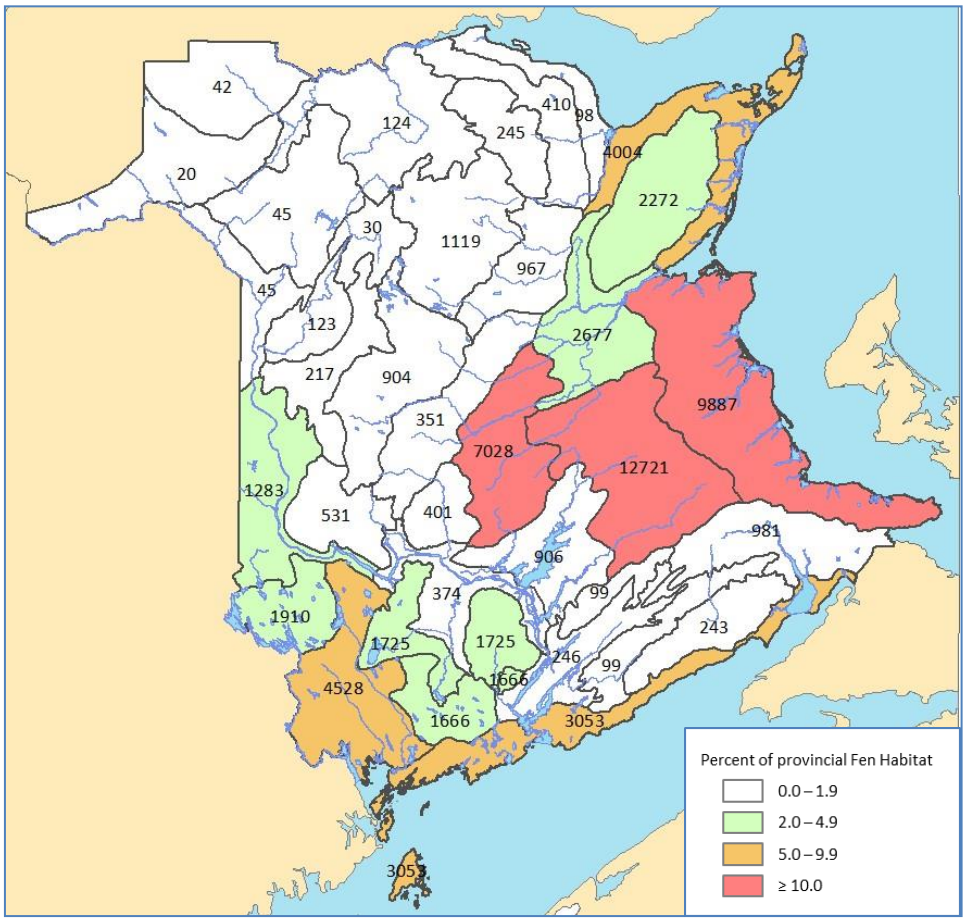

Figure 19. Distribution of Fen Habitat across New Brunswick ecodistricts. Fill colours represent proportions of the total provincial area of the habitat; within-polygon values are the absolute area of habitat in hectares.

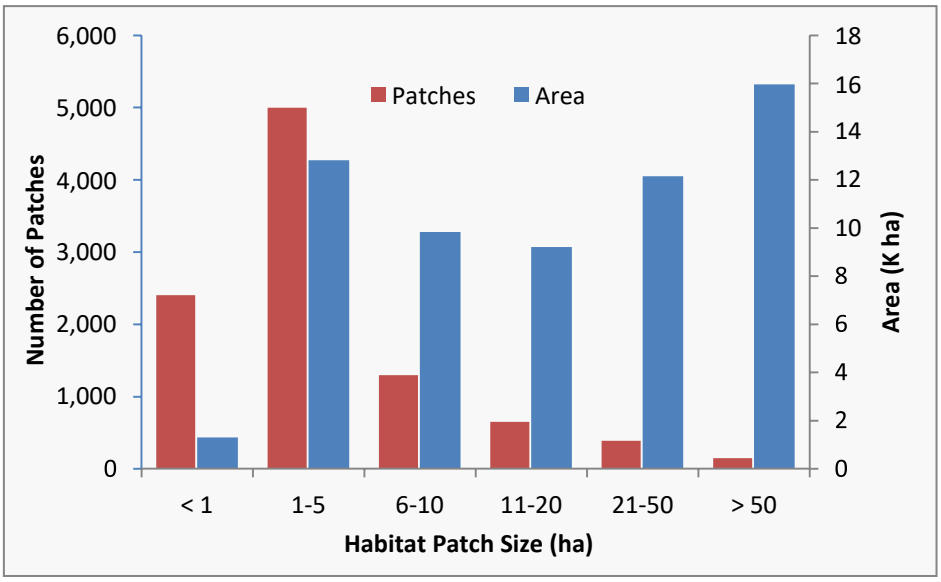

Figure 20. Patch size distribution for Fen Habitat in New Brunswick

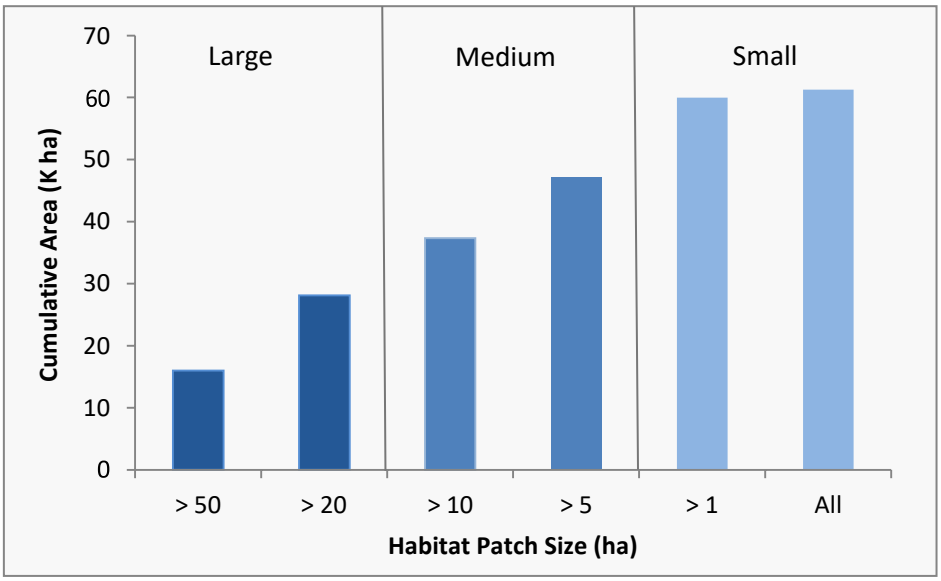

Figure 21. Cumulative area by decreasing patch size for Fen Habitat in New Brunswick.

Alder or Shrub Swamp

Alder or Shrub Swamp Habitat is composed of wetlands that support tall shrubs or alders and that are not associated with bogs or fens. Shrub swamps are often located along streams or small rivers, and within floodplain wetland complexes. Forty-five vertebrates are strongly associated with this habitat type, of which 36 are considered common (NB ERD 2017c).

There are 149K ha of Alder or Shrub Swamp Habitat in the Province, distributed among 25 ecodistricts (Figure 22). Habitat patches range in size from less than 1 ha to 258 ha, with most of the patches (85%) being small, and the area being mostly (74%) in small and intermediate patches (Figure 23, Figure 24).

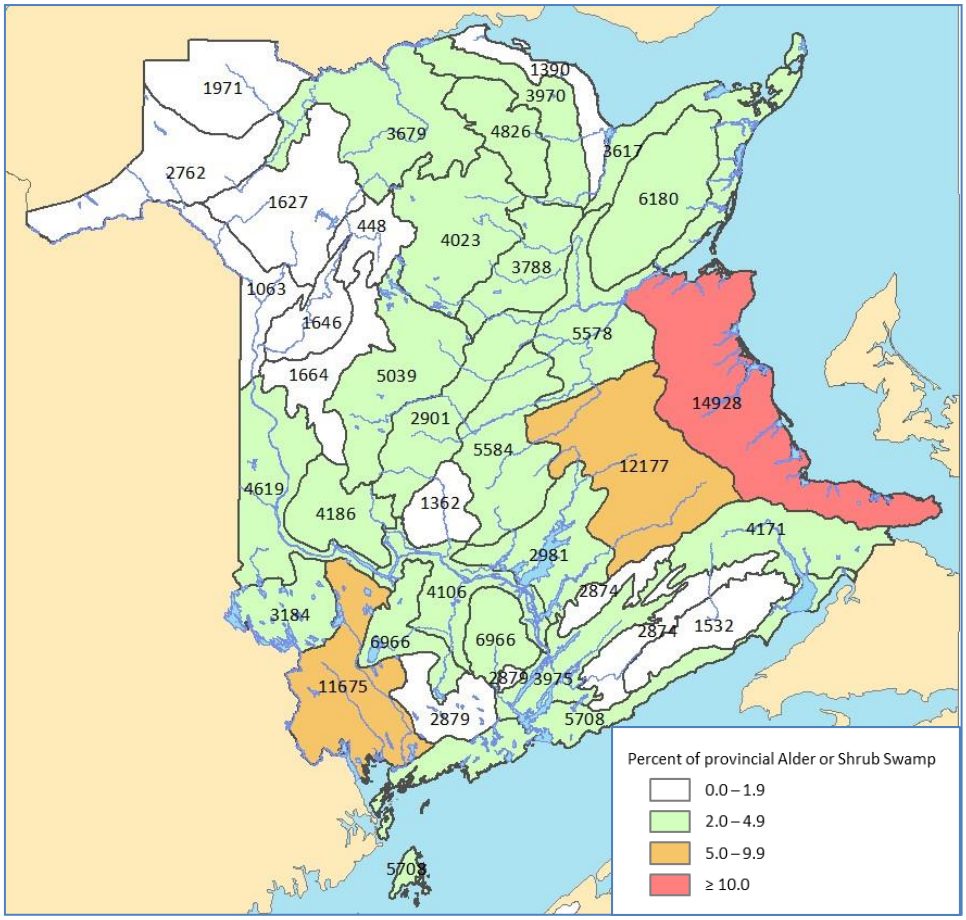

Figure 22. Distribution of Alder or Shrub Swamp Habitat across New Brunswick ecodistricts. Fill colours represent proportions of the total provincial area of the habitat; within-polygon values are the absolute area of habitat in hectares.

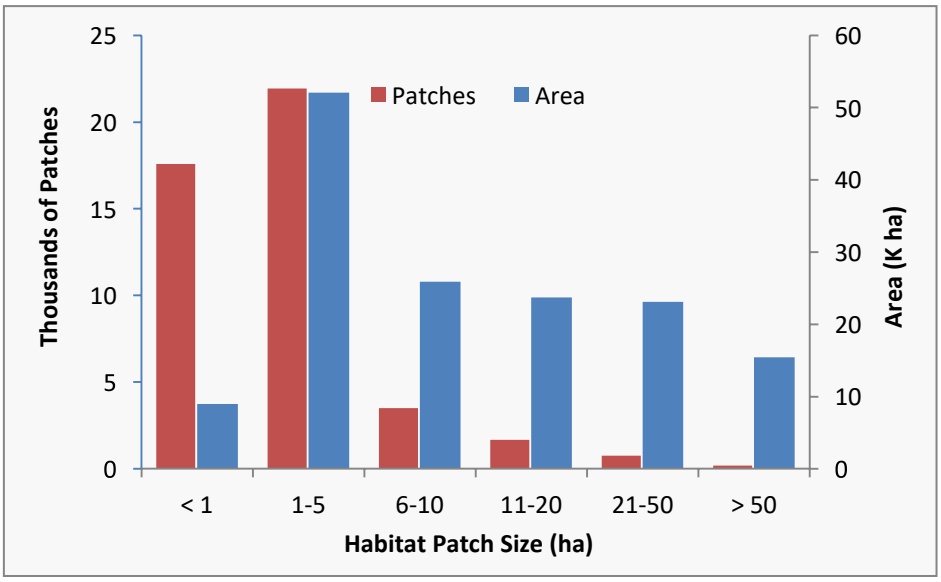

Figure 23. Patch size distribution for Alder or Shrub Swamp Habitat in New Brunswick.

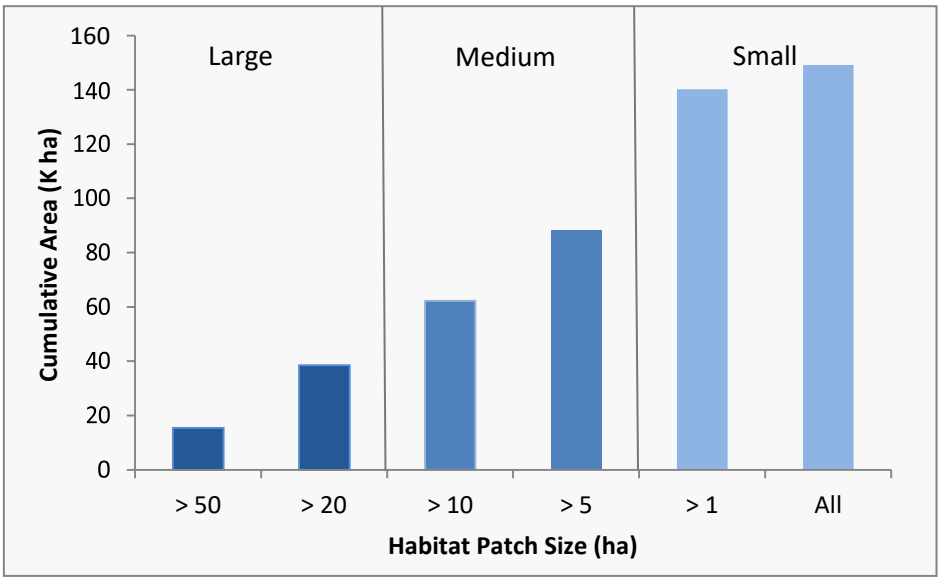

Figure 24. Cumulative area by decreasing patch size for Alder or Shrub Swamp Habitat in New Brunswick.

Floodplain Forest

Floodplain Forest Habitat includes bottomland hardwood and associated tall shrub swamp within river floodplains. Common tree species include silver maple, green ash, red oak and balsam poplar. Seventeen vertebrate species are strongly associated with the type, of which 16 are considered common (NB ERD 2017c). Many associated species require tree cavities during the breeding season. The distributions of 3 species, great-crested flycatcher, warbling vireo and Baltimore oriole, are closely tied to the distribution of this habitat type.

There are 11,200 ha of Floodplain Forest Habitat in the province, distributed primarily among 16 ecodistricts (Figure 25). Habitat patches range in size from less than 1 ha to 229 ha, with most (75%) of the patches being small, and the area being well distributed across patch sizes but weighted towards the larger ones (Figure 26, Figure 27).

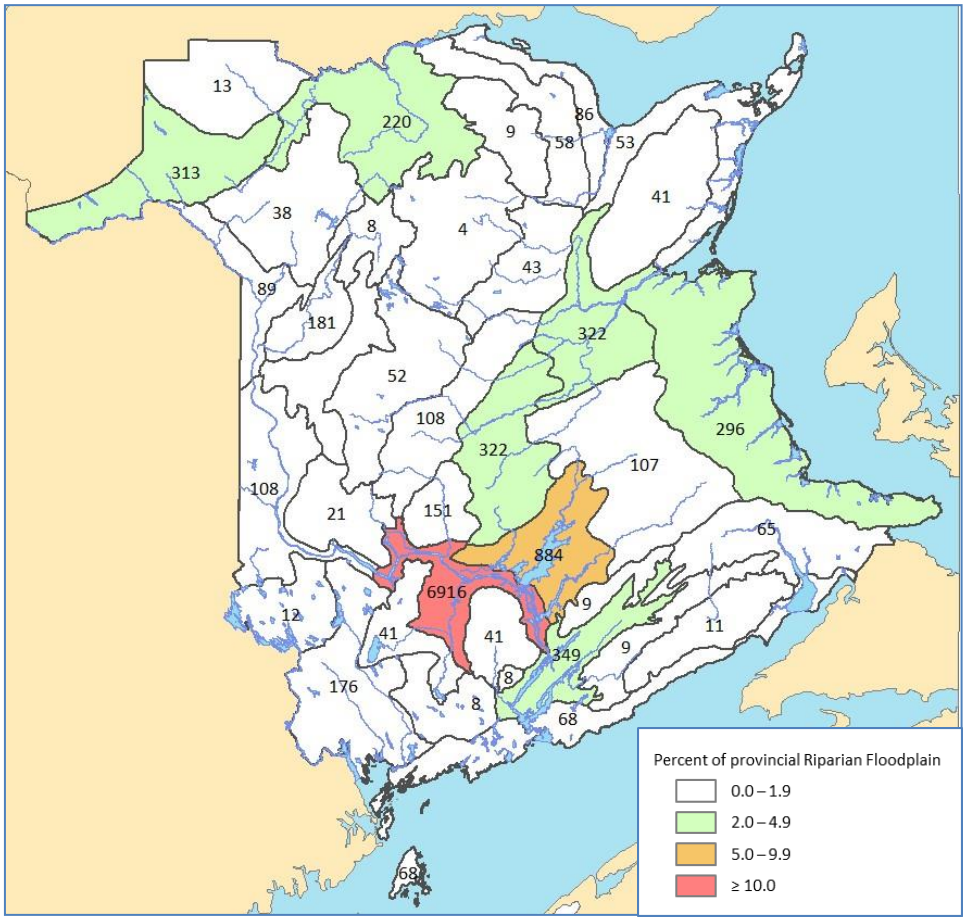

Figure 25. Distribution of Floodplain Forest Habitat across New Brunswick ecodistricts. Fill colours represent proportions of the total provincial area of the habitat; within-polygon values are the absolute area of habitat in hectares.

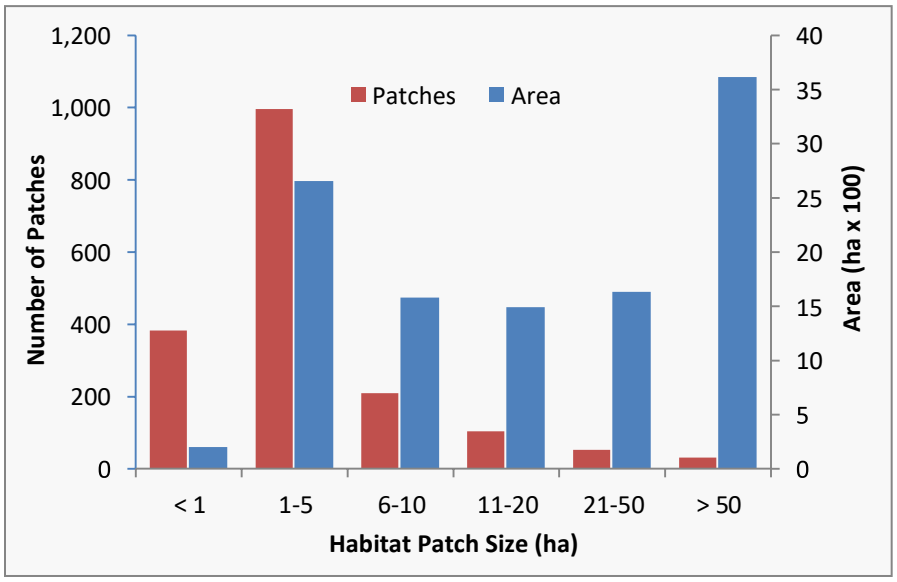

Figure 26. Patch size distribution for Floodplain Forest Habitat in New Brunswick.

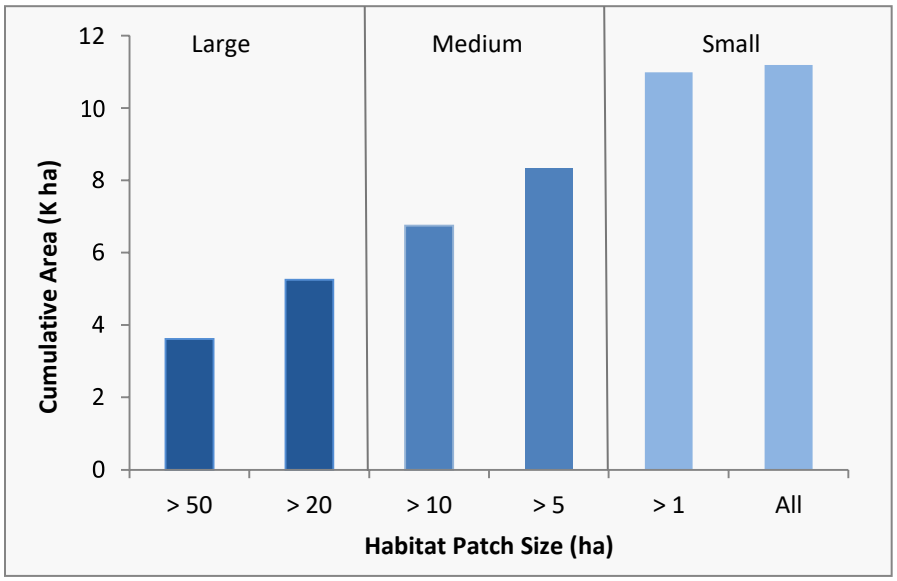

Figure 27. Cumulative area by decreasing patch size for Floodplain Forest Habitat in New Brunswick.

Cedar Swamp

Cedar Swamp Habitat is composed of coniferous forest stands dominated by eastern cedar and is saturated throughout the growing season. Soils in cedar swamps are less acidic and better oxygenated than forested wetlands dominated by black spruce or eastern larch. Fourteen vertebrate species are strongly associated with the type, all of which are common (NB ERD 2017c).

There are 67K ha of Cedar Swamp Habitat in the province, distributed primarily among 23 ecodistricts (Figure 28). Habitat patches range in size from less than 1 ha to 136 ha, with most of the patches (63%) being small, and the area being well distributed across patch sizes with almost half in an intermediate size (Figure 29, Figure 30).

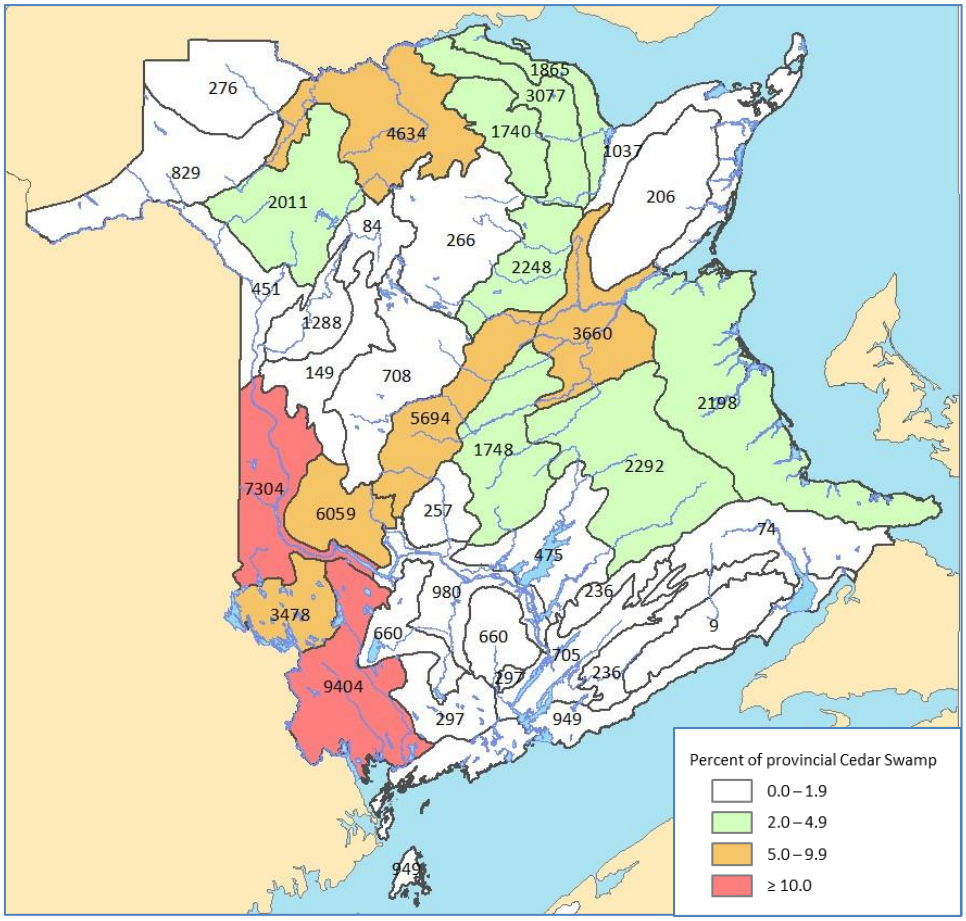

Figure 28. Distribution of Cedar Swamp Habitat across New Brunswick ecodistricts. Fill colours represent proportions of the total provincial area of the habitat; within-polygon values are the absolute area of habitat in hectares.

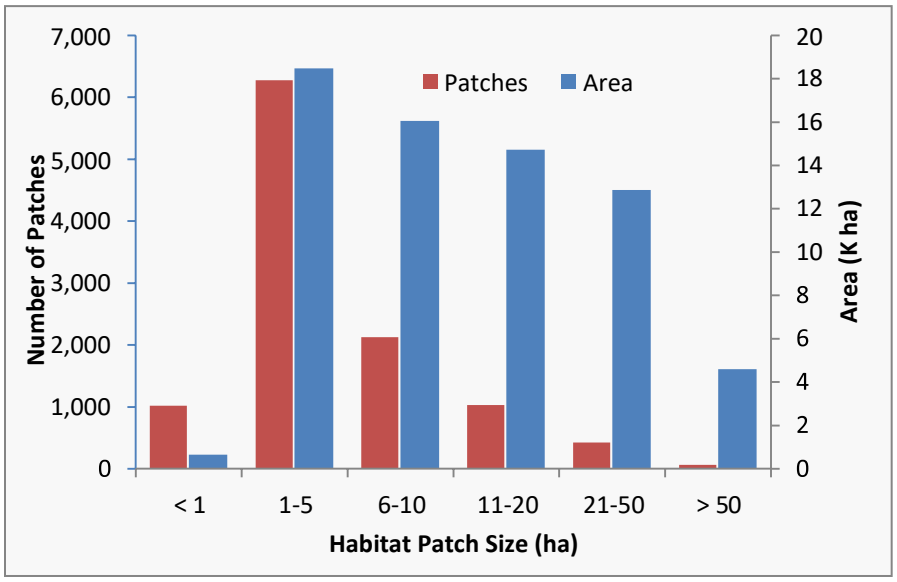

Figure 29. Patch size distribution for Cedar Swamp Habitat in New Brunswick.

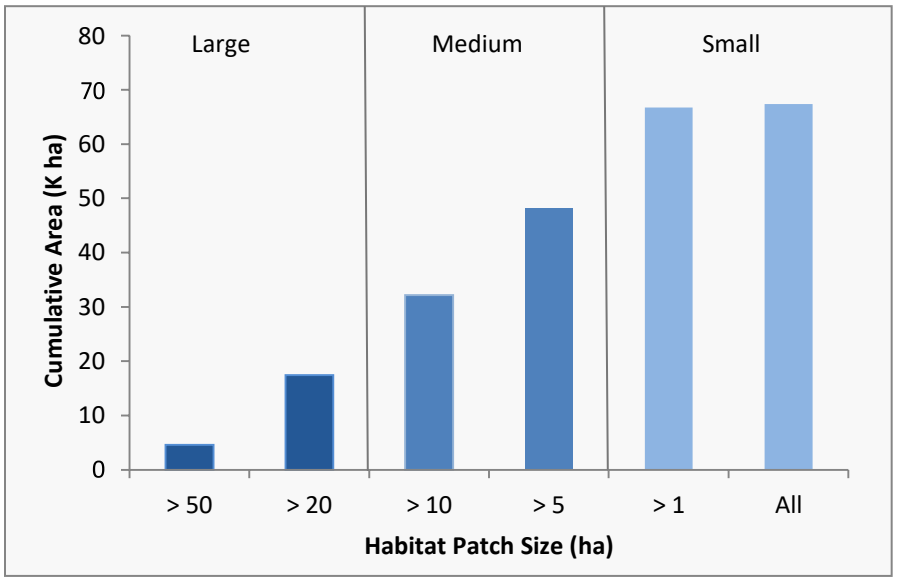

Figure 30. Cumulative area by decreasing patch size for Cedar Swamp Habitat in New Brunswick.

Salt Marsh

Salt Marsh Habitat is found in saline, coastal marshes that are sufficiently protected from wave action to allow accumulation of sediment and organic matter. It is characterized by species adapted to periodically-flooded salt or brackish environments. Coastal marshes can be divided into high and low marsh. High salt marsh generally lies above the mean high tide and is flooded only during the highest tides. Salt-meadow grass is common, along with other salt- and flood-tolerant plants. Low salt marsh sits below the mean high tide and receives daily inundation; salt-water cordgrass is often the dominant vegetation. Much of the Province's salt marsh has been lost due to protection from flooding by earthen dikes, or infilling to allow alternate land uses such as agriculture and coastal development. Thirty-five vertebrate species are associated with this habitat type, of which 30 are considered common (NB ERD 2017c).

There are 14K ha of Salt Marsh Habitat in the Province, most of which is distributed across 5 ecodistricts (Figure 31). Habitat patches range in size from less than 1 ha to 240 ha, with most of the patches (76%) being small (<5 ha) and most of the area (68%) being in large patches (>20 ha) (Figure 32, Figure 33).

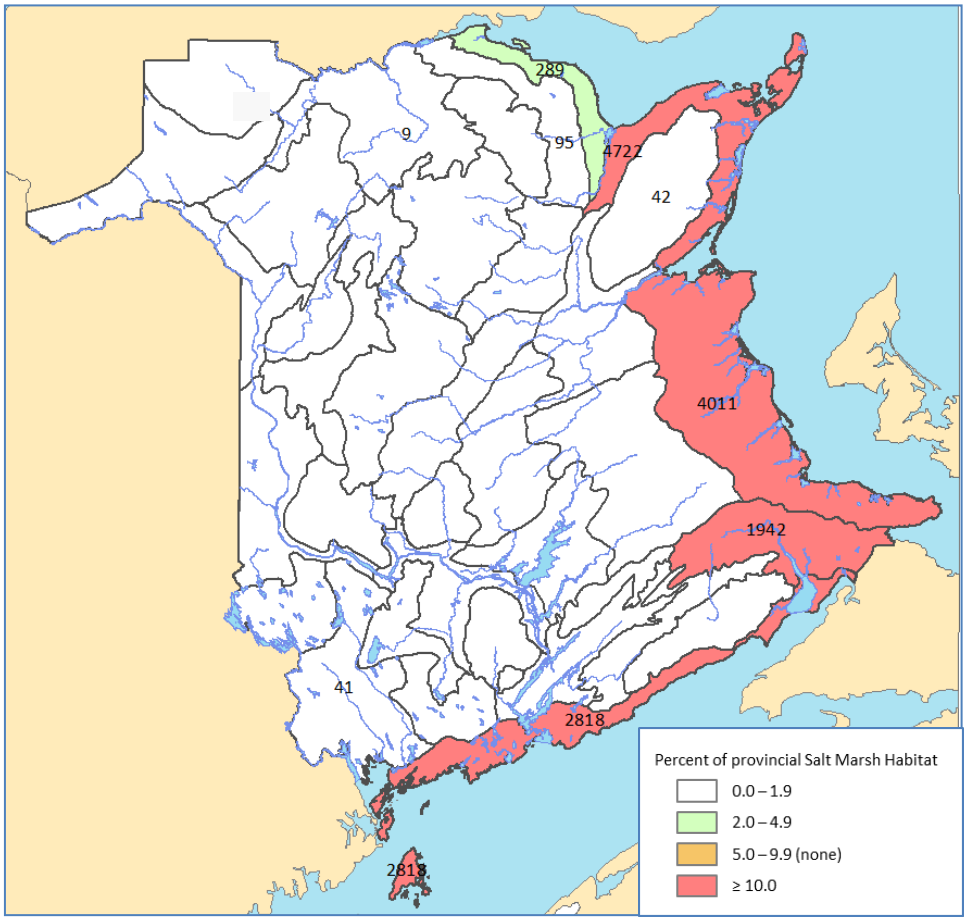

Figure 31. Distribution of Salt Marsh Habitat across New Brunswick ecodistricts. Fill colours represent proportions of the total provincial area of the habitat; within-polygon values are the absolute area of habitat in hectares.

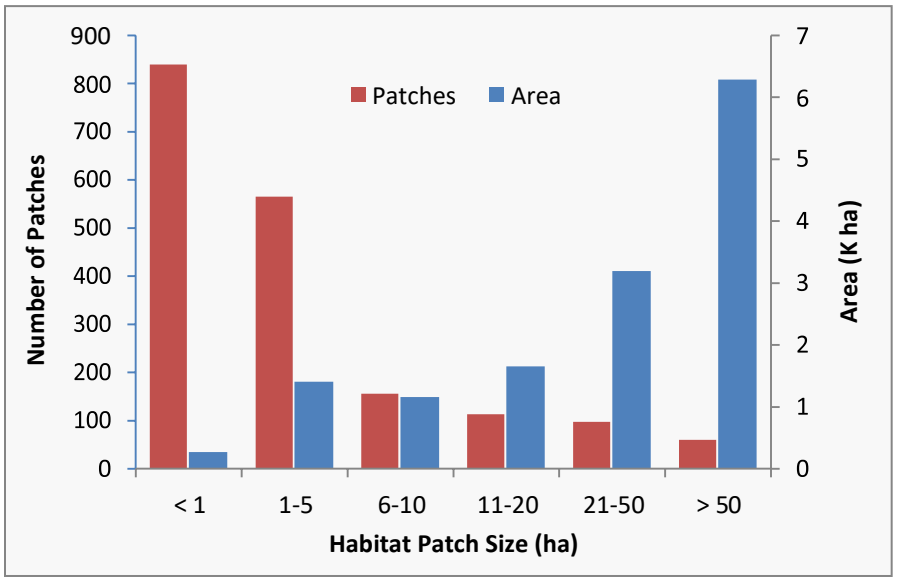

Figure 32. Patch size distribution for Salt Marsh Habitat in New Brunswick.

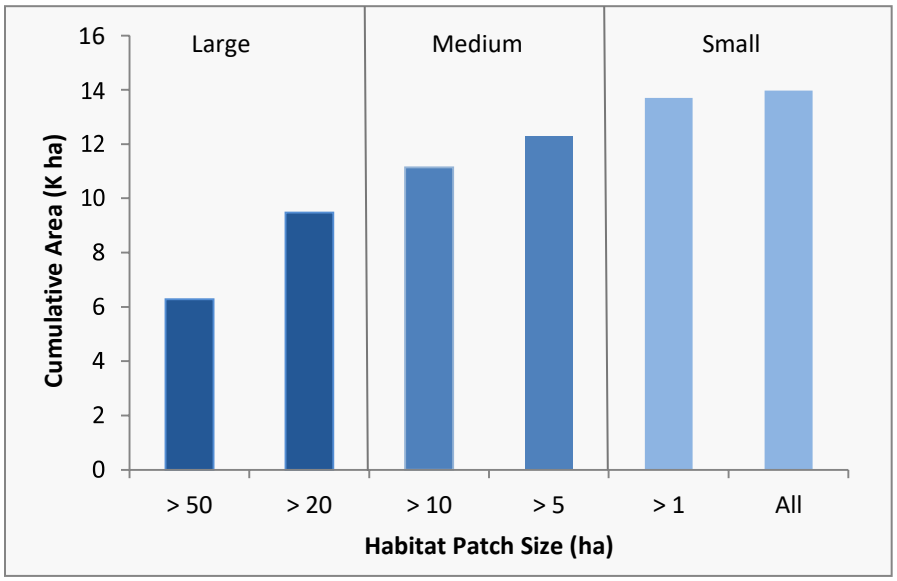

Figure 33. Cumulative area by decreasing patch size for Salt Marsh Habitat in New Brunswick.

Habitat Supplies for Wetland and Coastal Species

Many wetland and coastal species utilize more than one habitat type. Habitat use may differ among breeding, migrating and over-wintering populations, and it may differ within a single population among seasons. However, in many cases, different habitats may be used interchangeably by a population within a season, particularly when they are contiguous. In this case, a habitat patch is the entire area of contiguous suitable habitats, and effective habitat area is the sum of the areas of those amalgamated patches that are above the established minimum patch size. Calculation of habitat abundance for all wetland and coastal species is outside the scope of this report. However, the process is illustrated for 2 species, American black duck (ABDU) and pied-billed grebe (PBGR), and can be replicated for others.

The breeding population of American black duck utilizes a variety of habitat types: the beaver ponds of Wet Meadow / Tidal Marsh and Alder or Shrub Wetland and the entirety of Emergent Shallow Marsh, Deep Marsh / Aquatic Bed, Marsh Complex - Water Near and Wet Shrub Complex - Water Near (NB ERD 2017c). There are no patch size limitations to their use. An amalgamation of these habitats yields a total habitat supply of 81,720 ha, distributed primarily within 18 of 35 ecodistricts (Figure 34, top).

Pied-billed grebe utilizes Emergent Shallow Marsh Habitat and Deep Marsh / Aquatic Bed Habitat in patches of at least 5 ha (NB ERD 2017c). The combined total area of these habitat types is 29,310 ha. However, the area in patches of sufficient size, and hence the effective habitat area, is 17,090 ha. Pied-billed grebe habitat is distributed mainly among 12 of 35 ecodistricts (Figure 34, bottom).

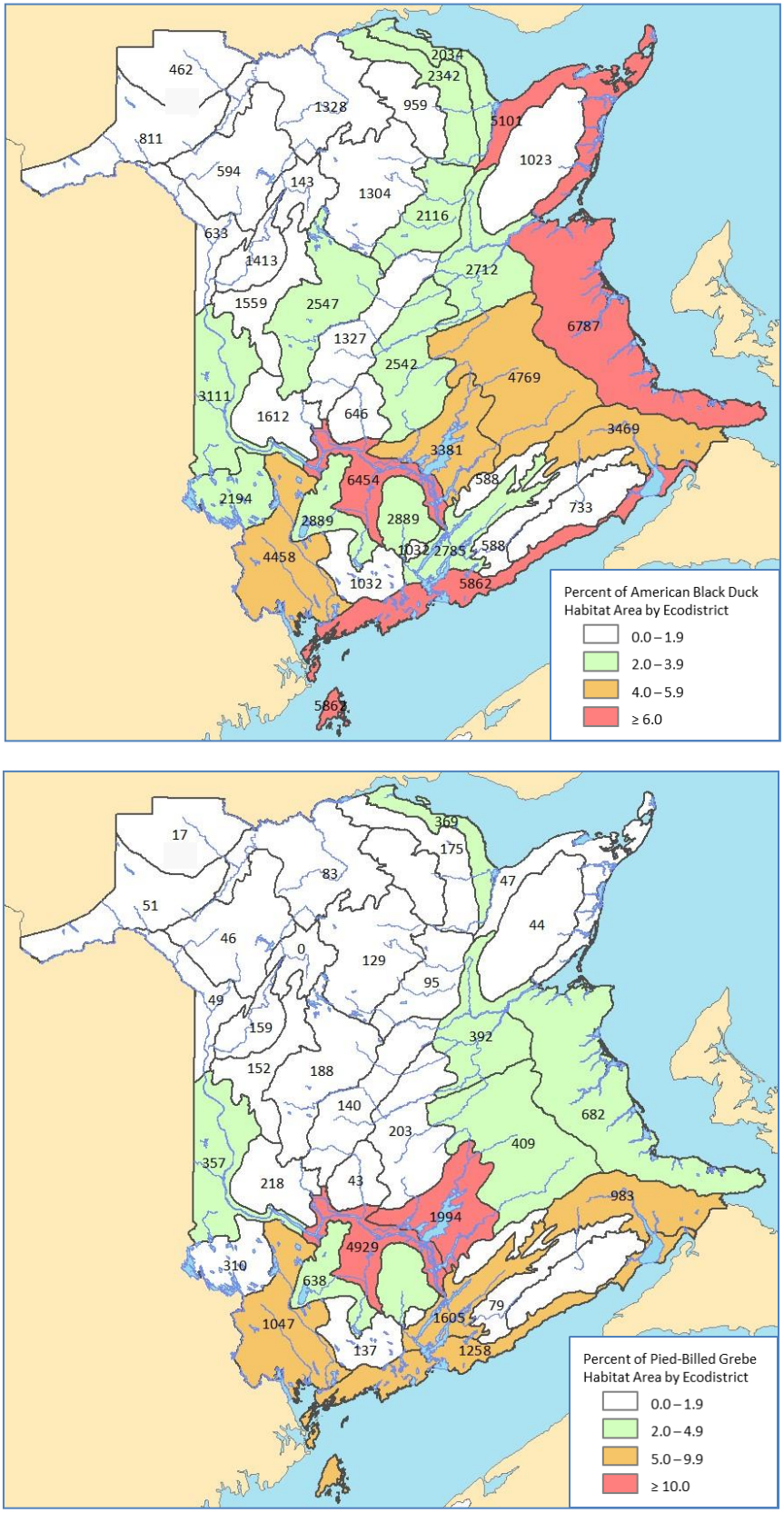

Figure 34. Distribution of American Black Duck (top) and Pied-Billed Grebe habitats across New Brunswick ecodistricts. Fill colours represent proportions of the total provincial area of the habitats; within-polygon values are the absolute areas of habitats in hectares.

DISCUSSION: HABITAT, INVENTORY, PROJECTION, SPATIALITY, THRESHOLDS AND THE FUTURE

The analyses and processes described in this and supporting documents were the most robust available that could be applied at landscape scales; we therefore present the results as reasonable and defensible estimates of past, present and future habitat supplies. Nonetheless, there are numerous points in the process where different assumptions could have led to somewhat different results.

Habitat Definitions: A key underpinning to the analyses is the way in which habitats are defined. Although information on habitat use abounds in the scientific literature, it was mostly not generated for the purpose of identifying all habitat values within a landscape. Information from small study areas had to be generalized; information from outside the province had to be localized; assumptions had to be made about habitat conditions that were not discussed; and habitat descriptions had to be converted to attributes available in the Province's photo-interpreted land cover inventory and supporting sample plots.

Forest habitat probabilities were calculated for each forest stratum as the ratio of the number of sample plots that met habitat criteria to the total number of plots. Habitat criteria related to live stem abundance and size were readily met in mature stands, whereas those related to dead stems were more likely to constrain probabilities and hence estimates of abundance. Standard variable-plot (prism) techniques provide good estimates of live stem abundance; however, the normally low frequency of dead stems makes their assessment highly variable.

Land Cover Inventory: The provincial inventory is not of sufficient resolution to assess many of the criteria used to define forest habitats, such as basal area, tree diameter and stand density. As part of the process of developing forest management plans, forest stands are grouped into strata based on inventory attributes and landscape-scale ecological characteristics. Data collected from ground plots are then used to characterize strata for multiple values, including for wildlife habitat. This process provides a valuable assessment of the average habitat value of a stratum, but does not identify which stands in a stratum are highly suitable and which are poor. This confounds the process of assembling habitat patches, which may affect estimates of habitat abundance.

Projections: The projection of future forest habitat abundance depends on our knowledge of the location and type of future harvest and other silvicultural interventions and on our ability to accurately predict stand development. Planned future treatments were known for Crown land but had to be estimated for small private holdings based on current treatment rates, which are likely to change according to market demand. The process of predicting stand development is well developed in New Brunswick. However, it depends on projecting past development patterns forward, a process that largely ignores the potential effects of a changing climate on species-specific growth rates and the likelihood of changes to patterns of fire damage and insect outbreaks. Projecting habitat probabilities depends on predicting both recruitment and persistence of dead stems, processes for which little empirical data exist.

Spatial Analyses: One of the most difficult components of this project was the process of reducing the modelled estimates of forest habitat abundance to account for areas that did not meet spatial criteria. The initial task was to assign appropriate species-specific spatial criteria. The scientific literature provides little guidance on the subject and much of that is from studies

that assessed forest patches within a non-forested matrix. As a result, considerable assumptions were made about the effects on patch viability of size, shape and inter-patch distance.

An open-source geographic information software model was modified to identify possible patches of each habitat type. It employed a moving-window approach that depended in part on user-defined assessment distances. Increasing the assessment distance generally had the effect of decreasing habitat abundance, increasing patch sizes and reducing the tendency of patches to have dendritic shapes. The decision on final assessment distance was made by assessing mapped outcomes in a largely intuitive fashion.

Landscape Connectivity: An assumption that underlies the spatial analyses of old-forest habitats is that patches are sufficiently well connected that important landscape barriers to wildlife movement do not occur. If the assumption is incorrect, then functional habitat supplies will be less than those reported. The assumption, though untested, is based upon 3 landscape conditions: (1) a significant portion (minimum 10%) of the forest outside of habitat patches meets stand-level old-forest habitat definitions at all times during the assessment period, (2) watercourse and wetland buffers of at least 30 m in width (on each side of the feature) occupy approximately 10% of the forest area and provide natural corridors, and (3) the area between old-forest patches remains in a forest condition and thus is not likely to form a barrier to most species over most of its development.

Forest Habitat Thresholds: There are undoubtedly habitat levels below which species cannot maintain viability over the long term and are at risk of extirpation. Our ability to determine those levels, especially at landscape scales for a large suite of species, is limited by our understanding of both population dynamics and the interactions of species and landscapes.

Guidance on estimating threshold levels is limited, and mostly refers to the minimum percent forest cover necessary to maintain the bulk of pre-settlement natural diversity in agricultural or developed landscapes (30% to 50%) (Environment Canada 2013). The extent to which that guidance can be transferred to the problem of maintaining *old* forest in a fully forested landscape is unclear. Young and mid-age forest, whether natural or planted, do not supply sufficiently complex structure, sufficiently large trees or a sufficient abundance of dead stems and woody debris to maintain old-forest species. However, they do provide some habitat value to some old-forest species and are less of a movement barrier for less time than agricultural or developed land.

Our approach to developing thresholds entailed calculating the habitat area required to support viable populations (500 breeding females) of 30 species with small home ranges in each of 35 ecodistricts, and of 14 others in larger units (NB ERD 2017d). Individual habitat blocks were assumed to have full occupancy of almost all species associated with them, and many blocks were assigned to more than one habitat type. Though the approach is difficult to defend precisely, it is intuitively reasonable and did not receive significant criticism at a peer workshop. The resulting thresholds are quite moderate (Table 5), with the largest being 285K ha for the broadly-defined Old Forest Habitat, an area equivalent to 5.6% of the forested component of assessment area.

Research and Development: There is need for both ecological research and process development to improve this type of landscape-scale analysis. The research needs are not new - continuous improvement to our understanding of how vertebrates utilize habitat at both stand and landscape scales. This is particularly important for species with large area requirements, those associated with complex stand structures or the occurrence of dead stems, and those whose habitat abundance assessments place them near their individual thresholds. The process improvements relate to assessment and prediction of habitat variables, in particular those defined by the occurrence of dead stems, and to the analysis of spatial habitat distributions.

Future Analyses: The provincial land cover inventory system is in transition from one based on visual interpretation of aerial colour images to one based on computerized interpretation of LiDAR (Light Detection and Ranging) data. As a result, many of the tools used for this analysis may not be relevant for similar future assessments. LiDAR can provide detailed information on stand structure for every 20 by 20 m unit, which may allow for a more direct assessment of many habitat variables. This may allow a habitat assessment process to avoid the errors introduced from working with strata-based averages.

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APPENDICES

Appendix 1. Old-forest habitat abundance in New Brunswick by ecoregion and minimum patch size on provincial and federal Crown land and non-industrial private land, 1987 to 2037.

Forest Habitat	Ecoregion	Minimum Patch Size	Year			
			1987	2012	2022	2037
Old Forest Habitat	1	10	229,491	18,454	Not Available	Not Available
		20	228,668	16,853		
		30	227,869	15,199		
		375	216,561	3,054		
	2	10	326,170	147,059		
		20	323,659	142,088		
		30	320,810	136,425		
		375	279,796	86,955		
	3	10	205,437	119,984		
		20	203,239	116,423		
		30	201,100	113,167		
		375	172,901	87,570		
	4	10	26,945	17,367		
		20	25,627	16,391		
		30	24,703	15,785		
		375	16,692	11,640		
	5	10	406,530	167,517		
		20	397,046	154,506		
		30	387,797	143,599		
		375	279,026	61,954		
	6	10	480,798	74,572		
		20	472,031	66,302		
		30	463,821	60,313		
		375	355,164	16,376		
	7	10	57,816	8,960		
		20	56,160	7,364		
		30	54,648	6,032		
		375	31,360	725		
	Totals	10	1,738,121	555,008	433,902	433,992
		20	1,711,285	520,954	406,340	407,363
		30	1,685,530	491,488	383,357	384,321
		375	1,355,339	268,799	209,661	210,189

Appendix 1 Continued

Forest Habitat	Ecoregion	Minimum Patch Size	Year			
			1987	2012	2022	2037
Old Spruce-fir Habitat	1	10	200,210	11,602	Not Available	Not Available
		20	199,351	10,570		
		30	198,462	9,565		
		40	197,620	8,907		
		50	196,480	8,132		
		375	188,575	1,639		
	2	10	255,811	109,876		
		20	252,781	104,685		
		30	249,802	99,649		
		40	247,352	95,744		
		50	244,550	92,214		
		375	214,820	54,424		
	3	10	86,967	36,410		
		20	83,840	33,145		
		30	81,430	30,457		
		40	79,095	28,576		
		50	77,625	26,601		
		375	63,018	16,710		
	4	10	25,411	18,549		
		20	24,263	17,356		
		30	23,266	16,611		
		40	22,556	15,947		
		50	22,144	15,435		
		375	15,329	11,727		
	5	10	220,054	135,590		
		20	207,792	123,096		
		30	197,833	112,115		
		40	189,444	103,335		
		50	181,814	96,020		
		375	109,950	35,262		
	6	10	328,785	69,797		
		20	317,210	60,565		
		30	306,476	53,254		
		40	296,759	47,057		
		50	288,465	43,089		
		375	185,688	12,818		

Appendix 1 Continued

Forest Habitat	Ecoregion	Minimum Patch Size	Year			
			1987	2012	2022	2037
Old Spruce-fir Habitat (Continued)	7	10	30,286	8,749	Not Available	Not Available
		20	28,120	6,887		
		30	25,985	5,706		
		40	24,219	4,934		
		50	22,442	4,316		
		375	9,362	593		
	Totals	10	1,148,845	388,569	279,315	270,256
		20	1,114,637	354,475	245,807	246,543
		30	1,084,501	325,676	234,106	226,513
		40	1,058,261	302,936	217,760	210,697
		50	1,034,708	284,339	204,392	197,762
		375	787,647	132,487	95,236	92,147
Old Mixedwood Habitat	1	20	43,262	4,726	Not Available	Not Available
		50	37,036	2,575		
	2	20	74,065	38,660		
		50	60,102	28,033		
	3	20	58,455	23,861		
		50	47,614	18,389		
	4	20	13,345	13,654		
		50	11,256	12,016		
	5	20	139,444	51,705		
		50	112,274	29,504		
	6	20	139,209	3,081		
		50	113,731	1,093		
	7	20	21,752	38,986		
		50	16,693	23,233		
	Totals	20	490,834	176,162	150,459	154,997
		50	399,763	115,823	98,924	101,908

Appendix 1 Continued

Forest Habitat	Ecoregion	Minimum Patch Size	Year			
			1987	2012	2022	2037
Old Hardwood Habitat	1	10	27,454	9,472	Not Available	Not Available
		20	25,060	8,491		
		30	23,289	7,432		
	2	10	73,311	28,324		
		20	68,577	26,048		
		30	64,074	23,706		
	3	10	120,041	76,542		
		20	117,126	73,748		
		30	114,775	71,000		
	4	10	2,921	401		
		20	2,324	315		
		30	1,885	235		
	5	10	166,767	25,193		
		20	155,852	22,309		
		30	147,073	20,239		
	6	10	97,191	6,718		
		20	87,389	5,742		
		30	79,604	5,190		
	7	10	20,896	311		
		20	19,121	283		
		30	17,840	240		
	Totals	10	512,500	148,120	136,738	145,212
		20	479,112	138,014	127,409	135,505
		30	451,994	129,048	119,132	126,514

Appendix 1 Continued

Forest Habitat	Ecoregion	Minimum Patch Size	Year			
			1987	2012	2022	2037
Old Tolerant Hardwood Habitat	1	10	18,119	8,583	Not Available	Not Available
		20	16,020	7,584		
		40	12,951	5,717		
		100	7,735	3,443		
	2	10	43,935	23,124		
		20	40,348	21,184		
		40	34,459	17,228		
		100	25,596	10,985		
	3	10	99,110	69,377		
		20	96,924	66,937		
		40	92,253	63,056		
		100	83,012	54,978		
	4	10	1,501	272		
		20	1,183	272		
		40	850	141		
		100	69	0		
	5	10	95,187	19,317		
		20	86,356	17,743		
		40	74,022	15,161		
		100	50,643	10,372		
	6	10	37,490	5,380		
		20	31,264	4,653		
		40	23,936	3,822		
		100	15,044	2,109		
	7	10	6,975	156		
		20	5,780	127		
		40	3,957	127		
		100	1,877	0		
	Totals	10	304,226	126,594	118,879	112,521
		20	279,626	118,860	111,616	105,647
		40	243,956	105,571	99,137	93,836
		100	185,133	82,134	77,129	73,004

Appendix 1 Continued

Forest Habitat	Ecoregion	Minimum Patch Size	Year			
			1987	2012	2022	2037
Old Pine Habitat	1	10	2,076	146	Not Available	Not Available
	2	10	1,827	854		
	3	10	125	365		
	4	10	0	0		
	5	10	4,617	3,532		
	6	10	33,018	4,275		
	7	10	1,531	1,075		
	Totals	10	43,891	10,290	10,744	12,329

Appendix 2. Young and mid-age forest habitat abundance in New Brunswick by ecoregion and minimum patch size on provincial and federal Crown land and non-industrial private land, 1987 to 2037.

Forest Habitat	Ecoregion	Minimum Patch Size	Year			
			1987	2012	2022	2037
Mid-aged Hardwood Habitat	1	10	1,092	11,129	Not Available	Not Available
		20	935	9,421		
		50	540	5,100		
	2	10	3,367	34,356		
		20	3,018	30,699		
		50	2,064	21,449		
	3	10	886	8,077		
		20	551	6,390		
		50	73	3,277		
	4	10	439	2,326		
		20	224	1,830		
		50	55	910		
	5	10	12,317	40,208		
		20	10,592	33,432		
		50	8,518	20,707		
	6	10	5,699	57,637		
		20	4,337	49,030		
		50	2,451	29,022		
	7	10	1,477	7,353		
		20	1,087	6,239		
		50	682	3,374		
	Totals	10	24,614	153,929	174,013	200,487
		20	20,200	130,953	148,038	170,562
		50	14,004	80,114	90,567	104,346

Appendix 2 Continued

Forest Habitat	Ecoregion	Minimum Patch Size	Year			
			1987	2012	2022	2037
Mid-aged Jack Pine Habitat	1	10	1,191	1,547	Not Available	Not Available
		50	944	1,194		
	2	10	2,151	1,323		
		50	1,257	836		
	3	10	521	11		
		50	234	0		
	4	10	104	0		
		50	86	0		
	5	10	800	839		
		50	451	303		
	6	10	9,077	12,872		
		50	6,963	5,818		
	7	10	371	1,056		
		50	298	570		
	Totals	10	14,341	18,316	13,420	8,097
		50	10,322	9,051	6,631	4,001
Young Spruce-fir Habitat	1	10	28,717	74,367	Not Available	Not Available
	2	10	41,598	63,846		
	3	10	28,058	32,286		
	4	10	10,900	7,257		
	5	10	47,784	49,526		
	6	10	102,597	113,864		
	7	10	7,381	9,778		
	Totals	10	266,681	354,747	436,765	412,141
Young Black Spruce Habitat	1	15	15,465	29,974	Not Available	Not Available
	2	15	25,415	53,768		
	3	15	14,554	15,343		
	4	15	3,393	1,084		
	5	15	20,703	32,314		
	6	15	46,061	78,895		
	7	15	2,675	6,192		
	Totals	15	133,678	223,966	248,057	210,214

Appendix 2 Continued

Forest Habitat	Ecoregion	Minimum Patch Size	Year			
			1987	2012	2022	2037
Young Mixedwood Habitat	1	20	7,872	28,593	Not Available	Not Available
		50	5,921	21,008		
	2	20	10,379	27,034		
		50	7,046	18,416		
	3	20	8,577	15,613		
		50	5,426	9,146		
	4	20	1,627	645		
		50	647	187		
	5	20	15,602	21,698		
		50	8,415	12,381		
	6	20	20,917	27,583		
		50	10,383	16,054		
	7	20	1,774	2,801		
		50	1,125	1,697		
	Totals	20	62,245	130,846	154,178	150,367
		50	36,335	83,266	98,114	95,688
Young Hardwood Habitat	1	10	14,498	27,256	Not Available	Not Available
	2	10	21,590	34,536		
	3	10	18,451	20,342		
	4	10	5,363	2,346		
	5	10	40,323	30,569		
	6	10	64,572	3,953		
	7	10	4,628	40,373		
	Totals	10	154,121	174,402	206,822	181,235

Appendix 2 Continued

Forest Habitat	Ecoregion	Minimum Patch Size	Year			
			1987	2012	2022	2037
Young Forest Habitat	1	10	34,593	96,923	Not Available	Not Available
		20	33,195	94,629		
		100	27,309	80,250		
	2	10	56,826	123,695		
		20	53,358	118,360		
		100	35,125	86,286		
	3	10	40,429	54,666		
		20	37,247	50,644		
		100	25,318	31,481		
	4	10	14,873	12,026		
		20	13,187	10,378		
		100	7,710	4,047		
	5	10	88,212	113,376		
		20	76,901	101,862		
		100	41,804	52,658		
	6	10	151,067	205,758		
		20	137,882	191,556		
		100	85,977	113,226		
	7	10	11,978	19,177		
		20	9,940	17,423		
		100	5,275	10,868		
	Totals	10	385,410	636,578	737,436	711,473
		20	350,282	595,095	689,380	665,109
		100	221,297	385,451	446,521	430,800

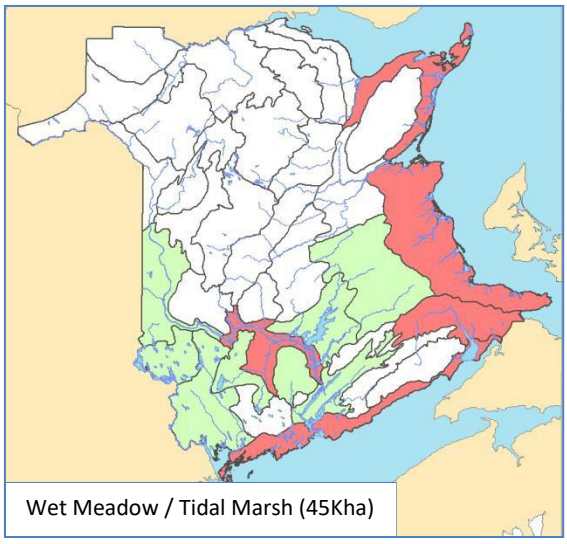
Appendix 3. Provincial wetland and coastal habitat abundance (ha) by patch size.

Patch Size (ha)	Alder or Shrub Wetland	Beach	Beaver Pond	Bog					Cedar Swamp	Deep Marsh / Aquatic Bed	Dune	Emergent Shallow Marsh	Fen	Floodplain Forest	Marsh Complex		Mud Flat	Rocky Shore	Salt Marsh	Wet Forest	Wet Meadow / Tidal Marsh	Wet Shrub Complex		Wetland Margin
				Coastal	Fully Treed	Open	Partially Treed	Shrub							Water Far	Water Near						Water Far	Water Near	
< 1	8,976	n/a	3,102	38	3,581	124	41	1,260	659	900	n/a	1,318	1,305	203	257	408	n/a	n/a	270	101,586	1,524	385	589	1,717
1 – 5	48,134	n/a	16,405	486	38,743	1,141	308	9,970	16,166	2,756	n/a	8,202	11,580	2,388	1,414	1,061	n/a	n/a	1,299	153,348	7,293	1,869	1,471	14,284
6 – 10	27,750	n/a	7,767	504	30,186	1,128	252	8,984	16,992	1,011	n/a	3,644	10,231	1,735	940	266	n/a	n/a	1,195	54,170	4,676	1,539	411	10,612
11 – 20	24,960	n/a	5,038	873	32,955	903	186	10,057	15,679	1,332	n/a	2,617	9,645	1,566	1,057	147	n/a	n/a	1,685	40,505	4,980	1,861	339	5,652
21 – 50	23,482	n/a	3,651	1,492	36,408	1,468	231	15,532	13,263	1,341	n/a	2,023	12,347	1,675	1,701	47	n/a	n/a	3,236	30,018	7,002	2,851	106	2,682
> 50	15,777	n/a	1,718	20,748	34,445	3,501	236	47,142	4,590	797	n/a	3,368	14,897	3,615	2,499	0	n/a	n/a	6,285	18,393	19,663	3,958	0	346
Totals	149,079	2,843	37,681	24,140	176,316	8,265	1,255	92,945	67,349	8,138	2,165	21,171	60,006	11,181	7,867	1,930	7,281	505	13,969	398,021	45,137	12,463	2,917	35,296

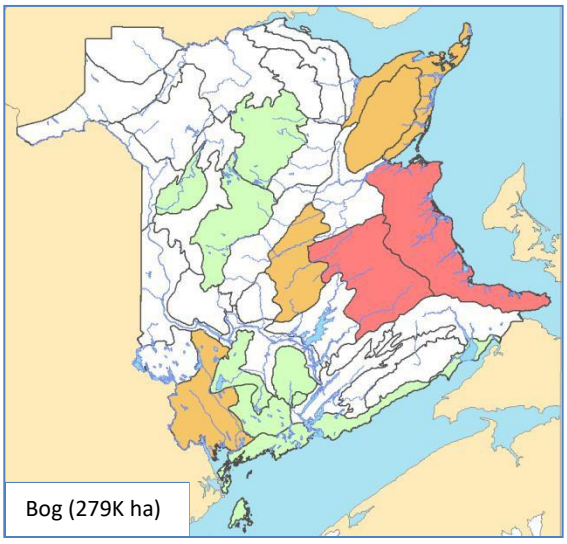
Appendix 4. Distribution of wetland and coastal habitats by ecodistrict. All patch sizes are included.

Ecoregion	Ecodistrict	Alder or Shrub Wetland	Beach	Beaver Pond	Bog					Cedar Swamp	Deep Marsh / Aquatic Bed	Dune	Emergent Shallow Marsh	Fen	Floodplain Forest	Marsh Complex		Mud Flat	Rocky Shore	Salt Marsh	Wet Forest	Wet Meadow / Tidal Marsh	Wet Shrub Complex		Wetland Margin
					Coastal	Fully Treed	Open	Partially Treed	Shrub							Water Far	Water Near						Water Far	Water Near	
1	1	1,971	0	365	0	1,013	14	0	14	276	13	0	103	42	13	0	0	0	0	0	3,260	15	7	6	271
1	2	4,023	0	804	0	4,349	148	53	1,189	266	4	0	180	1,119	4	40	18	0	0	0	6,451	117	413	127	578
2	1	3,679	0	1,035	0	1,449	8	6	130	4,635	220	12	304	124	220	25	12	0	0	9	7,600	226	100	38	875
2	2	4,826	0	721	0	1,407	47	0	300	1,740	9	0	224	245	9	61	33	0	0	0	4,652	185	44	20	601
2	3	3,970	0	1,952	0	1,567	7	14	416	3,077	58	0	494	410	58	10	7	68	0	95	8,348	208	44	26	1,043
2	4	3,788	0	1,840	0	3,628	314	37	520	2,248	43	61	240	967	43	52	15	0	0	0	7,420	113	110	52	697
2	5	1,390	175	1,554	0	616	0	0	95	1,865	86	22	690	98	86	0	0	297	0	289	5,672	521	51	12	1,309
3	1	2,762	0	607	0	719	0	0	14	829	313	0	232	20	313	10	6	0	0	0	4,857	108	64	43	474
3	2	1,627	0	500	0	2,231	0	0	146	2,011	38	0	128	45	38	0	0	0	0	0	10,825	50	24	15	301
3	3	448	0	124	0	693	0	0	25	84	8	0	15	30	8	0	0	0	0	0	2,030	0	0	0	49
3	4	1,664	0	1,308	0	1,587	0	33	182	149	0	0	378	217	0	0	0	0	0	0	3,066	101	60	21	954
3	5	5,039	0	997	0	4,778	12	97	1,497	708	52	0	477	904	52	13	9	0	0	0	9,745	194	302	117	1,332
3	6	1,532	0	571	0	1,135	21	7	274	9	11	0	64	243	11	23	9	0	0	0	3,430	113	65	17	179
4	1	5,708	703	1,177	1,750	8,541	130	110	5,017	949	68	82	1,082	3,053	68	360	124	3,284	343	2,818	9,366	6,081	957	204	1,309
5	1	1,646	0	1,224	0	7,335	0	0	174	1,288	181	0	326	123	181	36	18	0	0	0	5,623	188	76	27	771
5	2	1,063	0	514	0	279	13	0	40	451	89	0	155	45	89	5	0	0	0	0	3,179	187	35	13	353
5	3	4,619	0	2,079	0	1,842	214	19	1,439	7,304	108	0	880	1,283	108	280	44	0	0	0	10,565	1,063	1,263	289	1,836
5	4	2,901	0	888	0	1,654	16	6	271	5,694	108	0	285	351	108	6	0	0	0	0	6,954	194	74	28	855
5	5	1,362	0	506	0	1,126	0	0	311	257	151	0	278	401	151	0	0	0	0	0	3,367	86	0	0	715
5	6	4,186	0	865	0	2,871	31	20	714	6,059	21	0	563	531	21	22	6	0	0	0	7,295	468	278	88	1,154
5	7	3,184	27	1,014	0	2,515	171	52	2,102	3,478	12	10	458	1,910	12	560	263	0	0	0	7,200	1,251	1,044	402	822
5	8	11,675	86	1,844	0	11,125	969	146	4,824	9,404	176	5	1,528	4,528	176	843	272	137	162	41	24,855	1,855	1,870	538	2,333
5	9	6,966	0	2,091	0	4,064	231	12	2,015	660	41	0	1,067	1,725	41	196	39	0	0	0	10,331	1,453	297	65	1,637
5	10	2,879	0	319	0	3,915	221	32	1,520	297	8	0	221	1,666	8	276	107	0	0	0	4,423	303	445	164	696
5	11	3,975	13	684	0	1,363	78	10	210	705	349	0	1,003	246	349	685	132	0	0	0	8,048	1,385	71	22	1,025
5	12	2,874	0	474	0	826	62	0	76	236	9	0	80	99	9	23	0	0	0	0	3,613	78	17	6	200
6	1	6,180	0	609	0	9,776	179	237	5,102	206	41	0	195	2,272	41	27	17	0	0	42	19,389	190	42	5	364
6	2	3,617	978	19	8,389	8,688	68	132	11,420	1,037	53	1,071	66	4,005	53	120	64	1,320	0	4,722	18,761	5,428	659	56	104
6	3	5,578	0	2,276	0	9,336	123	14	4,484	3,660	322	0	627	2,677	322	58	18	0	0	0	23,543	468	349	73	1,695
6	4	12,177	0	3,992	0	28,835	3,562	44	15,926	2,293	107	0	902	12,721	107	56	10	0	0	0	42,691	1,043	1,167	111	1,911
6	5	5,584	0	2,076	0	18,391	39	53	9,036	1,748	321	0	645	7,028	321	0	0	0	0	0	19,702	557	159	31	1,547
6	6	14,928	751	845	13,979	20,255	1,373	89	20,610	2,198	296	902	915	9,887	296	344	141	1,368	0	4,011	51,190	6,146	1,379	162	1,661
6	7	4,171	31	171	20	3,316	108	8	1,690	74	65	0	625	981	65	670	126	807	0	1,942	12,595	8,972	391	73	444
7	1	4,106	7	767	0	1,690	89	12	453	980	6,916	0	4,315	374	6,916	2,316	295	0	0	0	13,238	4,813	533	38	3,196
7	2	2,981	72	713	0	3,403	14	6	708	475	884	0	1,429	906	884	742	131	0	0	0	14,752	980	74	27	2,007

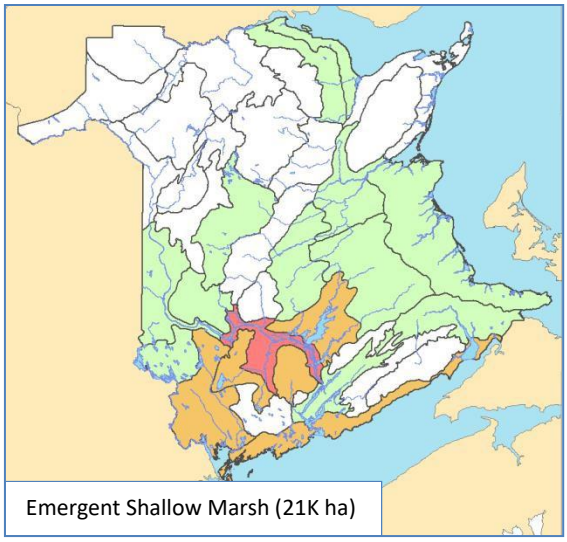
Appendix 5. Wetland and Coastal Habitat distribution maps.



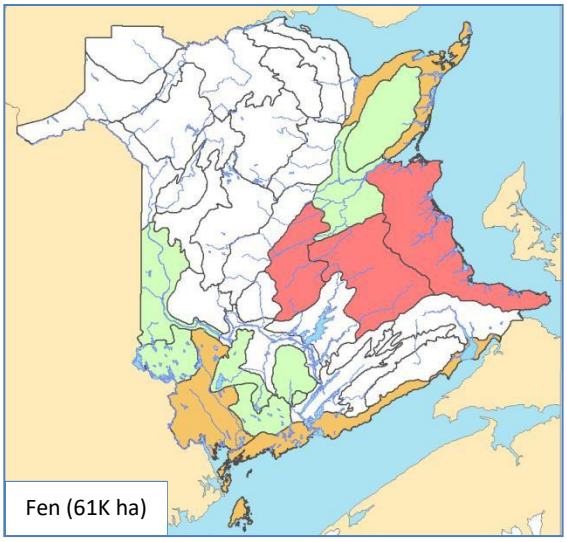
Wet Meadow / Tidal Marsh (45Kha)



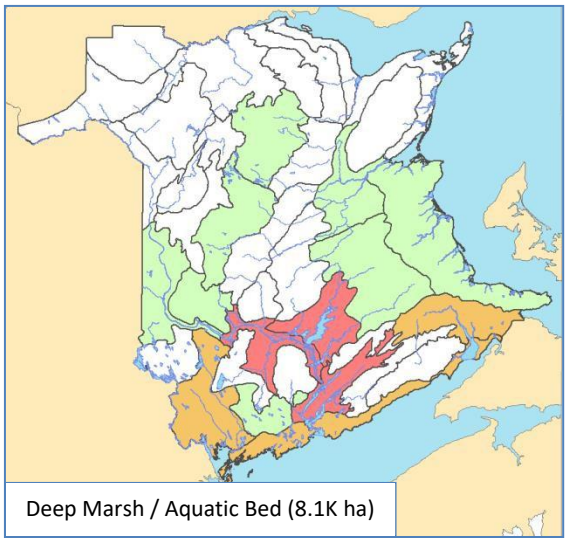
Bog (279K ha)



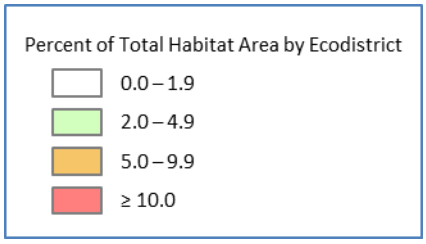
Emergent Shallow Marsh (21K ha)



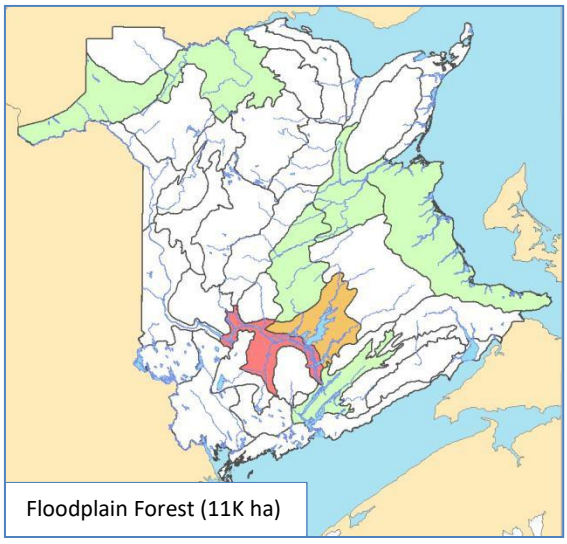
Fen (61K ha)



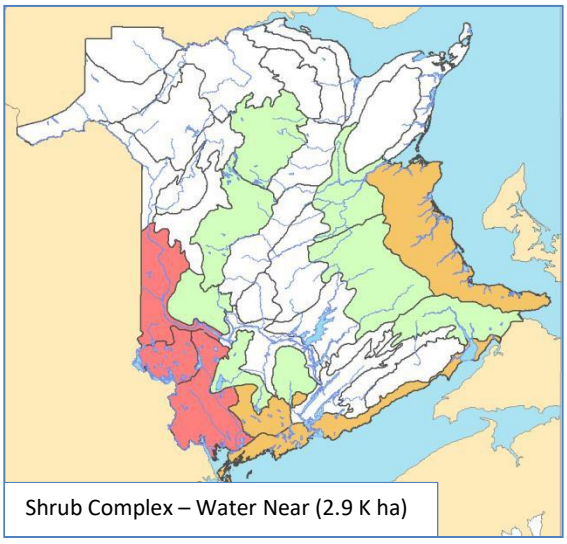
Deep Marsh / Aquatic Bed (8.1K ha)



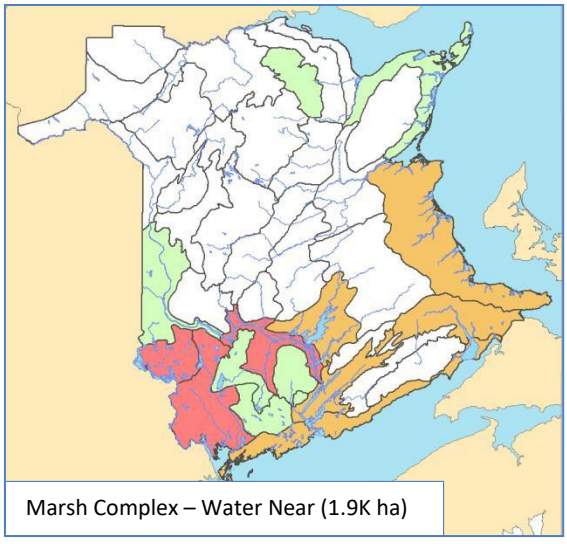
Appendix 5 (Continued 2)



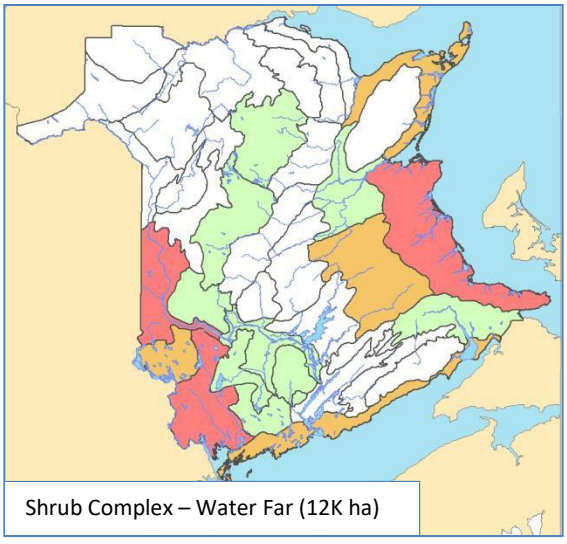
Floodplain Forest (11K ha)



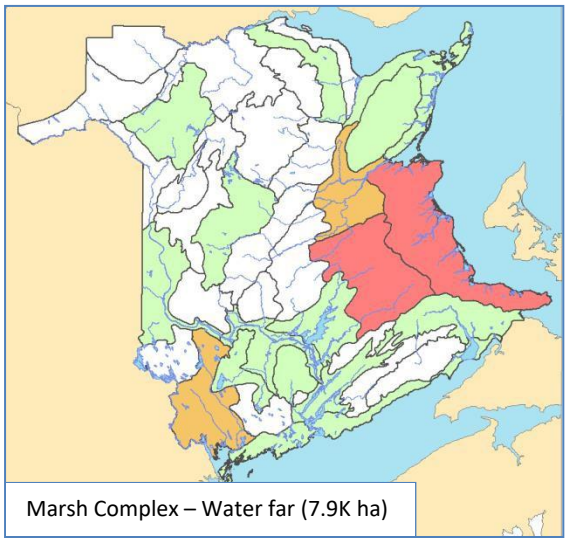
Shrub Complex – Water Near (2.9 K ha)



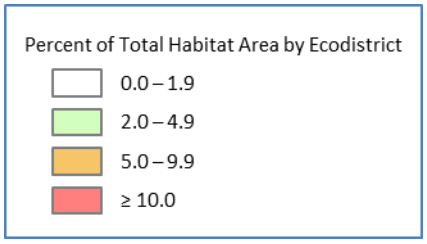
Marsh Complex – Water Near (1.9K ha)



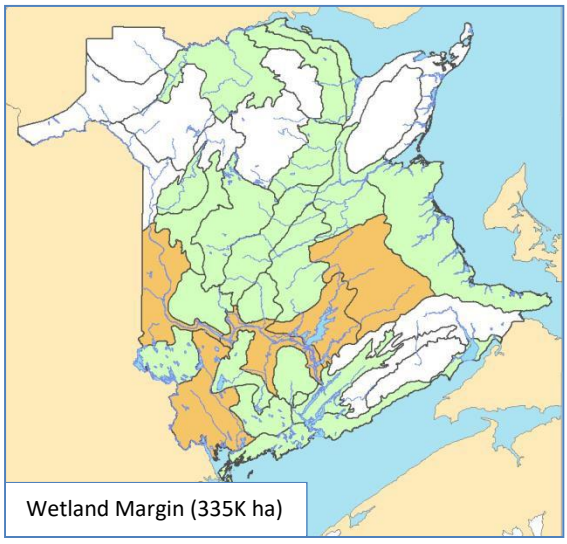
Shrub Complex – Water Far (12K ha)



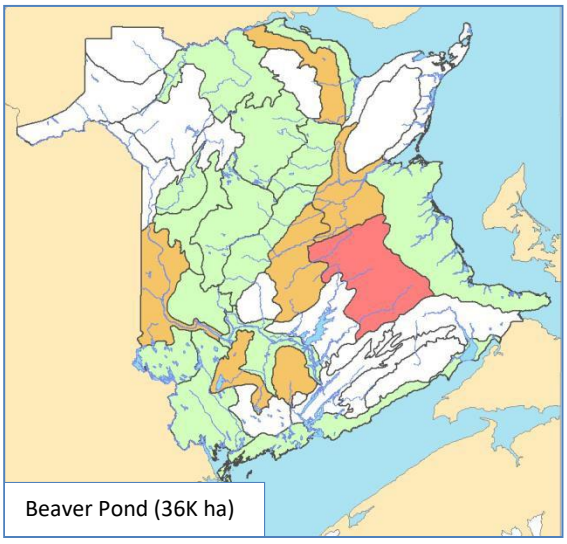
Marsh Complex – Water far (7.9K ha)



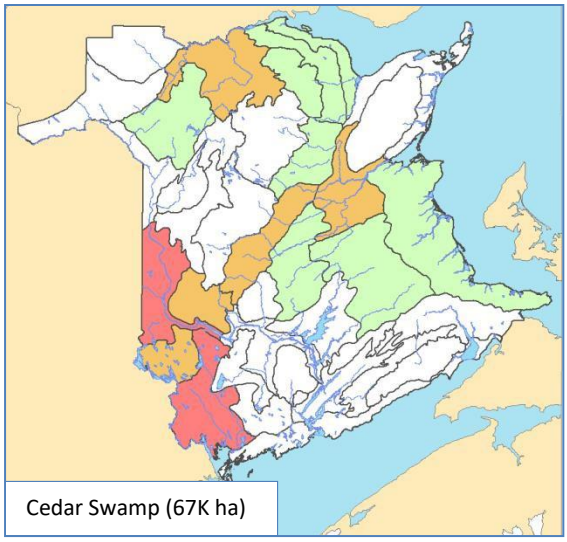
Appendix 5 (Continued 3)



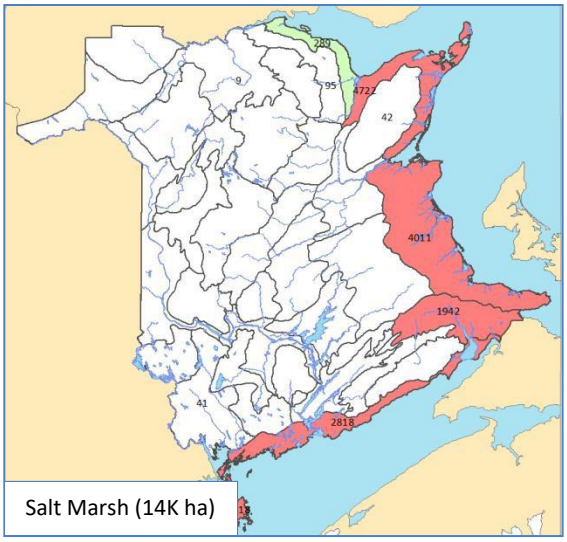
Wetland Margin (335K ha)



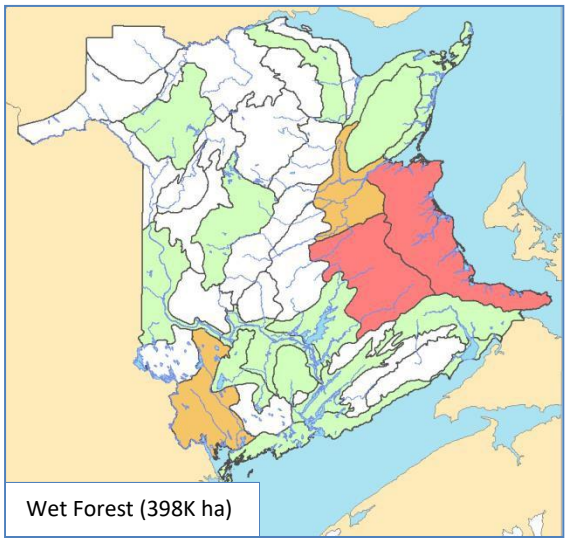
Beaver Pond (36K ha)



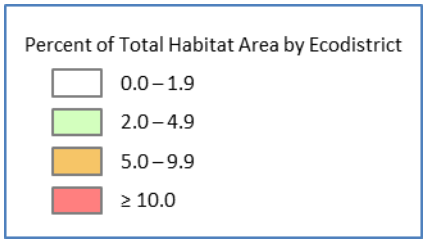
Cedar Swamp (67K ha)



Salt Marsh (14K ha)



Wet Forest (398K ha)



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