



A Wildlife Connectivity Analysis for the Chignecto Isthmus Region

Final Report to the Habitat Conservation Fund, Nova Scotia

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Introduction

The Nature Conservancy of Canada (NCC) is a national charity dedicated to the preservation of biological diversity through land protection and stewardship. NCC aims to conserve Canada's natural heritage by securing ecologically significant land through purchase, donation, conservation agreements or other mechanisms, and by implementing management on those lands for the long-term stewardship of biodiversity. NCC practices sound science to implement effective conservation, which ensures that limited resources are invested wisely and with maximum conservation impact. With financial support from the Habitat Conservation Fund, NCC completed a 1-year project modelling connectivity within the Chignecto Isthmus region, with the aim of identifying structural connectivity corridors for wildlife movement throughout the study area. This will assist in the identification of priority private lands for securement, provide materials to communicate the importance of Isthmus connectivity, and provide decision support materials to landowners, natural resource developers, and government land managers.

The Chignecto Isthmus has been recognized regionally, nationally and internationally as a critical wildlife corridor. It provides the only terrestrial connection between Nova Scotia and the rest of North America. Passage of terrestrial animals and plants along this critical migration corridor has already been significantly altered by anthropogenic impacts from highways, urban development, agriculture and forestry (Mazerolle et al 2016). While the key structural connectivity pinch points exist on the NB side of the border, maintaining or enhancing connectivity on the NS side is critical. By facilitating gene-flow between New Brunswick and

Nova Scotia, the Chignecto Isthmus plays an important role in maintaining healthy wildlife populations over the long-term.

Project Goals and Objectives

Goals:

1. Short-term Goal: Identify priority corridors within the Chignecto region for a suite of focal species (focus on wide-ranging mammals).
2. Long-Term Goal(s): Inform landscape and resource management decision making in the region as well as provide guidance to future land conservation initiatives in the region. Additionally, increased awareness and understanding of wildlife use of particular areas may provide local private landowners and land managers information and tools to better manage private lands for wildlife.

Objectives:

The process of modelling connectivity within the Chignecto Isthmus region involved the following steps, which will be discussed in further detail throughout the remainder of this report:

- 1) Develop a list of terrestrial wildlife species with habitat requirements that would collectively act as a surrogate for a broader range of biodiversity.
- 2) Create habitat suitability models for each of the species identified through literature review and expert opinion.¹
- 3) Model habitat suitability across the study area for each species to determine potential patches of suitable habitat.
- 4) Use cost-distance mapping to optimize the least-cost paths within the Chignecto Region for each species.
- 5) Optimize a connectivity corridor(s) using the combined least-cost paths.
- 6) Identify and prioritize private land parcels within the corridor that could be secured for conservation.

¹ The majority of the habitat models were completed by NCC and biologists in New Brunswick. Some modifications were made to reflect the opinions of NS biologists.

Study Area

The boundary of the analysis was confined to the Chignecto Isthmus region of New Brunswick and Nova Scotia using level 2 watersheds that incorporate the major linkage features identified in Figure 1. The five major linkage features represent the largest protected areas within the Chignecto region. The Canaan Bog Protected Natural Area in NB, the Cape Chignecto Provincial Park, Kelley River Wilderness Area, Economy River Wilderness Area, and Portapique Wilderness Area in NS, were selected as core linkage areas due to their relative size and the legal protection assigned to the habitats within them.

The focus of this report is related to the patterns and distribution of structural connectivity on the Nova Scotia side of the Isthmus. However, it was crucial to include the area on the NB side in the analysis to fully understand the potential for wildlife movement throughout the Isthmus region. Restricting the analysis to the NS side of the border would fail to achieve the goal of identifying structural connectivity corridors through the NB / NS border region by ignoring the distribution and condition of habitats that exist on the NB side of the border. The analysis boundary therefore incorporates the area included in the previous connectivity analysis completed by NCC in New Brunswick in 2014.

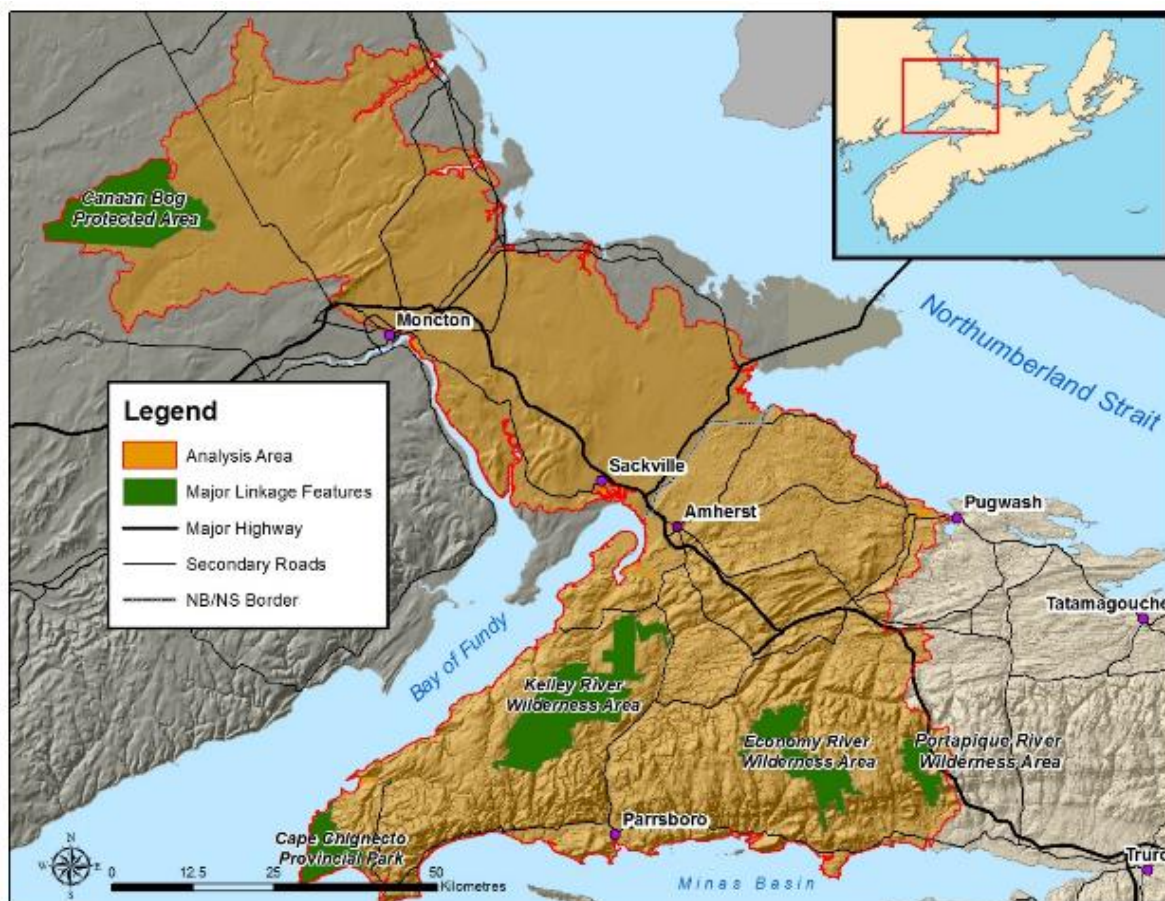


Figure 1: Area of analysis and major linkage features.

Methods

Species Selection

One of the fundamental principles of wildlife connectivity analyses is to use an inclusive species-strategy. Since the habitat requirements of every species of wildlife cannot be assessed, the alternative is to develop a suite of species that will serve as a surrogate for a broader range of biodiversity (Beier & Loe 1992). The initial list of species was identified in the 2014 NB connectivity analysis that had been adapted from a report by MacDonald & Clowater (2005) and modified to capture a broader range of terrestrial habitat requirements (forest community and wetland type; age-class) and life-history strategies (territory size; ecological guild). Consideration was also given to those species that have well-documented habitat requirements, which provides greater confidence in the resulting habitat models. The species list in the New Brunswick analysis was reviewed by the Nova Scotia Department of Natural Resources, Wildlife Division, and refined to include some alternative bird species due to their more specialized habitat requirements. The final list of species used in the NB and NS analysis are seen in Table 1. Birds which were removed and their replacements are also identified.

Table 1. Common name, scientific name and justification for inclusion of the 12 species chosen for the Nova Scotia Chignecto Isthmus connectivity analysis. Bolded – NB Removed; Grey Highlight - NS Substitution

<u>Common Name</u>	<u>Scientific Name</u>	<u>Justification for Inclusion</u>
Moose	<i>Alces alces</i>	Habitat generalist; large territory size; wide ranging
Black Bear	<i>Ursus americanus</i>	Habitat generalist; large territory size; wide ranging
Red Fox	<i>Vulpes vulpes</i>	Habitat generalist; medium ranging
Bobcat	<i>Lynx rufus</i>	Habitat specialist; wide ranging; large territory size
Snowshoe hare	<i>Lepus americanus</i>	Habitat generalist; important prey species
Fisher	<i>Martes pennanti</i>	Habitat specialist; large territory size; fragmentation sensitive
Northern Flying Squirrel	<i>Glaucomys sabrinus</i>	Habitat specialist; umbrella species; fragmentation sensitive
Barred Owl	<i>Strix varia</i>	Habitat specialist; umbrella species; large home range
Northern Goshawk	<i>Accipiter gentilis</i>	Habitat specialist; umbrella species; large home range
Pileated Woodpecker	<i>Dryocopus pileatus</i>	Habitat specialist; umbrella species; keystone species
Yellow Warbler	<i>Dendroica petechia</i>	Habitat specialist; umbrella species
Brown Creeper	<i>Certhia americana</i>	Habitat specialist; fragmentation sensitive
Ruffed Grouse	<i>Bonasa umbellus</i>	Habitat generalist; important prey species
Boreal Chickadee	<i>Poecile hudsonicus</i>	Habitat specialist; fragmentation sensitive
Blackburnian Warbler	<i>Setophaga fusca</i>	Habitat specialist; fragmentation sensitive

Habitat Suitability Modelling

Modelling habitat suitability across the isthmus for each of the 12 species required the development of a standardized land cover grid for use within a GIS framework. Following the methods as described within the CorridorDesign approach (Majka, Jenness & Beier 2007), a land cover class system was developed for the Chignecto Isthmus based on the 35 distinct classes previously identified within the NB study (Noseworthy 2014). The land cover classes

were originally selected in NB using the New Brunswick Resource Inventory Database (2008), which included forest, wetlands and anthropogenic features. The forest inventory was grouped into seven habitat types based on the NBDNR habitat definitions (2013), each of which was further separated into three age class categories (young, mid-aged, old). Wetland features were grouped into cover types based on vegetation (non-vegetated, emergent, shrub, forested) and anthropogenic features were grouped by land use (agriculture, human settlement, forest plantation, etc.). Once the finalized list of land cover types was completed and reviewed, numerical identifiers were assigned to each class and spatially projected across the study area. Habitat suitability scores were then assigned to each land cover class for each species based on a scoring system between 0 and 100 (100 = best available habitat or highest survival and reproductive success; 0 = absolute non-habitat). The method of assigning these habitat parameters involved a literature review and expert opinion survey. The literature review was conducted using a variety of sources, but relied heavily on U.S. Fish and Wildlife Habitat Suitability Index reports whenever possible (Appendix C1). Expert opinion was given by the NBDNR Habitat Section. Once completed, the values from both the review and survey were compared to assess the level of agreement between the predicted values. Generally, values were found to be in close agreement for all species. In the few cases where a discrepancy was found, the issues were resolved through discussion and further review of the literature. The final species/land cover matrix can be viewed in Appendix D.

In order to adapt the analysis for the NS side of the Isthmus, the same 35 habitat classes were used (Appendix D). However, the Nova Scotia provincial forest resource and wetland inventories had to be re-classified to best mimic the habitat class qualifiers identified for NB. Five thematic GIS layers were used to develop a compatible cover type layer. The NS provincial forest resource inventory (2014) was used to delineate anthropogenic landcover types including roads, human settlement, agriculture, soil/gravel extraction sites, and plantations, as well as natural features such as shrublands and some non-vegetated wetlands. The recently developed Forest Ecosystem Classification (FEC) layer, obtained from NSDNR Wildlife (2015), is a species based re-classification of the original provincial forest inventory, and was used to classify the various forest habitat types. The Development Class layer obtained from NS DNR Forestry (2015) was used to assign an age class to the forest types classified in the FEC layer. The Wet Areas Mapping / Depth to Water layer (Arp 2009) was used to delineate wet and poorly drained stands of Black Spruce forest. Finally, the provincial wetlands inventory vegetation layer (2011) was used to classify wetland types to best mimic the classification in the NB study. The combination of these layers resulted in the creation of a seamless habitat layer for the study area that with comparable habitat classes in NB and NS. For all species, it was determined that that species would not be limited by topography in their movement throughout the majority of the study area. This is due to the flat topography on the NB and NS sides of the Isthmus and the absence of steep slopes in the majority of the study area. (Steep slopes limited to coastal areas on the Bay of Fundy). Species movement may however be

influenced by changes in vegetation and/or local climate as a result of changes in elevation. This could be accounted for in the mapped habitat classes used in the analysis.

This methodology permitted the use of the existing species habitat suitability indices values assigned to each of the original 35 habitat classes. The table in Appendix D compares the NB and NS classifications as well as the inventory qualifiers for each class.

Once the re-classification of the NS landcover was completed, the NS data was combined with the layer created for NB. Additional editing was necessary along the border where provincial data sets did not align. Habitat polygons along the border were manually merged based on habitat classes to eliminate gaps and overlaps between provincial layers.

The final step in the habitat assessment was to establish patch sizes for each species (Appendix C2). Following the CorridorDesign approach, Majka, Jenness & Beier (2007) suggest that patch sizes for each species be determined based on the following definitions:

“(1) Breeding patch: the smallest area of suitable habitat to support 1 breeding pair for 1 breeding season, and (2) Population patch: the smallest area of suitable habitat to sustain an isolated breeding population for 5-10 years.”

These values were derived from a literature review on territory size of each species. Generally, breeding patch size metrics were easily obtained as territory sizes are well known for many species of wildlife. However, population patch size metrics were often not available within the literature. To account for this, breeding patch sizes were multiplied by 5, as suggested by Majka, Jenness & Beier (2007). Additionally, a habitat quality threshold value of 75% was assigned for all species. This value was used across all NBDNR Habitat Definitions (2013), and was therefore deemed suitable to apply within this analysis.

Connectivity Modelling

Connectivity throughout the analysis area was modeled for each species using the Linkage Mapper software (McRae & Kavanagh 2014) for ArcGIS 10. The tool relies on least-cost algorithms to identify a route between the linkage features that would minimize the resistance of movement (energetic cost, difficulty or mortality risk) for each species based on their habitat suitability as described above. The final output for each species is a linear pathway for each respective species (Appendix E). Wildlife corridors can then spatially assigned where multiple species share common pathways across the landscape.

Parcel Prioritization

In addition to identifying wildlife corridors, the combined species least-cost paths can also be used to identify connectivity “pinch points” across the landscape. Pinch points are habitat

bottlenecks, where multiple species paths tend to congregate due to a lack of suitable habitat in the surrounding matrix (e.g. a forest fragment within an agricultural landscape). Identifying private land parcels within pinch points will allow NCC to prioritize these areas for securement, ultimately contributing to the long-term maintenance of structural connectivity throughout the Chignecto Isthmus. Additionally, pinch points located adjacent to transportation corridors could assist in identifying areas of elevated wildlife crossings where further on-the-ground research could be focused.

Results

As is seen in Figure 2, habitat-based movement pathways for most species are restricted to within a 5 – 10 km corridor in New Brunswick, while paths begin to diverge and become less concentrated on the NS side of the Isthmus. All species paths are seen to converge at the NS/NB border within a narrow 5 km stretch of the border. For individual maps depicting each species' least-cost path with modelled habitat patches, see Appendix E.

To model potential wildlife corridors across the Isthmus, the 12 species' least-cost paths were combined using a Kernel Density model. The Kernel Density model estimates the probability of corridors across the landscape based on the density of least-cost paths per unit area (10m^2) within a 1.5 km search radius. The result of the Kernel Density analysis (Figure 3) does not portray a corridor with discrete boundaries, but instead reflects a high-low probability scale of corridor occurrence across the landscape.

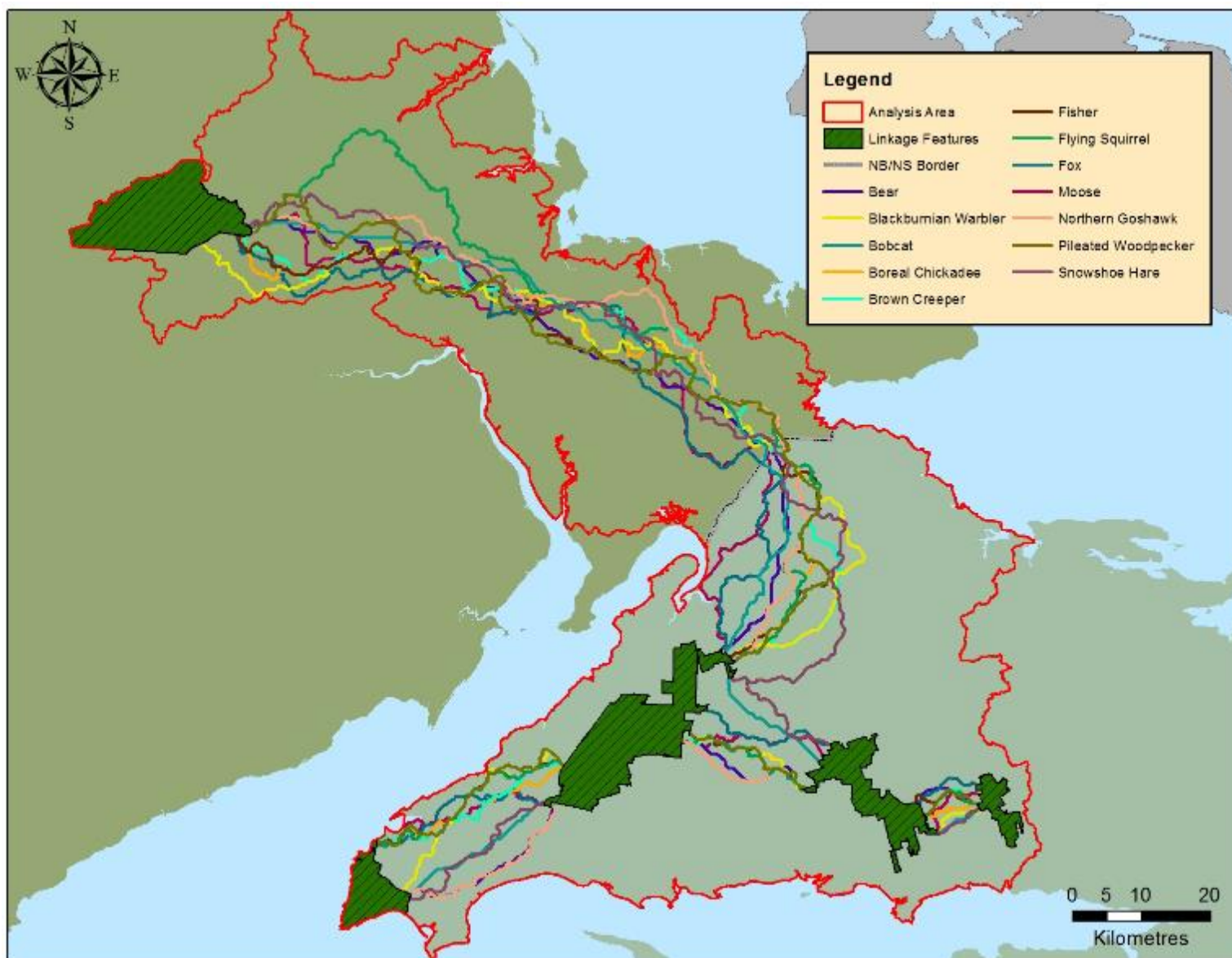


Figure 2: Least-cost paths of the 12 species included in the analysis

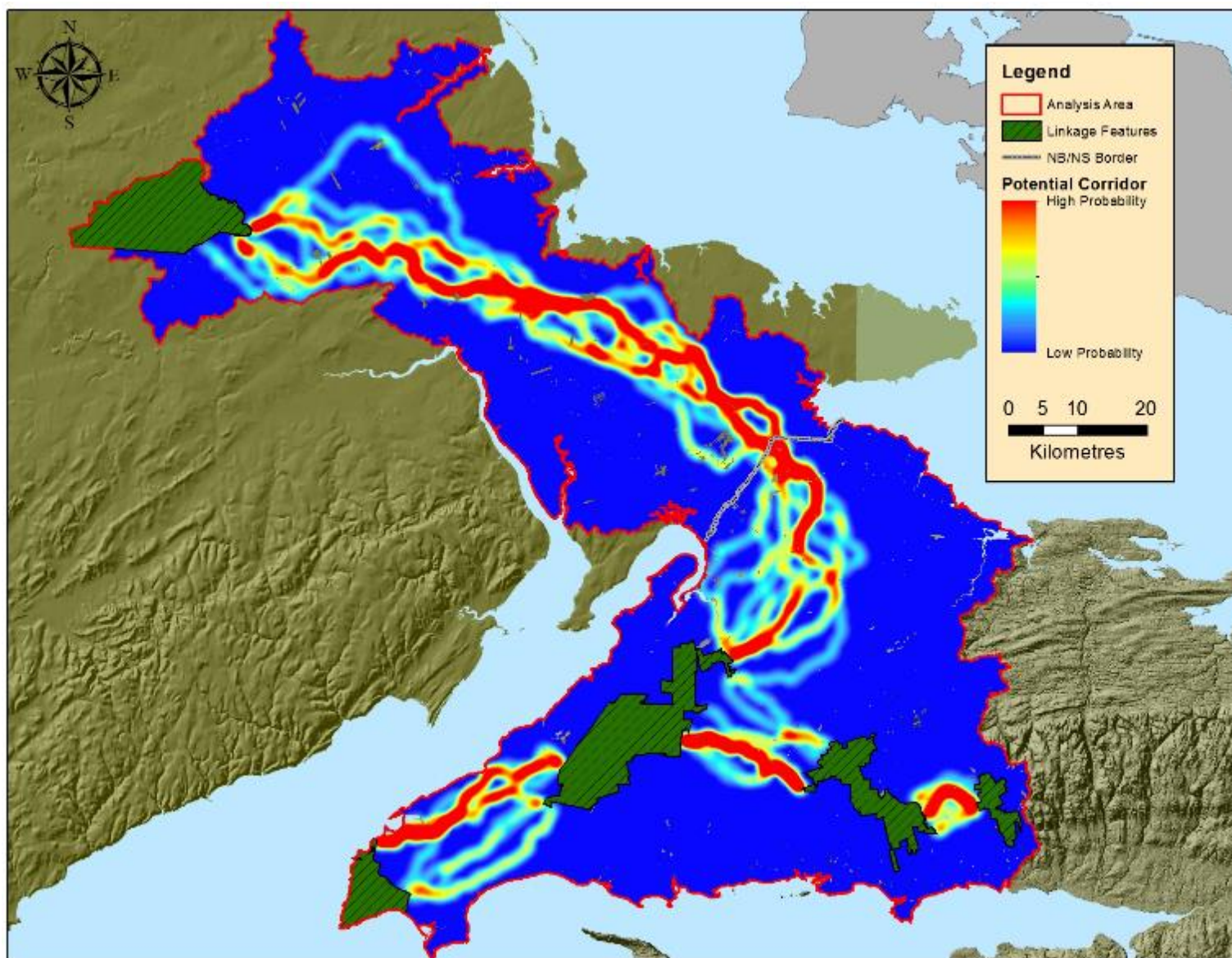


Figure 3: Kernel Density model of potential corridors across the study area

To create a discrete corridor, the Kernel Density model was reclassified using a Jenks natural breaks optimization, which aims to minimize the variance within each class ($n=2$) while maximising the variance between classes. This results in the best possible arrangement of density values into 2 classes (high density and low density). The resulting high density class was extracted as the optimal corridor across the study area, and is 83,315 ha in size: 43,875 Ha in NB, and 39,440 Ha in NS (Figure 4)².

Pinch points were manually selected by reviewing the least-cost paths in relation to anthropogenic features (roads, agricultural land, urban and rural settlement, etc.), as well as by reviewing the kernel density model extracted from the high-density class corridor (Figure 5). Since the kernel density tool highlights the areas of greatest density amongst the paths within the restricted boundary of the corridor, the areas of high probability may potentially signify connectivity bottlenecks. Bottlenecks represent an area where suitable habitat for many species is geographically constricted by unfavorable habitat and species' least-cost paths must pass through a confined area. A number of connectivity pinch points are clearly visible from the results, the most obvious being the convergence of all species at the Nova Scotia border (Pinch point 1). For the purpose of this report, a total of 8 pinch points were selected within the high density corridor on the NS side of the Isthmus, which can be seen individually in Appendix F with private land parcels overlaid. For land acquisition purposes, property assessments using satellite imagery and ground-truthed surveys will provide information on habitat type, quality and condition within each pinch point, which will ultimately be used to prioritize conservation actions.

Discussion

A number of past analyses have been conducted within the Chignecto Isthmus region to assess wildlife connectivity at the landscape scale (MacDonald & Clowater 2005; Nussey 2010; de Graaf 2011; Noseworthy 2014). However, this attempt to capture structural connectivity based on the specific habitat requirements of focal species for the entire cross border Chignecto region is the first of its kind. The results are based on the best available data and would reflect to a degree the reality of landscape conditions on the ground, however, there is bound to be some error in the identification of habitat and landcover types throughout in the initial interpretation and creation of the forest inventories for both provinces. Other errors in landcover data could be attributed to landscape disturbances occurring after the most recent inventory updates. This analysis is meant as an early step in the identification of potential corridors in the Isthmus region and should not be used as a stand-alone product when directing resources into conserving or enhancing connectivity. The results are ultimately meant to direct further study within the identified corridor area and more specifically within the eight identified pinch points (Figure 5). The results can, with further study, be incorporated as support into

² The final boundary was modified to eliminate 'islands' of high density that were not connected to the main corridor.

land conservation and management decision making such as land acquisition, forestry management plans, wildlife crossing infrastructure and signage.

Other possible next steps could include landcover verification and modelling within the high density corridor (Figure 4) using up-to-date satellite and aerial imagery; wildlife camera placement within pinch points that cross transportation corridors; discussions with land and woodlot owners in the region to visually communicate the importance of connectivity in the region; and testing the validity of identified habitat patches and movement pathways with species observation data.

This analysis is limited to an investigation and analysis of structural connectivity within the Chignecto region. The second aspect is functional connectivity, which is the response of individual organisms to modelled habitat structure, both of which are required to ensure long-term viability of wildlife populations. Beier and Loe (1992) suggest five criteria that can be used to evaluate corridor functional connectivity:

1. Wide-ranging animals can travel, migrate and breed;
2. Plants can propagate;
3. Genetic interchange can occur;
4. Populations can move in response to environmental change;
5. Individuals can recolonize habitat from which populations have been locally displaced.

Whether the corridor(s) identified within this analysis meet these criteria is yet to be determined, and considerable time / financial resources will be needed to address these questions. However, given the fragmented landscape and ongoing land development and resource extraction occurring throughout the Chignecto region, this analysis should be used to inform and assist in taking a precautionary approach to land use decisions in the study area.

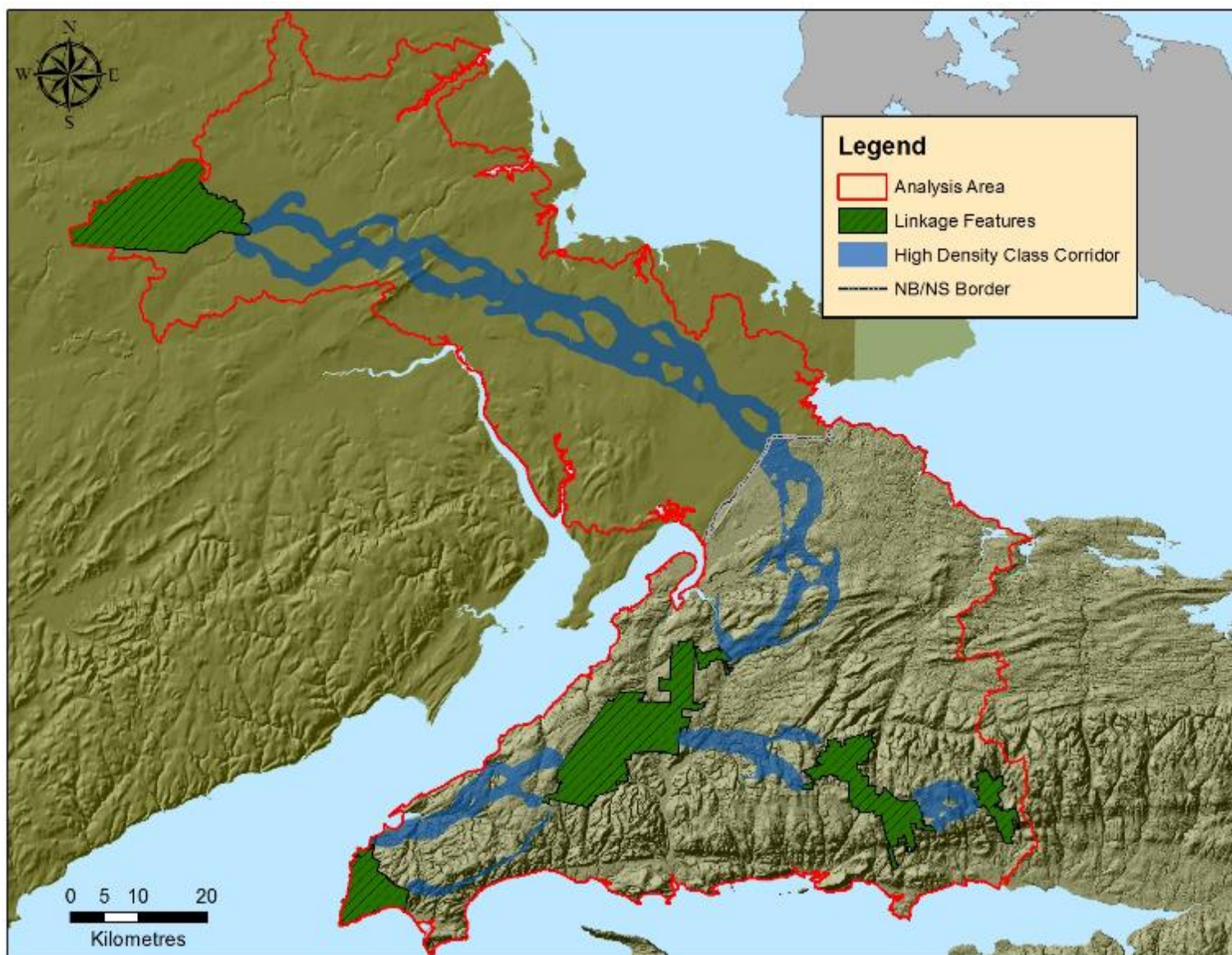


Figure 4: High density class corridor

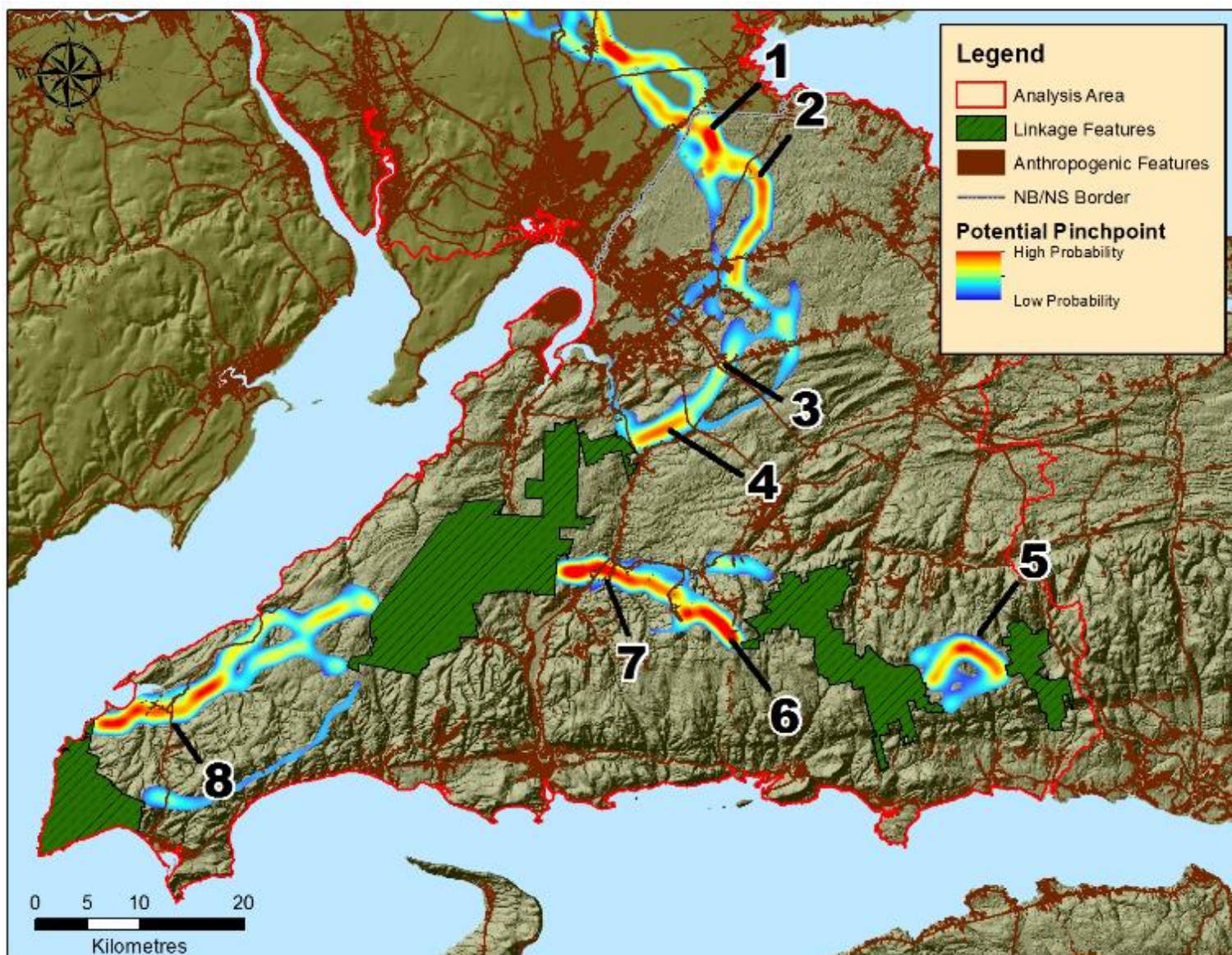


Figure 5: Nova Scotia high density class corridor potential pinch points

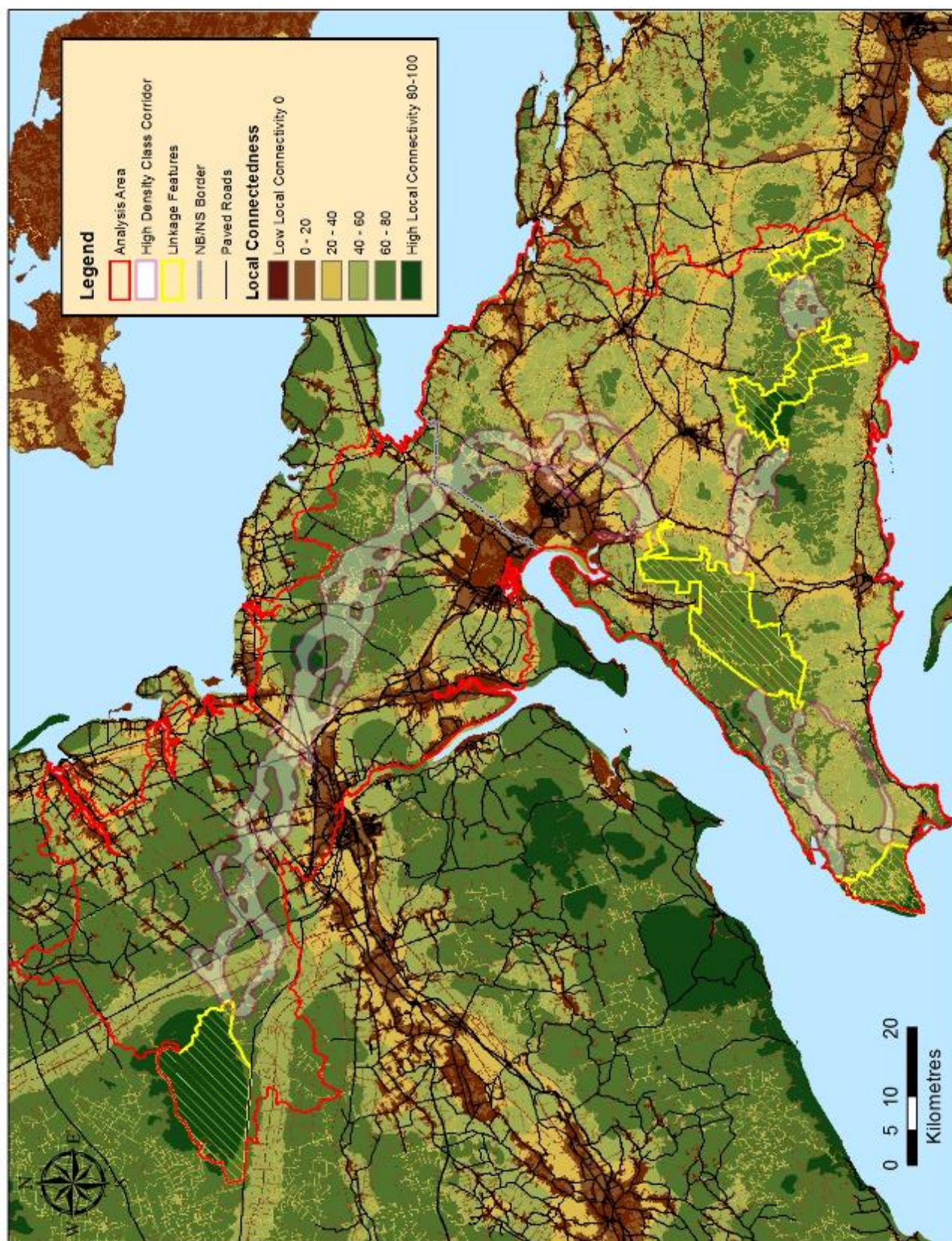
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Appendix A – Local Connectedness (TNC 2012)



Appendix B – Land Cover Classes

Vegetation class	NB Inventory Qualifiers	NS Inventory Qualifiers
Evergreen Forest		
Young Black Spruce Forest	Forest Community = BS (wet and poorly drained)	FEC = SP?, SP5, SP6, SP7, SP8 (< 1m DTW)
Mid Black Spruce Forest		
Old Black Spruce Forest		
Young Jack Pine Forest	Forest Community = JP	FEC = SP1
Mid Jack Pine Forest		
Old Jack Pine Forest		
Young Pine Forest	Forest Community = WP, RP	FEC = SP2, SP3, SP4
Mid Pine Forest		
Old Pine Forest		
Young Spruce - Fir Forest	Forest Community = HE, CE, RS, WS, SWTH, BF, TOSW, SWMX, BS (moderately drained)	FEC = SH?, SH1, SH2, CE2, SH3, SH4, SH5, SH6, SH7, SH10, SH8, SH9, MW1, MW?, MW2, MW3, MW4, OF1; FEC = SP?, SP5, SP6, SP7, SP8 (>1m DTW)
Mid Spruce - Fir Forest		
Old Spruce - Fir Forest		
Young Larch Forest	Forest Community = TL	FEC = SP10
Mid Larch Forest		
Old Larch Forest		
Deciduous Forest		
Young Intolerant Hardwood Forest	Forest Community = IH	FEC = All IH Types, MW5, MW6, SP9
Mid Intolerant Hardwood Forest		
Old Intolerant Hardwood Forest		
Young Tolerant Hardwood Forest	Forest Community = THP, THSW, THIH	FEC = All TH types
Mid Tolerant Hardwood Forest		
Old Tolerant Hardwood Forest		
Shrubland		
Shrubland	(Forest Inventory) L1S1 = AL	FORNON = 33, 38, 39, 83, 88, 89, 84, 85
Wetland		
Emergent Wetland	Wetland VT = EV, FV, OV	Wet Veg = Gramanoid, Aquatic, Sphagnum, Salt Marsh
Forested Wetland	Wetland VT = FF, FH, FS	Wet Veg = Treed
Non-vegetated Wetlands	Wetland VT = FU	FORNON 76, 94; Wet Veg = Exposed
Shrub Wetland	Wetland VT = AW, SV	Wet Veg = Tall Shrub, Low Shrub, Lichen
Open Water		
River or Stream	Wetland VT = OW; Water_Code = PN, LK	NS Openwater - Double-line Rivers
Lake or Pond	Water_Code = RV	NS Openwater - Lakes
Developed and Agriculture		
Agriculture	NONFOREST PLU = AGR	FORNON = 86
Soil / Gravel Extraction	NONFOREST PLU = IND	FORNON = 95
Transportation	NONFOREST PLU = INF	FORNON = 96, 97, 98, 99
Human Settlement	NONFOREST PLU = SET, REC	FORNON = 87, 92, 93
Young Softwood Plantation	L1TRT = PL (Overrides the forest community classifiers)	FORNON = 20
Mid Softwood Plantation		
Old Softwood Plantation		
Forest Age Class Categories		
	New Brunswick (L1DS)	Nova Scotia (Development Class)
Young	Regenerating (R) and Sapling (S)	Establishment
Mid-aged	Young (Y) and Immature (I)	Young / Mature 1
Old	Mature (M) and Overmature (O)	Mature 2 / Multi Aged

Appendix C – Habitat Suitability Data Sources

C1 – Habitat requirement data sources by species

Species	Source
Moose	Allen et al., 1987; Dussault et al., 2006
Black Bear	Rogers & Allen, 1987; Graves and Wang, 2012; Costello and Sage, 1997
Red Fox	DeGraaf & Yamasaki, 2001; Thompson et al., 1989; Natureserve
Bobcat	Boyle & Fendly, 1987; Litvaitis et al., 1986; Graves and Wang, 2012
Snowshoe hare	Carreker, 1985; Natureserve
Fisher	Allen, 1986; Graves and Wang, 2012
Northern Flying Squirrel	Smith, 2007; Ritchie et al., 2009; O'Connell et al., 2001
Barred Owl	Hamer et al., 2007; Nicholls and Warner, 1972
Northern Goshawk	Squires & Kennedy, 2006; Speiser and Bosakowski, 1987; Natureserve
Pileated Woodpecker	Schroeder, 1982a; Lemaître & Villard, 2005; Savignac et al., 2001
Yellow Warbler	Schroeder, 1982b; Natureserve
Brown Creeper	Davis, 1978; Poulin et al., 2008; Natureserve
Ruffed Grouse	Cade & Sousa, 1985; Natureserve

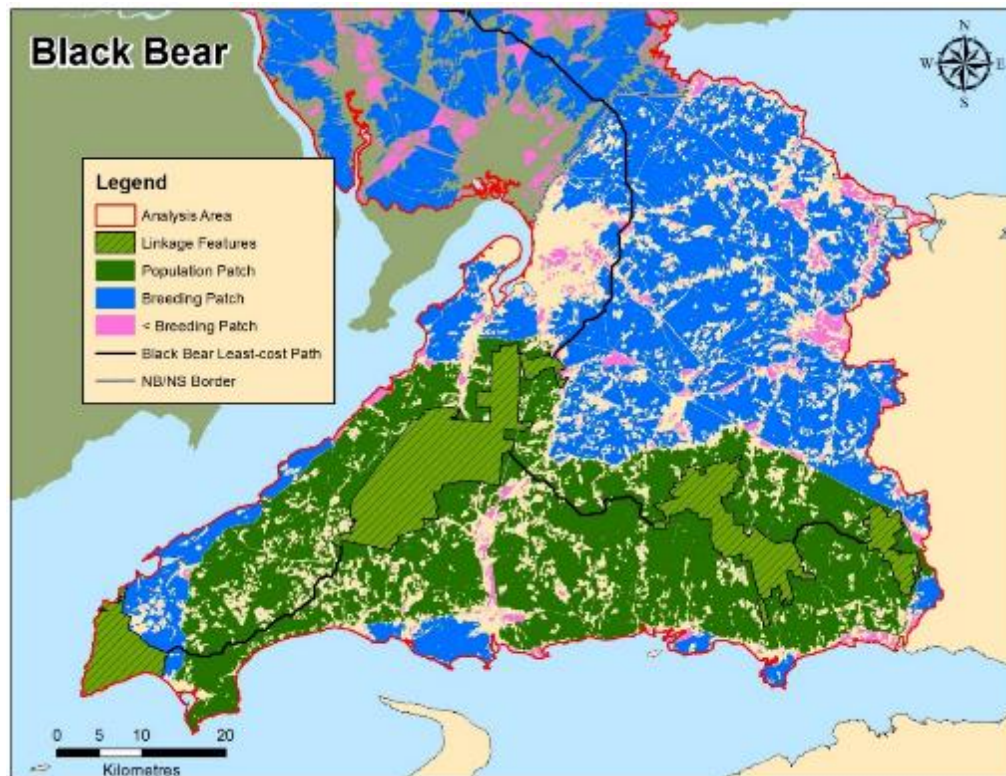
C2 Habitat patch size requirement data sources by species

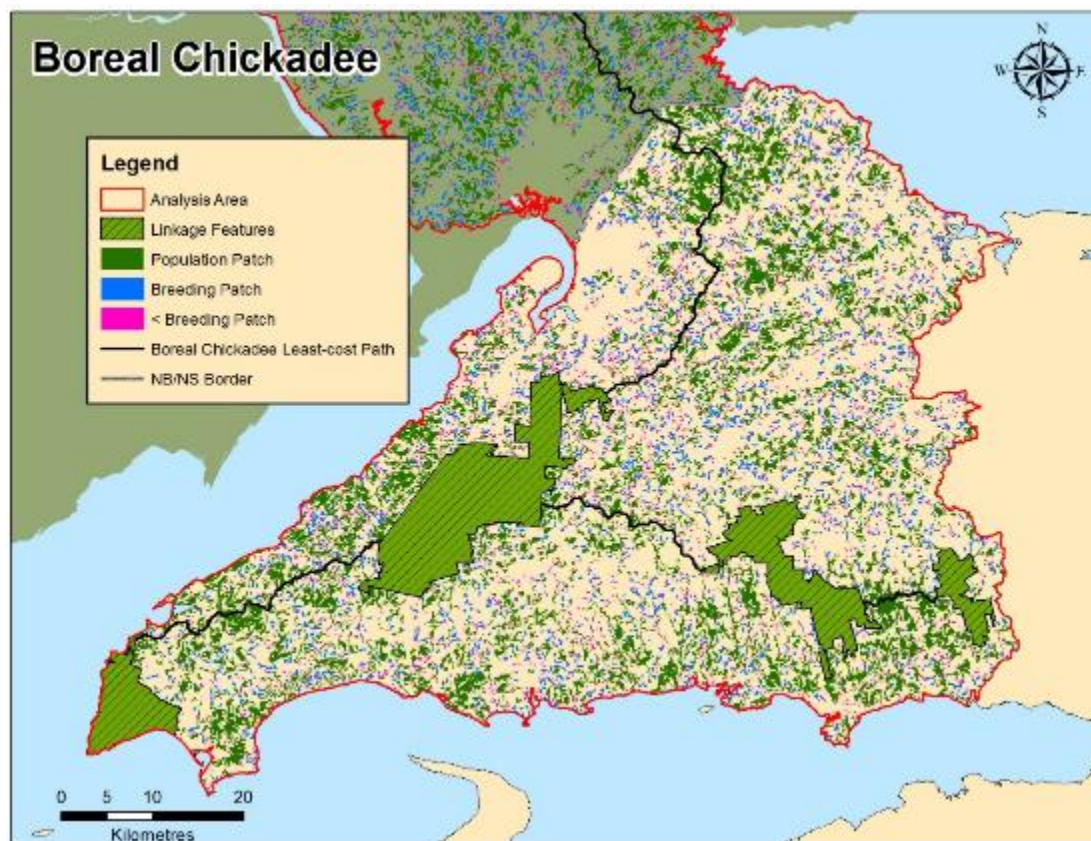
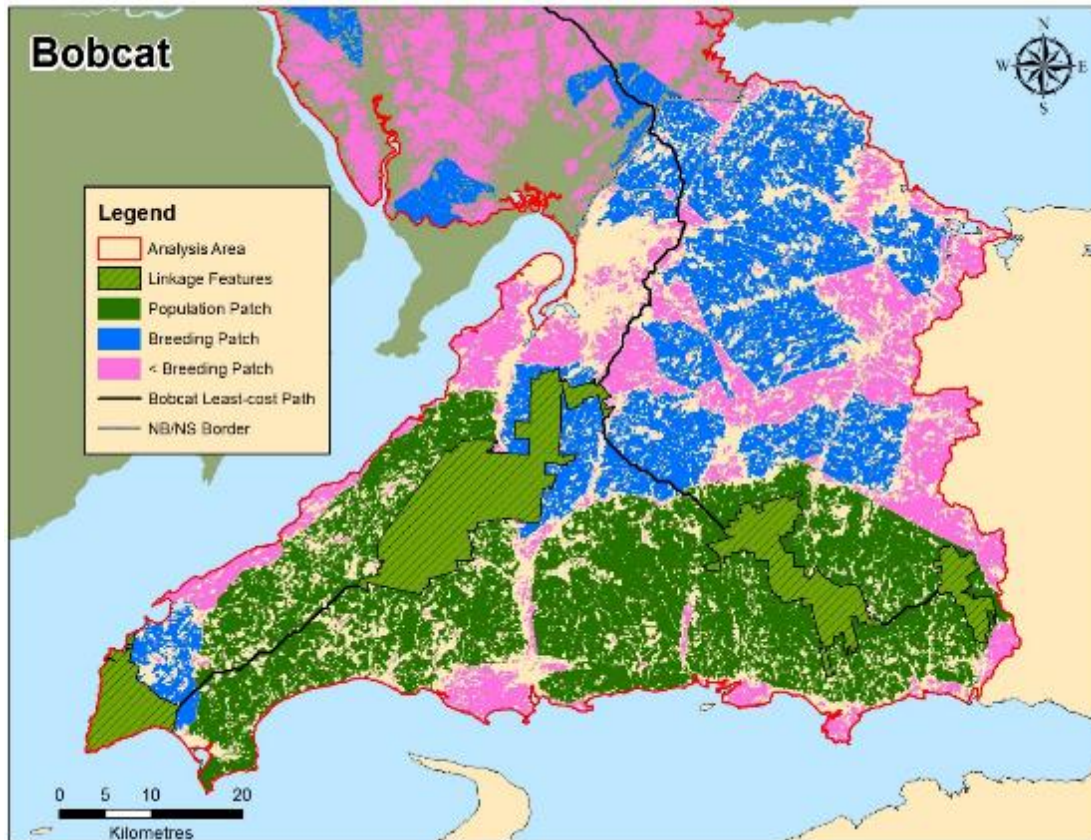
Species	Patch Size (ha)		Source
	Breeding	Population	
Moose	40	243	Allen et al., 1987
Black Bear	388	11655	Rogers et al., 1987
Red Fox	900	4500*	DeGraaf & Yamasaki, 2001
Bobcat	3120	15600	Litvaitis et al., 1986
Snowshoe hare	3	160	Carreker, 1985
Fisher	1920	9600*	Allen, 1986
Northern Flying Squirrel	10	50*	Smith, 2007
Northern Goshawk	12	60*	Squires & Kennedy, 2006
Pileated Woodpecker	129	645*	Schroeder, 1982a
Brown Creeper	2	10*	Davis, 1978
Boreal Chickadee	2	10*	Erskine, 1977
Blackburnian Warbler	1	5*	Morse, 1994
* Values obtained by multiplying breeding patch size by 5			

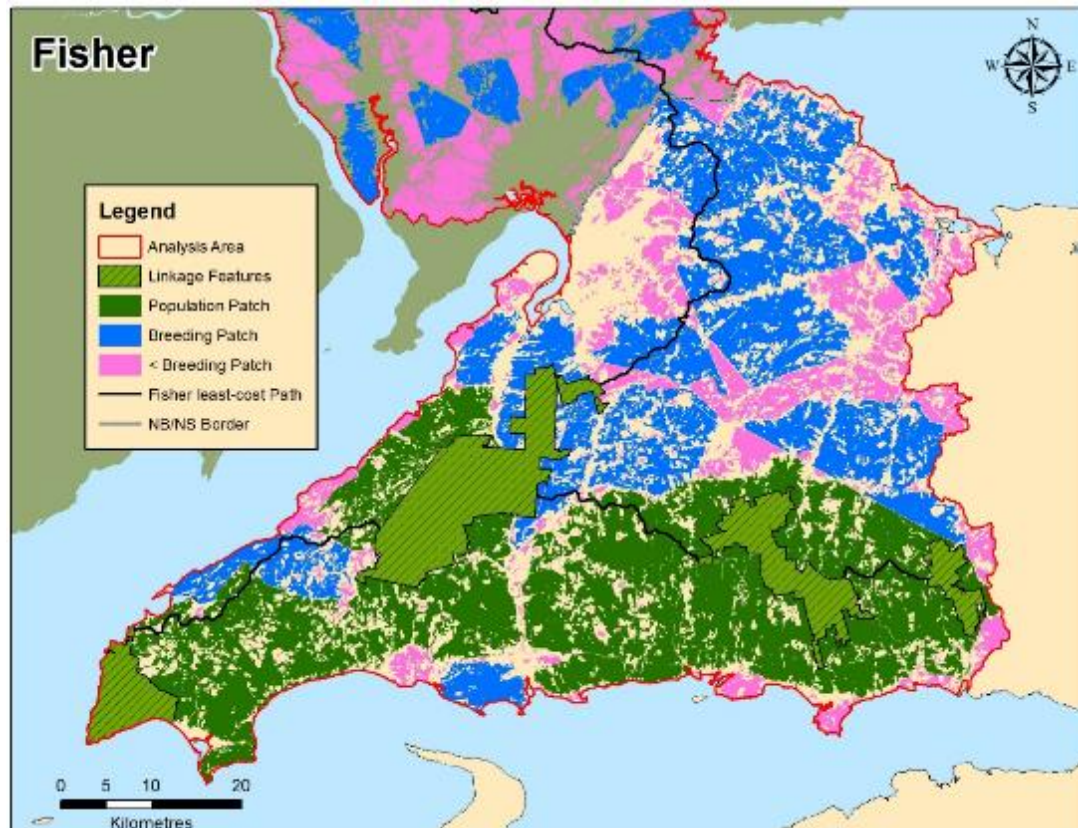
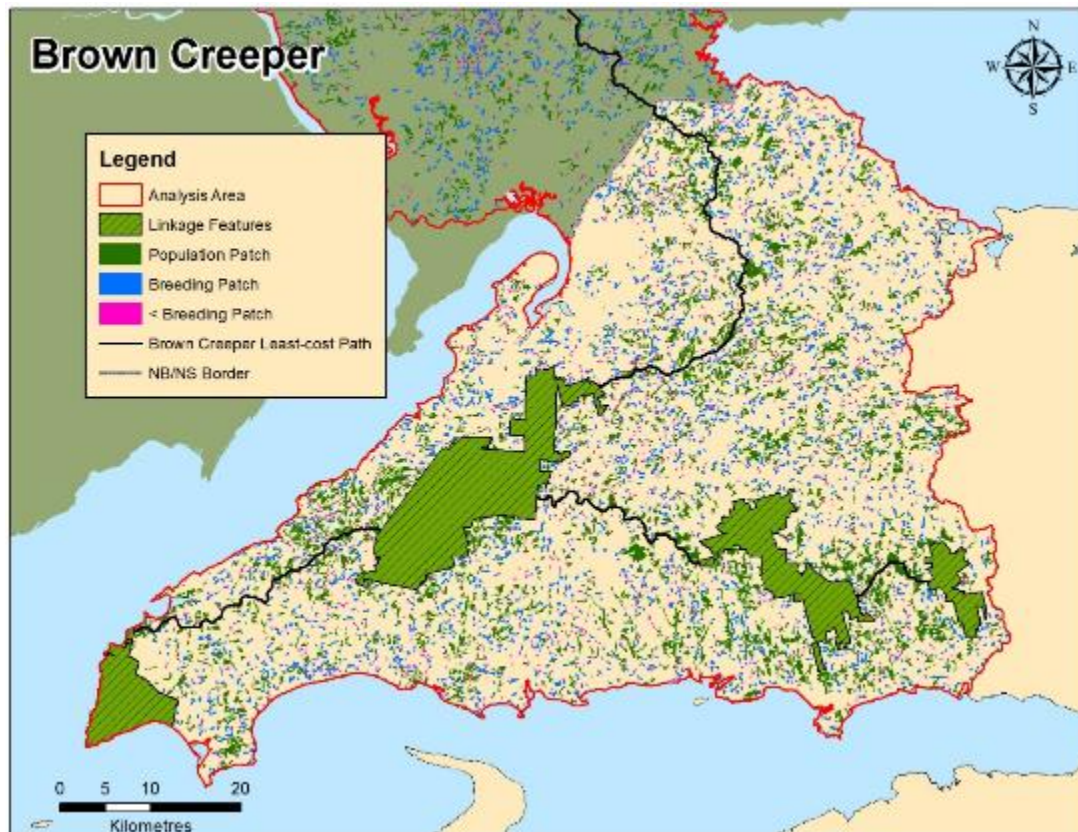
Appendix D – Habitat Suitability Matrix (100 is most Suitable Habitat)

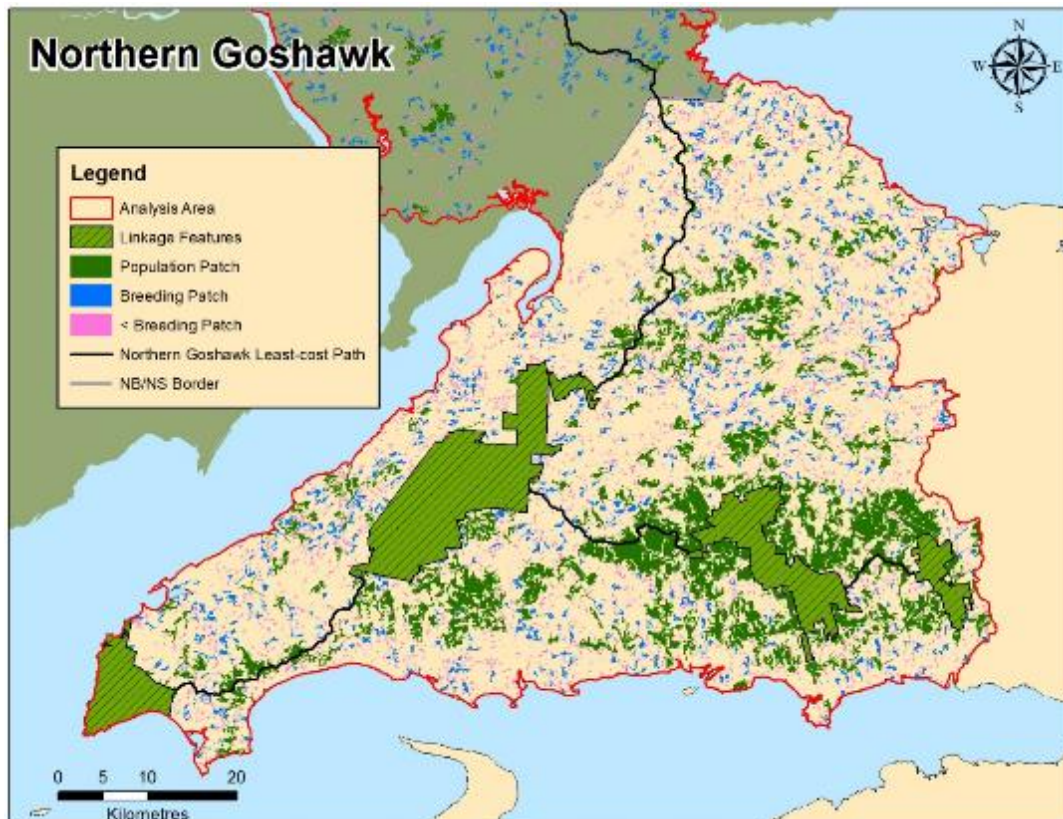
	Moose	Bear	Fox	Bobcat	Hare	Fisher	Squirrel	Goshawk	Wood_P	Creepers	B. Chick	Blk. Warbler
Agriculture	20	30	70	40	30	0	0	20	10	0	10	10
Non-vegetated Wetlands	100	45	90	20	30	30	20	45	30	10	10	10
Mid Black Spruce Forest	40	90	65	90	65	90	45	45	65	65	80	60
Old Black Spruce Forest	60	90	65	70	80	100	65	65	90	90	100	100
Young Black Spruce Forest	40	90	90	90	100	80	30	45	45	45	50	10
Emergent Wetland	100	45	90	50	30	30	20	45	30	30	10	10
Forested Wetland	100	90	70	80	40	50	50	65	45	90	80	20
Mid Intolerant Hardwood Forest	30	90	65	90	80	90	65	65	65	65	10	10
Old Intolerant Hardwood Forest	30	90	65	90	65	100	90	90	100	30	30	60
Young Intolerant Hardwood Forest	90	90	30	90	90	80	45	45	45	45	10	10
Soil / Gravel Extraction	0	20	40	10	10	20	0	20	0	0	0	0
Transportation	20	0	30	10	0	0	0	20	0	0	10	10
Mid Jack Pine Forest	30	90	65	90	80	90	45	45	65	65	10	10
Old Jack Pine Forest	30	90	65	70	90	100	60	65	70	90	10	10
Young Jack Pine Forest	30	90	90	90	100	80	30	45	45	45	10	10
Lake or Pond	90	20	20	10	20	20	20	45	30	30	30	30
Mid Larch Forest	30	90	65	90	65	90	50	45	65	65	70	10
Old Larch Forest	40	90	65	70	90	100	90	90	70	100	80	20
Young Larch Forest	30	90	90	90	100	80	45	45	45	45	40	20
Mid Pine Forest	30	90	65	90	65	90	50	45	65	65	20	20
Old Pine Forest	30	90	65	70	65	100	90	90	70	100	10	50
Young Pine Forest	30	90	90	90	100	80	45	45	45	45	10	10
Mid Softwood Plantation	20	45	65	65	45	65	45	45	45	45	10	10
Old Softwood Plantation	45	45	65	90	45	65	65	65	65	65	30	70
Young Softwood Plantation	30	40	90	90	90	45	30	45	20	45	30	10
River or Stream	90	45	20	10	20	20	20	45	30	30	30	30
Shrubland	30	90	100	100	90	70	30	45	30	30	10	10
Shrub Wetland	90	90	100	90	90	70	30	45	30	30	10	10
Human Settlement	0	0	0	0	0	0	0	0	0	0	0	10
Mid Spruce - Fir Forest	65	90	65	90	80	90	80	70	65	65	80	80
Old Spruce - Fir Forest	90	90	65	70	90	100	100	90	90	100	100	100
Young Spruce - Fir Forest	65	90	90	90	100	80	45	45	45	45	40	30
Mid Tolerant Hardwood Forest	45	90	65	90	70	90	65	80	65	65	20	40
Old Tolerant Hardwood Forest	90	100	65	90	80	100	90	100	100	90	20	50
Young Tolerant Hardwood Forest	90	80	90	90	90	80	45	45	45	45	10	20

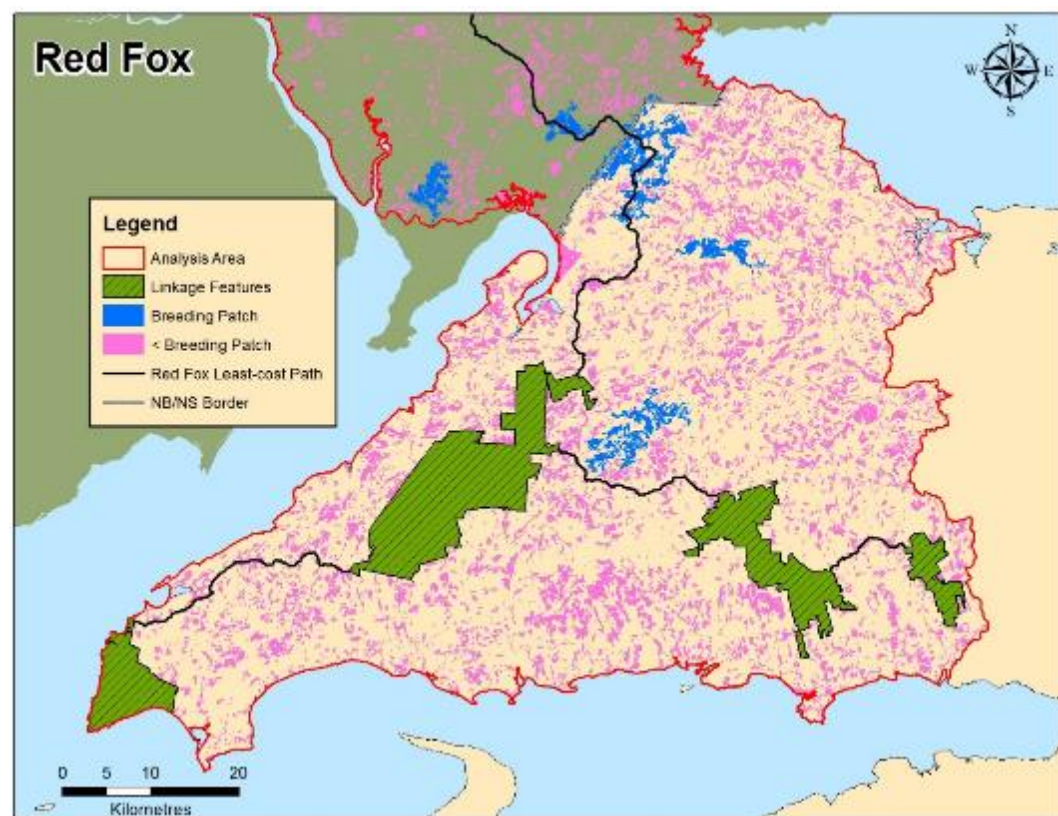
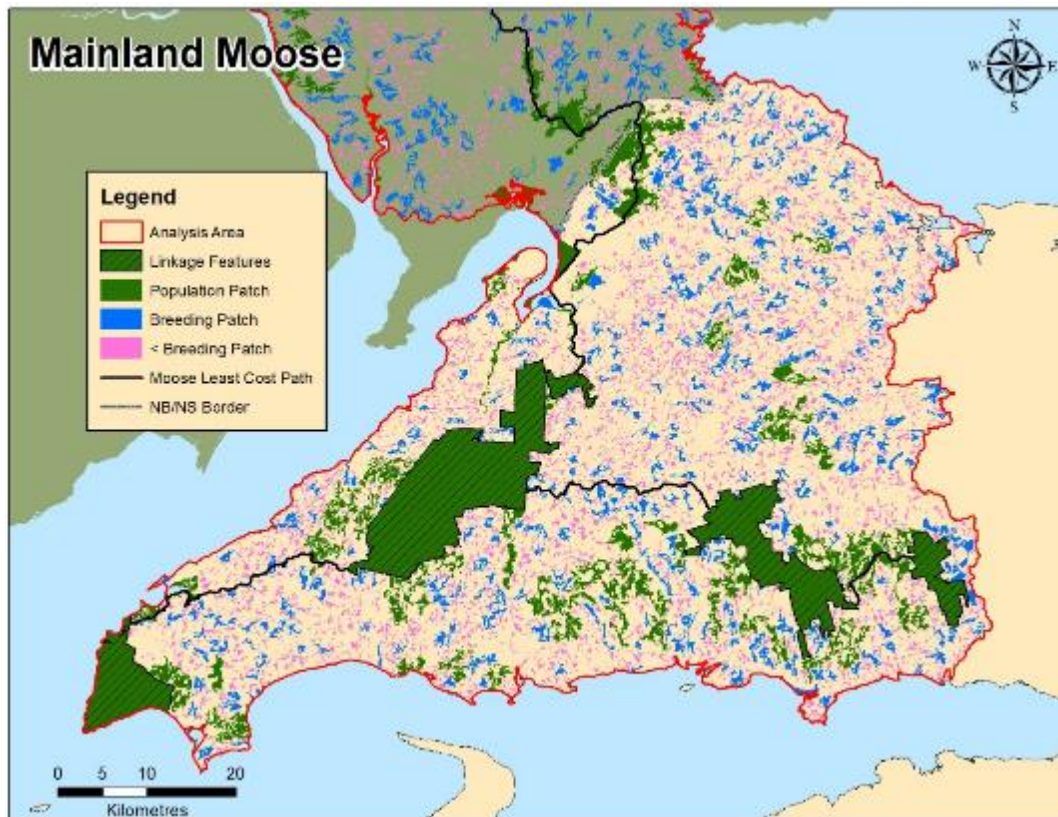
Appendix E – Species Least-cost paths and habitat patches

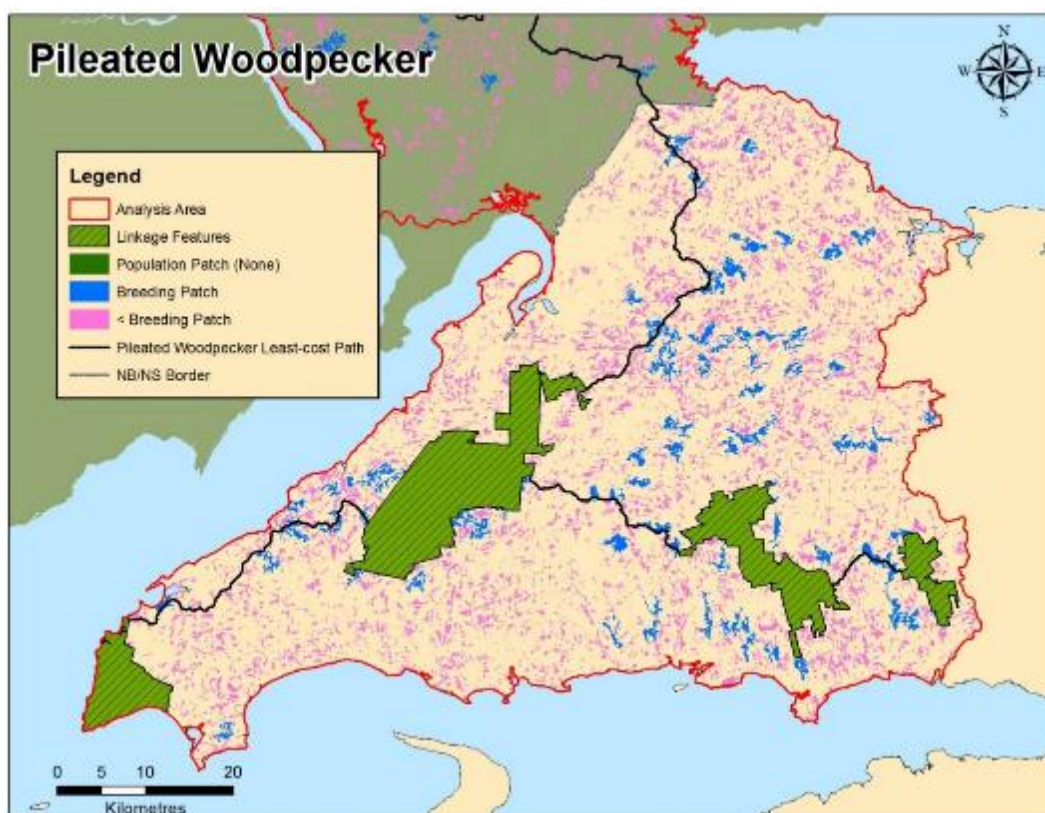
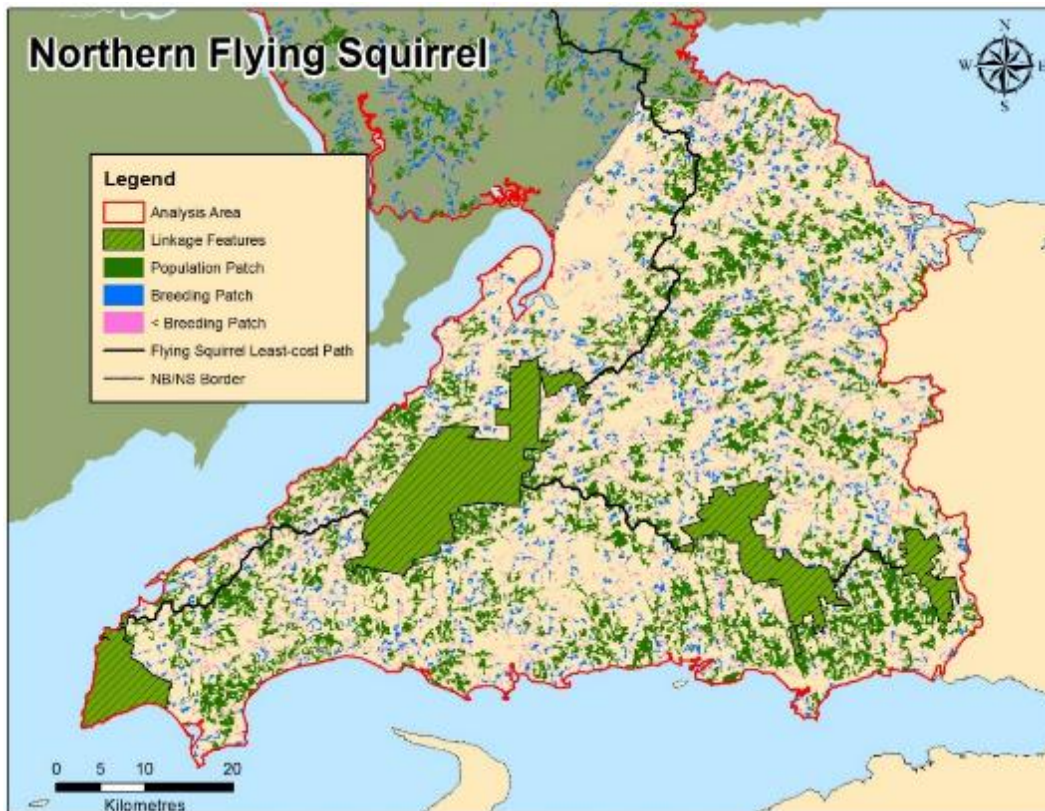












Appendix F – Private parcels within connectivity pinchpoints (1-8)

