Forest Connectivity in Nova Scotia

In partnership with Nova Scotia Department of Lands and Forestry

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ASSESSING FOREST CONNECTIVITY IN NOVA SCOTIA

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ED: Edge density

ELC: Ecological Land Classification

m_{eff} : Effective Mesh Size

MedPS: Median Patch Size

MPAR: Mean Perimeter-Area Ratio

REZ: Road Effect Zone

INTRODUCTION

In 2016, the New England Governors and Eastern Canadian Premiers passed Resolution 40-3 which recognizes the significance of the Northern Appalachian-Acadian forest at both local and global scales. Locally, many communities throughout the region are economically dependent on the forest and have built their culture and identity around it. Globally, the forest is recognized as being the most intact temperate broadleaf forest in the world. In recognition of the importance of the forest for the region's human and ecological communities, the resolution calls for the maintenance and restoration of ecological connectivity. The work in this document is meant to contribute to Nova Scotia's commitments to this resolution and aims to better understand ecological connectivity across the province.

Broadly speaking, ecological connectivity is "the degree to which the landscape facilitates or impedes movement among resource patches" (Taylor, Fahrig, Henein, & Merriam, 1993). It has both a structural (based on the spatial structure of the landscape) and a functional (based on how a particular organism reacts to the spatial structure of the landscape) component (Brooks, 2003). In this work, the focus was on the structural components of connectivity, but the two are not mutually exclusive concepts, with each informing the other. The work described here has also been designed to allow for future work on the functional connectivity of specific species (e.g. moose [*Alces alces*] or fisher [*Martes pennanti*]) to be incorporated to enhance our understanding of forest connectivity across Nova Scotia even further. Related to landscape connectivity is landscape fragmentation, the splitting of contiguous habitat or land cover into smaller parcels that are disconnected from one another (Turner, Gardner, & O'Neill, 2001, p. 3). Fragmentation may occur naturally through means such as a rivers or islands, but it is also often the product of human influence on the landscape.

In Nova Scotia (as in many other jurisdictions), roads are a frequent source of landscape fragmentation, cutting through the landscape and affecting both structural and functional connectivity. Roads have a multitude of impacts on their surrounding ecosystems which can be divided into seven key categories: (i) wildlife mortality associated with their construction; (ii) wildlife mortality associated with vehicular traffic; (iii) modification of animal behaviour; (iv) alterations to the physical environment; (v) alterations to the chemical environment; (vi) spread of exotic species; (vii) increased human access to surrounding areas (Trombulak & Frissell, 2000). While some of these impacts are localized, only applying to the actual road or a few meters from them, others extend several kilometers outwards from the edge of the road. The outer limit of these effects delineates the road effect zone (REZ), the size of which is dependent on a number of factors including the size and traffic volume of the road, the type of land cover surrounding the road and the suite of wildlife species present in the area (Benítez-López, Alkemade, & Verweij, 2010; Forman, 2000). For example, roads surrounded by dense forest typically have a smaller REZ than those surrounded by open grasslands (Benítez-López et al., 2010). In addition, wildlife species vary in how sensitive they are to the presence of roads. Some (e.g. woodland caribou [*Rangifer tarandus*]) are highly sensitive to the presence of roads and will avoid them at all costs (Dyer, O'Neill, Wasel, & Boutin, 2001), while others (e.g. bobcat [*Lynx rufus*]) are far less affected by roads (Jalkotzy, Ross, & Nasserden, 1997).

Ecological connectivity and fragmentation are measured through a variety of different metrics, each of which having their own strengths and weaknesses. In this work, multiple

approaches were used to better understand the current state of ecological connectivity and fragmentation in Nova Scotia through a variety of lenses. This will enhance our understanding of connectivity and fragmentation across the province, and will also result in the opprotunity to compare and contrast the results of multiple methods and metrics on the same landscape, something that is rarely done in the literature. Specifically, effective mesh size (m_{eff}), a variety of metrics from the Patch Analyst for ArcGIS extension (percentage class area, median patch size [MedPS], edge density [ED] and mean perimeter-area ratio [MPAR]) and Circuitscape were all used. For each of these methods, the results for today's landscape were compared to a historical baseline landscape to assess how landscape connectivity and fragmentation across the province has changed since the arrival of Europeans.

STUDY AREA

For each method and model, several analytical units were employed: (i) the entire province of Nova Scotia; (ii) landmasses (Cape Breton and the mainland); (iii) ecoregions and; (iv) ecodistricts (Figure 1). The ecoregions and ecodistricts were as defined in the Nova Scotia Ecological Land Classification (ELC) (Neily, Basquill, Quigley, & Keys, 2017).

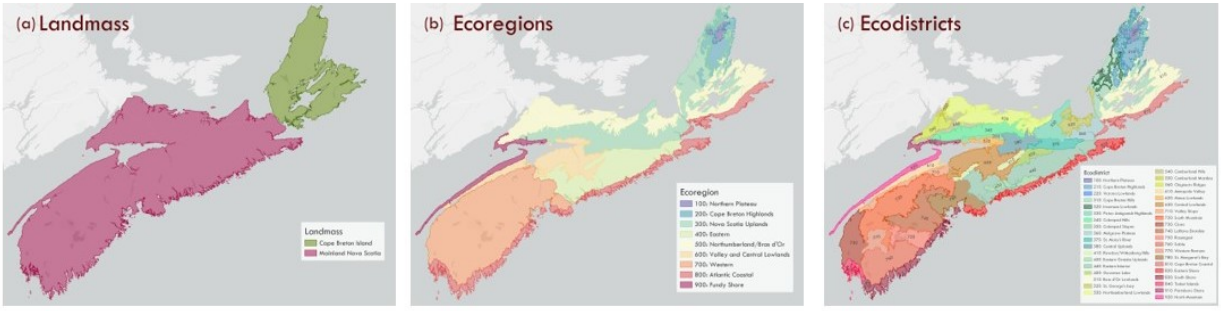

Figure 1. In addition to across the entire province, the analysis was conducted based on the different (a) landmasses, (b) ecoregions and (c) ecodistricts in Nova Scotia. Data from Nova Scotia's Ecological Land Classification (Neily et al., 2017).

Resolution 40-3 is primarily concerned with broad, ecological connectivity, but it also discusses forest connectivity. Given the broadness of these terms, all analyses in this work were conducted on multiple classifications of the terrestrial landscape: (i) all natural ecosystems (all forested, wetland and barren land covers from the Nova Scotia Forest Inventory); (ii) all forests (all treed land covers from the Nova Scotia Forest Inventory); (iii) mature forests (forests over 40 years old, proxied as natural forest stands with a height over 12 meters in the Nova Scotia Forest Inventory) (Table 1; Figure 2) (Nova Scotia Department of Lands and Forestry, 2016). In addition to these different landscape classifications, there was also an interest in examining connectivity under different scenarios of road influence. Therefore, each analysis was also conducted based on three different road effect zones (REZ): (i) No REZ; (ii) a 1 km REZ and; (iii) a 5 km REZ) (Figure 2).

Table 1. FORNON Codes from the Nova Scotia Forest Inventory Comprising each Classification

Classification	FORNON Codes
Natural Ecosystems	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 20, 33, 38, 39, 60, 61, 62, 70, 71, 72, 73, 74, 75, 76, 83, 84, 85, 88, 89
Forests	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 20, 33, 38, 39, 60, 61, 62
Mature Forests	0, with a height over 12 m

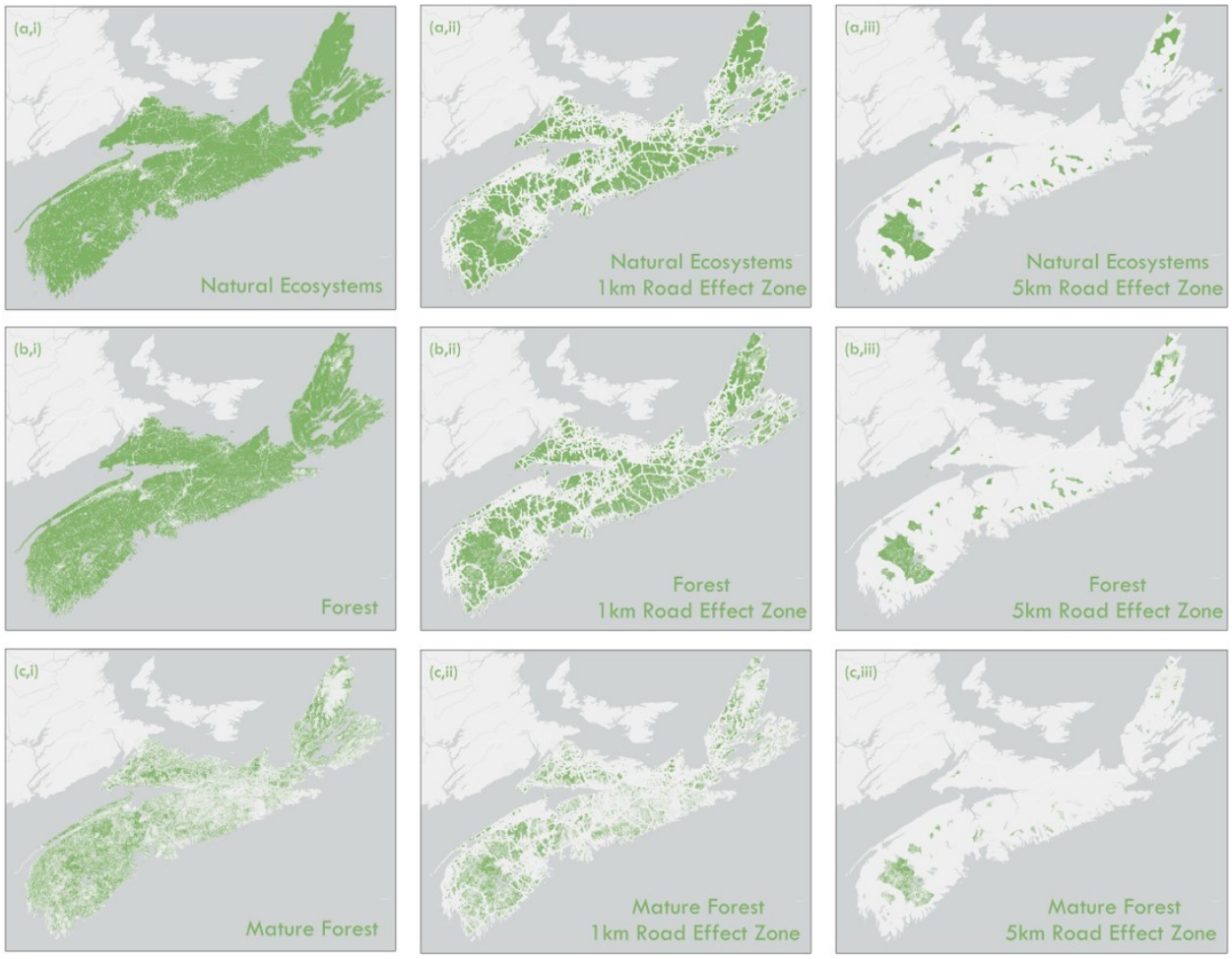

Figure 2. Different classifications of forest on which the analysis was conducted in the study region. Natural ecosystems are defined as all forested, wetland and barren classifications in the Nova Scotia forest inventory (a), forest consists of all treed classifications in the Nova Scotia forest inventory (b) and mature forest are those forested stands with a minimum age of 40 years (proxied as a minimum stand height of 12m) (c). Analyses were conducted on each forest classification without taking into account the road effect zone (i), using a 1km road effect zone (ii) and using a 5km road effect zone (iii). Nova Scotia forest inventory data is from the Nova Scotia Department of Lands and Forestry;, Nova Scotia Roads database is from GeoNova;, basemap is from ESRI.

The influence that humans have had on landscape connectivity and fragmentation in Nova Scotia was examined through the comparison of the results of the analyses based on natural ecosystems with no road effect zone (Figure 2b,i) to a historical baseline (Figure 3). The historical baseline was defined by classifying all terrestrial land classes in the Nova Scotia Forest Inventory as natural. In other words, in the historical baseline the only barriers to connectivity/causes of landscape fragmentation were water and the natural shape of the landmasses.

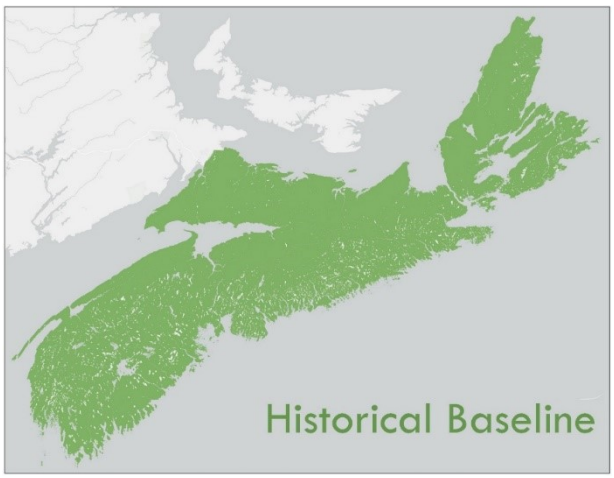

Figure 3. Historical baseline to which today's data was compared to determine changes in landscape connectivity caused by humans. For the baseline, all terrestrial systems were considered to be natural, thus the only barriers to connectivity were water and the natural shape of the landmasses.

METHODS

Determining the Road Effect Zone

As discussed above, the road effect zone (REZ) is dependent on local context, influenced by the type of road, surrounding landscapes and local wildlife (Benítez-López et al., 2010). A global meta-analysis of the impacts of roads on wildlife by Benítez-López and colleagues (2010) found that a 5 km REZ captures the effects roads have on most mammals, and a 1 km REZ captures effects on birds. However, there are exceptions to these rules, with some species having up to a 17 km REZ. To determine the REZ used in this work, these distances were considered in the Nova Scotia context. The maximum REZ determined by Benítez-López et al (2010) were tied to highly sensitive species (i.e. woodland caribou, *Rangifer tarandus*) that are not found in Nova Scotia. Furthermore, an analysis of distance to road across the province revealed that 99.5% of the land is within 17 km of a road (Figure 4, Table 1). This suggests that the wildlife in the province have adapted to being in closer to proximity to roads, though it must be acknowledged that this does not necessarily mean that these species are living in optimal conditions, nor does it mean that the current suite of species would be the species present without roads. Species that are highly sensitive to roads (and thus would be associated with a large REZ), such as wolf (*Canis lupus*), cougar (*Puma concolor*) and lynx (*Lynx canadensis*) have already been extirpated and/or are currently endangered. Applying a 5 km REZ to Nova Scotia leaves just 8.6% of the province, primarily in the southwestern part of the mainland and the Cape Breton Highlands, unaffected (Table 1). However, a 5 km REZ is in line with the wildlife species found in the province based on the species-specific database of REZs curated by Torres and colleagues (2016) (which looked at the species in Benítez-López et al., 2010 in more detail).

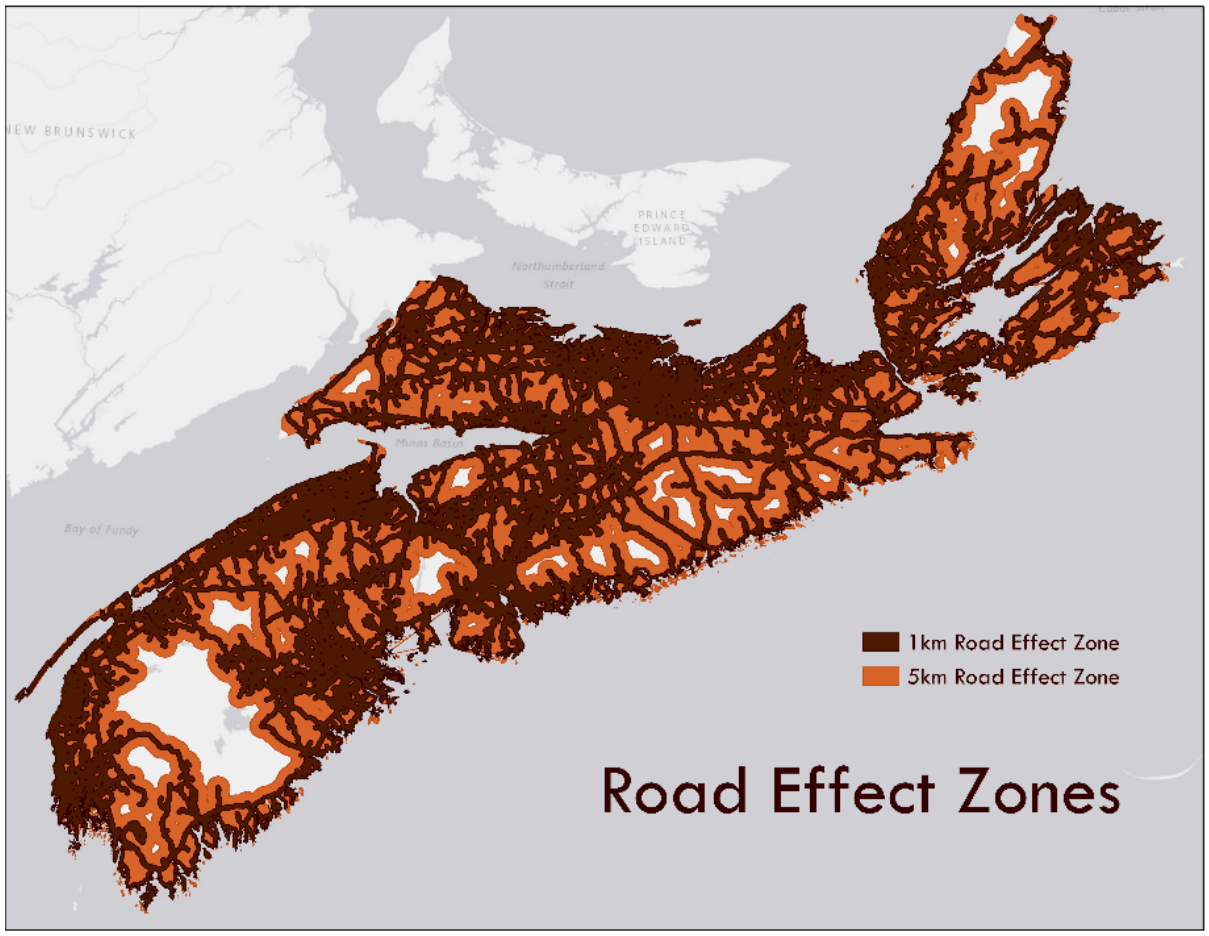

Figure 4. The 1 and 5 km road effect zones across Nova Scotia. Across the province, the mean distance to road across the entire province was 1.8km and the maximum distance was 25.6km.

Table 2. Percentage of the province of Nova Scotia (not including Sable Island) within specified distances of a road. Percentages were calculated through a Euclidean Distance analysis on the provincial road database (obtained through GeoNova). The mean distance to road across the entire province (not including Sable Island) was 1.8 km and the maximum distance was 25.6 km.

Distance (km)	Percentage of Province within distance to road
0.1	10.4%
0.5	36.0%
1	54.1%
5	91.4%
10	97.5%
15	98.9%
17	99.5%
20	99.9%
25	99.9%
26	100%

In addition to REZ, road density can be used to better understand the effects of roads on wildlife. Forman et al (1997) identified 0.6 km road/km^2 as a threshold, above which natural populations of certain large vertebrates (generally the most sensitive category of mammals to roads as reported by Benítez-López et al (2010)) decline. Mapping both road densities at or above 0.6 km/km^2 and a 1km REZ across Nova Scotia produced maps that are 95% congruent, indicating that a 1 km REZ is probably relevant to Nova Scotia. For some species (i.e. bobcat, for which 1.5 km roads/km^2 has been identified as a threshold value in other landscapes; Jalkotzy et al., 1997), this may be an overestimate. However, it must be noted that while much of the province has a road density of 0.6 km/km^2 or more, there are refugia of areas with low road densities that are important to the maintenance of many wildlife populations, which are captured through a 5 km REZ. Based on these findings, the analyses conducted in this work were done for each forest classification with no REZ, a 1 km REZ and a 5 km REZ (Figure 2). Fine-tuning this work for a specific species and their REZ is a potential avenue for future research.

Measuring and Mapping Connectivity

Patch Based Metrics

In this work, five patch-based metrics were examined across Nova Scotia. Four of the metrics describe between patch connectivity, and the fifth describes within patch connectivity. Metrics describing between patch connectivity focus on characterizing patterns and attributes of patches of different land use/land cover types, and can be divided into four categories: (i) class area; (ii) patch size; (iii) edges and; (iv) patch shape. For this work, one metric from each category was selected and analysed using the Patch Analyst extension for ArcGIS: (i) percentage class area; (ii) median patch size; (iii) edge density and; (iv) mean-perimeter area ratio. For within patch connectivity, effective mesh size was analysed.

Percentage Class Area

Percentage class area measures the percentage of a landscape comprised of a particular patch type. In this work, percentage class area of natural ecosystems, forest and mature forests were calculated.

Median Patch Size

Median patch size (MedPS) indicates the middle patch size, or the 50th percentile. In this work, it was used to get a sense of typical patch sizes while avoiding the influence of outliers that would be more of an issue when using mean patch size.

Edge Density

Edge density (ED) measures the meters of patch edge per hectare, giving an indication of how fragmented a landscape is. The greater the ED, the more fragmented a landscape is.

Mean Perimeter-Area Ratio

Mean perimeter-area ratio (MPAR) is a measure of shape complexity that is calculated by dividing the sum of each patch's perimeter-area ratio by the number of patches for each class. The higher the MPAR, the more complex the patch shapes in the study area are.

Effective Mesh Size

Effective mesh size (m_{eff}) is a measure of landscape fragmentation based on the probability that two randomly chosen points will fall within the same patch of a landscape (Jaeger, 2000). m_{eff} (km^2) is calculated using Equation 1, where A_{total} is the total study area (or reporting unit area) (km^2) and A_i is the size of the patch (km^2).

$$m_{eff} = \frac{1}{A_{total}}(A_1^2 + A_2^2 + \cdots + A_n^2)$$

Equation 1. Calculating effective mesh size (Jaeger, 2000)

Reporting Unit-Based Analysis

Each of the metrics described above were calculated for each of the analytical units described in Figure 1 (i.e. for the province as a whole, and for each landmass, ecoregion and ecodistrict) and for each of the landscape classifications shown in Figure 2 (i.e. natural ecosystems, forests, mature forests, all without accounting for the REZ, with a 1 km REZ and a 5 km REZ, for a total of 36 analysis for each metric.

Continuous Surface-Based Analysis

The reporting-unit based analyses described above only yield one value for each reporting unit, which creates a challenge for determining how patch-based metrics change across a landscape, as the size and shape of the reporting units have a lot of influence on the analysis (Jelinski & Wu, 1996; Openshaw, 1984; Openshaw & Taylor, 1981). To better understand how patch-based metrics change across Nova Scotia, a method was developed using a modified moving window approach, using the model in Figure 5. The model used a set of 100 fishnets with the same grid size, but random origins. For each square of the grid, the metric in question was calculated, and the resulting layer converted to a raster. Following all 100 iterations of the model, the resulting rasters were averaged together to produce a continuous surface of average patch-based metric values.

To find the optimal fishnet size for this work, the model was run with a variety of different sizes and a sensitivity analysis was run. This analysis indicated that there was no significant difference when the input fishnets were smaller than 100 km^2 or larger than 625 km^2. The significant difference came between these two starting points, so the model was run using both sets of fishnets for each dataset.

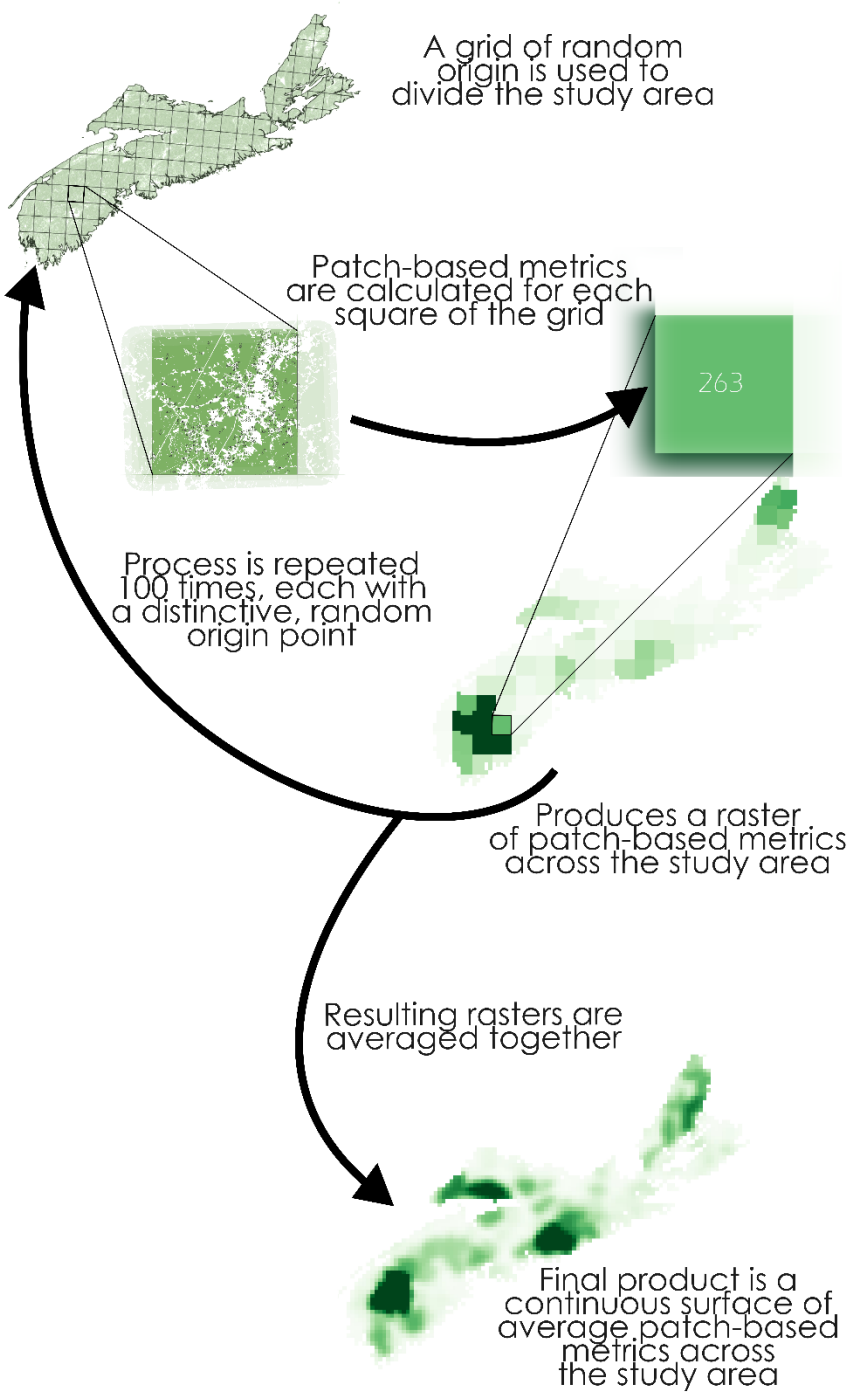

Figure 5. Model used to generate continuous surfaces of average patch-based metrics

Circuitscape

Circuitscape is an open source software package that uses electric circuit theory to predict patterns of connectivity across heterogeneous landscapes. The most common applications of the software are to model wildlife movement, gene flow and (as it was used for in this work) identifying key pinch points for connectivity across the landscape (Shah & McRae, 2008).

In this work, the methods of Pelletier et al (2017) were used as a guide to look at the connectivity of natural ecosystems and forested ecosystems with no REZ, and forested ecosystems with a 1 km REZ. For each landscape classification, a raster (25 m cell size) generalizing the landscape into three categories: natural ecosystems (or forest), non-natural ecosystems (or non-forest) and no data was created and then used to generate the resistance surface. Natural ecosystems (or forests) cells were assigned a resistance value of 1 and non-natural ecosystems (or non-forest) and no data cells were assigned a resistance value of 500. To make the processing in Circuitscape more manageable, the resistance raster was broken into tiles of 3000 x 3000 cells (75 x 75 km), including a buffer of 1000 cells (25 km) that overlapped with neighbouring tiles. Each tile of the resistance raster was then processed using the pairwise mode of Circuitscape in both the horizontal (east-west) and vertical (north-south) directions. Once finished, the buffers were removed from each tile and the outputs were used to generate two current density maps (one for each direction), which were then multiplied together to create an omnidirectional connectivity mosaic.

Historical Baseline

In effort to better understand the effects that humans have had on landscape connectivity and fragmentation in Nova Scotia, the results of the analyses for natural ecosystems with no REZ (Figure 2 a,i) for each method described above, were compared to the results of the same analysis conducted on the historical baseline (Figure 3). For each metric and each analytical unit the percentage change from the baseline to the present day was calculated.

RESULTS

Percentage Class Area

The detailed tables and maps of the results for the percentage class area analysis can be found in Appendix I.

Total Province

Across the entire province, natural ecosystems were found to comprise between 87.0% (no REZ) to 94.4% (1 km REZ) of the terrestrial area, which is a 8.9% reduction from the historical baseline. Most of this is forested (ranged from 78.1% [no REZ] to 82.2% [5 km REZ]) and the mature forest classes were consistently ~40% for all REZs.

By Landmass

Natural ecosystems and forests were found to comprise a higher percentage of the land on Cape Breton, but percentages of mature forest were higher on the mainland, especially when a 5 km REZ was considered (16.7% on Cape Breton; 44.6% on the mainland). The changes from the historical baseline were comparable to the reduction seen across the entire province, with a reduction in natural ecosystems of 7.1% on Cape Breton and 9.4% on the mainland.

By Ecoregion

Natural ecosystems were found to be more than 80% of the land area of each ecoregion except for the Valley and Central Lowlands (69.7%) when no REZ was considered. However, once a REZ was applied, the percentage natural ecosystems in the Valley and Central Lowlands increased quickly, reaching 99.4% with a 5 km REZ. In most ecoregions, the natural ecosystems were found to be primarily forest, as the percentage forest was generally only about 10-20% lower than the percentage natural ecosystems. The exception to this pattern was the Northern Plateau (96.7% natural ecosystems [no REZ], 38.5% forest [no REZ]). The percentage mature forest ranged from 0.7% (Northern Plateau [5 km REZ]) to 54.7% (Fundy Shore [1 km REZ]). When compared to the historical baseline, all ecoregions were found to have a reduction in the percentage of the land covered by natural ecosystems, ranging from 0.4% (Northern Plateau) to 29.1% (Valley and Central Lowlands).

By Ecodistrict

The ecodistrict breakdown of the data produced more variation than the other breakdowns. For natural ecosystems, many of the ecodistricts were well above 90%, and some even reach 100% when a 5km REZ is considered (e.g. St. Mary's River). However, there were some ecodistricts that were found to be less than 50% natural ecosystems (e.g. Annapolis Valley). Percentages of the land

that is forested were varied, but most were within range of the full province numbers, though there were a few outliers. For example, the Northern Plateau was less than 40% forested (but it is more than 96% natural ecosystems). The percentage mature forests across ecodistricts were generally correlated with the percentage forest (i.e. a low forest percentage corresponded to a low mature forest percentage). As was the case with all of the other analytical units, all ecodistricts were found to have a reduction in the percentage natural ecosystems today compared to the historical baseline, with reductions that ranged from 0.2% (Western Barrens) to 53.0% (Annapolis Valley).

Median Patch Size

The detailed tables and maps of the results for the median patch size (MedPS) analysis can be found in Appendix II.

Total Province

When calculated across the entire province, MedPS were found to range from 0.4 ha (natural ecosystems [5 km REZ]) to 3.2 ha (mature forest [no REZ]). Compared to the historical baseline of 2937.8 ha, today's MedPS for natural ecosystems (1.6 ha) represents a 99.9% reduction.

By Landmass

MedPS were found to be higher on Cape Breton than the mainland for all landscape classifications. This pattern was also found in the historical baseline (3770.4 ha [Cape Breton], 1708.9 ha [mainland]), but the MedPS today on both landmasses were found to be 99.9% lower than the baseline.

By Ecoregion

When calculated by ecoregion, there was more variation in the MedPS than by landmass, but in general values were highest with a 1 km REZ. However, unlike some of the other metrics analysed in this work, MedPS was not necessarily tied to human populations in the province. For example, the MedPSs in the Northern Plateau are relatively low (ranging from 0.11 ha – natural ecosystems with a 5km REZ to 1.70 ha – forests with no REZ) and those in the Valley and Central Lowlands are relatively high (ranging from 1.20 ha – forests with a 5km REZ to 29.99 ha – natural ecosystems with a 5km REZ). As was the case with the full province and landmass breakdowns, the reductions in MedPS from the historical baseline to today were high, ranging from 98.8% in the Valley and Central Lowlands to 100% in the Northern Plateau, Western and Atlantic Coastal ecoregions.

By Ecodistrict

As was the case in all the metrics analysed in this work, MedPSs were the most varied at the ecodistrict level, and ranged from 0.01 ha (Lahave Drumlins [natural ecosystems, 5 km REZ]) to

1206.4 ha (Parrsboro Shore [natural ecosystems, 5 km REZ]). However, most MedPS values were found to be below 5.0 ha. The reductions in MedPS for natural ecosystems from the historical baseline to today were high, just as was the case in the other analytical units. All were found to be over 90%, except for the Pictou Antigonish Highlands (81.3%) and Cumberland Hills (17.7%) ecodistricts.

Edge Density

The detailed tables and maps of the results for the edge density (ED) analysis can be found in Appendix III.

Total Province

Across the entire province, ED were highest in the mature forest classifications and lowest for natural ecosystems. ED ranged from 11.98 m/ha (natural ecosystems, 5 km REZ) to 47.30 m/ha (mature forest, no REZ). Compared to the historical baseline of 0.001 m/ha, the ED for natural ecosystems (with no REZ) across Nova Scotia today (20.8 m/ha) is a 2601566% increase.

By Landmass

EDs were found to be consistently higher on the mainland (ranging from 10.14 m/ha – natural ecosystems with a 5km REZ to 39.35 m/ha – mature forests with a 5 km REZ) than on Cape Breton (ranging 1.77 m/ha – natural ecosystems with a 5km REZ to 8.05 m/ha – mature forest with no REZ). In both cases the EDs today are much higher than they were in the historical baseline (0.001 m/ha for both landmasses).

By Ecoregion

When calculated by ecoregion, EDs were found to be lowest in the Northern Plateau (ranging from 0.03 m/ha – mature forest with no REZ to 0.76 m/ha – natural ecosystems with a 5km REZ) and highest in the Western ecoregion (ranging from 4.74 m/ha – natural ecosystems 1km REZ to 32.00 m/ha – mature forests with a 5km REZ). The historical baseline EDs were similar across all ecoregions (all were either 0.001 m/ha or 0.002 m/ha), but today there is much more variation, a result of percentage changes ranging from 7930% (Northern Plateau) to 616649% (Western).

By Ecodistrict

For most ecodistricts and landscape classifications, the ED was less than 2 m/ha (the majority of which are less than 1 m/ha). Overall, EDs range from 0.01 m/ha (St. Mary's River and Bras d'Or Lowlands – mature forest with a 5km REZ) to 11.50 m/ha (South Mountain – mature forest with a 5km REZ). The EDs for the historical baseline were like those seen in the other

breakdowns, ranging from 0.001 to 0.003 m/ha, meaning that today's EDs represent an increase of 5581% (Victoria Lowlands) to 184535% (Northumberland Lowlands).

Mean Perimeter-Area Ratio

The detailed tables and maps of the results for the mean perimeter-area ratio (MPAR) analysis can be found in Appendix IV.

Total Province

Across the whole province, the MPAR was found to range from 420.38 m/ha (mature forests, no REZ) to 5935.81 m/ha (mature forest, 1 km REZ). The historical baseline for this metric across the province was determined to be 0.26 m/ha, meaning that the MPAR for today's natural ecosystems (with no REZ), represents a 960463% increase.

By Landmass

MPARs were generally found to be higher on the mainland than Cape Breton and were also found to be highest for the landscape classifications that account for a 1 km REZ. The historical baseline ratios were comparable to the full province analysis (0.11 m/ha on Cape Breton and 0.71 m/ha for the mainland), and again, the percentage increases between the baseline and today were high (827645% on Cape Breton and 393941% on the mainland).

By Ecoregion

As calculated by ecoregion, MPAR was generally found to be lowest in the Western ecoregion (ranging from 536.2 m/ha – mature forests with a 5km REZ to 50171.3 m/ha – natural ecosystems with no REZ) and highest in the Valley and Central Lowlands (ranging from 8792.5 m/ha - mature forest with no REZ to 2860860 m/ha (natural ecosystems with a 5km REZ). While all ecoregions saw an increase in the MPAR between the historical baseline and today, the increases were varied, ranging from 782% (Western) to 1948031% (Fundy Shore).

By Ecodistrict

As with other measures in this work, the MPAR exhibited the highest amount of variation when calculated by ecodistrict. Overall, the ratio ranged from 15.1 m/ha (Parrsboro Shore – natural ecosystems with a 5km REZ) to 2856030.0 m/ha (Central Lowlands – natural ecosystems with a 5km REZ). Historical baselines were also found to be varied, ranging from 0.43 m/ha (North Mountain) to 258.48 m/ha (Pictou Antigonish Highlands). All ecodistricts saw an increase from the baseline, with the percent changes ranging from 19305% (Governor Lake) to 9522461% (Bras d'Or Lowlands).

Effective Mesh Size

The detailed tables and maps of the results for the effective mesh size (m_{eff}) analysis can be found in Appendix V.

Total Province

When calculated across the entire province, m_{eff} was found to be highest for the natural ecosystems and lowest for the mature forest classes. It also decreased as the road effect zone (REZ) was increased. Across all landscape classifications for all of Nova Scotia, m_{eff} was found to vary from 4.49 km^2 (mature forest with a 5 km REZ) to 435.40 km^2 (natural ecosystems with no REZ). Comparing today's landscape (natural ecosystems, no REZ) to the historical baseline indicates that there has been a 99.1% reduction in the m_{eff} across Nova Scotia.

By Landmass

m_{eff} was consistently lower on Cape Breton Island (ranged from 0.06 km^2 [mature forest with a 5 km REZ] to 351.99 km^2 [natural ecosystems with no REZ]) than on the mainland (ranged from 5.48 km^2 [mature forest with a 5 km REZ] to 454.39 km^2 [natural ecosystems with no REZ]). Like the results across the entire province, the comparison of today's m_{eff} to the historical baseline indicates large reductions in the measure – by 96.3% on Cape Breton and 98.9% on the mainland.

By Ecoregion

When calculated by ecoregion, m_{eff} was found to be highest in the Western region (ranged from 15.23 km^2 [mature forest with a 5 km REZ] to 758.82 km^2 [natural ecosystems with no REZ]) and the Northern Plateau. Though for the Northern Plateau this only applied to the natural ecosystems and all forest classifications; the m_{eff} for mature forests in the ecoregion were quite low. The lowest m_{eff}s were found in the Atlantic Coastal (ranged from 0.04 km^2 [mature forest with a 1 km REZ] to 44.41 km^2 [natural ecosystems with no REZ]) and Fundy Shore (ranged from 0.09 km^2 [mature forest with a 5 km REZ] to 31.68 km^2 [natural ecosystems with no REZ]) ecoregions. This general pattern was also consistent in the historical baseline. Changes in m_{eff} varied across ecoregions from a reduction of 62.4% in the Northern Plateau to 97.5% in the Nova Scotia Uplands.

By Ecodistrict

When calculated by ecodistrict, m_{eff} were generally low in the ecodistricts on Cape Breton Island (with the exception of the highlands) and highest in the central portion of the province, particularly in the Eastern Granite Uplands (ranged from 1.15 km^2 [mature forest with a 5 km REZ] to 1529.19 km^2 [natural ecosystems with a 1 km REZ]). Percentage changes from the historical baselines to today range from a loss of 11.9% in the Western Barrens (from 432.74 km^2 to 381.33 km^2) to 99.8% in the Annapolis Valley (from 990.74 km^2 to 1.64 km^2).

Continuous Surfaces

For both sets of effective mesh size surfaces (generated from both the 100 km^2 and 625 km^2 fishnets), the highest m_{eff} values were found in the parts of Nova Scotia around Kejimkujik National Park, the Cape Breton Highlands, the Tangier Grand Lake Wilderness Area and the north shore of the Minas Basin. The lowest m_{eff} were generally around populated areas, such as the eastern side of Cape Breton Island, the area between Halifax and Truro and the Annapolis Valley. Both sets of effective mesh sizes also represent a substantial reduction from the historical baseline. In the historical baseline, the highest m_{eff} values were found along the Northumberland Shore in what is now Pictou County and across the Chignecto Isthmus towards New Brunswick. The lowest reductions in m_{eff} values correspond with the highest m_{eff} today, particularly around the provinces two national parks, Kejimkujik and Cape Breton Highlands. However, in the historical baseline, these were also the parts of the province that had some of the lowest m_{eff} values.

Circuitscape

The detailed maps of the results for the Circuitscape analysis can be found in Appendix VI.

Natural Ecosystems

For the analysis based on natural ecosystems, a few key areas where current flows are constricted emerged. On the mainland, flow was constricted along the Digby Neck, the North Mountain and the south shore of the Chedabucto Bay. Flow was also constricted leaving the Chebucto Peninsula, and connections to the rest of the province was restricted to two corridors that roughly follow the areas adjacent to highways 101 and 103. There were also several areas of constricted flow on Cape Breton, specifically around the southern and eastern shores of the Bras d'Or Lakes and the area around Sydney.

Forests

The results for the analysis based on forests were similar to that of the natural ecosystems. The same hotspots of high current density emerged with an additional hotspot in the northern part of Cape Breton, around the northwest corner of Cape Breton Highlands National Park. The hotspot along the south shore of the Chedabucto Bay was also not as strong as it was with natural ecosystems. The areas of diffuse flow were also narrower than in the natural ecosystem results in all areas of the province.

Forests with a 1 km Road Effect Zone

In the analysis for the forest data where a 1 km road effect zone was applied, there were many more areas of no flow than the other two analyses, as a lot of the province (54%) was excluded from the analysis. Areas of constricted flow were found in all of the patches of forest that are beyond 1 km from roads,

Historic Baseline

The results for the analysis based on the historic baseline indicated that there was diffuse flow across most of the province. Historically, there were only a few places where current was restricted: Digby neck, the area around Sydney and to a lesser extent the southern tip of the Bras d'Or Lakes and the south shore of the Chedabucto Bay.

A few key areas of interest

The Area around Sydney: This was an area of restricted flow in all of the analyses with the exception of the forests with a 1 km road effect zone applied, where most of the area had no flow.

The Area around Halifax: In the historic baseline, this was an area of diffuse flow, save for a minor concentration of current around the tip of the Bedford Basin. In the analysis for the present-day natural ecosystems and forests, the patterns of current flow are similar. There is no flow on the Halifax peninsula, and most of the concentrated flow is on the Chebucto Peninsula, and moving off it around Bedford through the Blue Mountain-Birch Cove Lakes Wilderness Areas and Hammonds Plains. In the analysis where the 1 km road effect zone was taken into account, there is hardly any flow, save for a few pockets of concentrated flow on the Chebucto Peninsula.

Annapolis Valley: In the natural ecosystems and forest based analyses, flow is concentrated on the North Mountain and to a lesser extent the Valley Slope and South Mountain, with very little flow in and across the Valley itself. When the 1 km road effect zone was applied, the high density areas of flow on the North Mountain disappear, making the area look more like the Valley from the first two analyses. In the historic baseline, the entire region is an area of diffuse flow.

Digby Neck: The results for the analyses based on natural ecosystems, forests and the historic baseline indicate that this is an area of high current density. In the analysis where a 1km road effect zone is taken into account, there is very little flow as most of the land has been excluded.

DISCUSSION

Key Trends by Analytical Unit

There are some general trends that are consistent among all of the different analytical units used in this work, but there are unique pieces of information produced by each of the different breakdowns. Having four different pictures of landscape connectivity and fragmentation across Nova Scotia yields more information than just choosing a single analytical unit.

Total Province

Overall, Nova Scotia has seen a reduction of 8.9% in natural ecosystems between the historical baseline and today. The metrics included in this work indicate that at the provincial level, there has been an increase in fragmentation between the historical baseline and today as median patch size (MedPS) and effective mesh size (m_{eff}) have decreased and edge density (ED) and mean perimeter-area ratio (MPAR) have increased.

The Circuitscape analysis produced a more detailed picture of the patterns of connectivity across the province. Despite being a peninsula, there are few places in the province where ecological connectivity is naturally restricted based on the historic baseline analysis. Most places where flows are naturally constricted are on Cape Breton, with the exception of the Digby Neck. This was to be expected as Cape Breton has a lot of narrow inlets and peninsulas in comparison to the mainland. The biggest concentration of current on the island was around Sydney, which was also found to be a hotspot of restricted current flow in the present-day analyses where there was no road effect zone taken into account. In the present-day analysis, the patterns of current flow were similar for the analyses based on natural ecosystems and forests were similar, except that the areas of flow, particularly those of diffuse flow are narrower in the forest-based analysis. This was to be expected as the forests are a subset of the natural ecosystems dataset. When a 1 km road effect zone was taken into account, 54.1% of the province is excluded from analysis, returned as areas of no flow. The areas that remain in the analysis, reveal a highly fragmented forest, where flow even within the patches is often restricted to a few corridors of constricted flow.

Landmass

Except for m_{eff}, the metrics included in this work indicate that the landscape is more fragmented on the mainland than Cape Breton. Although this was also the case in the historical baseline, the percentage changes in the metrics analysed in this work indicate that connectivity has been better maintained on Cape Breton compared to the mainland. This was not entirely unexpected given that Cape Breton has a lower human population density and associated human landscapes such as roads and agriculture.

Ecoregion

In general, patterns of landscape connectivity and fragmentation at the ecoregion level were associated with patterns of human landscape modification across the province. In the sparsely populated, and generally little-modified landscapes of the Cape Breton Highlands (the Northern Plateau and Cape Breton Highlands ecoregions), the metrics involved in this work indicated low levels of fragmentation and higher connectivity. In contrast, the more intensely modified Valley and Central Lowlands landscapes has measures indicating higher fragmentation and lower connectivity. This pattern also held for the changes from the historical baseline to today, in that the Northern Plateau generally exhibited the least change and the Valley and Central Lowlands the most.

Ecodistrict

The results of this analysis at the level of ecodistrict were generally consistent with what would be expected in regard to the link between human settlements and impacts on the landscape and increased landscape fragmentation. There were high indications of fragmentation, and large changes from the historical baseline, in ecodistricts such as the Annapolis Valley, Minas Lowlands and Valley Slope. On the other hand, there were lower indicators of fragmentation and smaller changes from the baseline in ecodistricts such as the Northern Plateau and Western Barrens.

Metropolitan Halifax

When one thinks about landscape connectivity and modification in Nova Scotia, the metropolitan part of Halifax Regional Municipality (i.e. Halifax, Dartmouth, Bedford, Sackville) generally comes to mind as one of the most fragmented landscapes in the province as a result of the dense human populations. However, the ecoregion and ecodistrict that include this area (Eastern ecoregion and Eastern Interior ecodistrict) are never included in the lists of regions that stand out as having high levels of fragmentation and large changes from the historical baseline in the patch-based metrics analyses. Yet, it is logical to assume that the province's most densely populated area should be among the most fragmented. This is because even at the ecodistrict, Halifax is included in a large geographic region, likely resulting in the highly modified metro landscapes being masked by the more intact, rural parts of Halifax and Guysborough county that are also in the Eastern Interior ecodistrict. This is an example of how the scale and physical construction of reporting units influence the aggregation of data, and thus the results generated and conclusions drawn from an analysis (Jelinski & Wu, 1996; Openshaw, 1984; Openshaw & Taylor, 1981). It was only in the surface models that the high fragmentation of the Halifax region was detected, highlighting the importance of looking at landscape connectivity and fragmentation through a variety of metrics and analytical units.

Protected Areas

The results for many of the metrics and analytical units indicated that the parts of the province with protected areas (Figure 6), particularly the two national parks (Kejimkujik and Cape Breton Highlands) were associated with high connectivity and low fragmentation. These parts of

the province were also associated with some of the smallest changes between the historical baseline and today for the various metrics examined in this work. However, it is important to note that historically, these were some of the most fragmented landscapes in the province. Some of the most fragmented landscapes (especially the Chignecto Isthmus) today were historically some of the most connected.

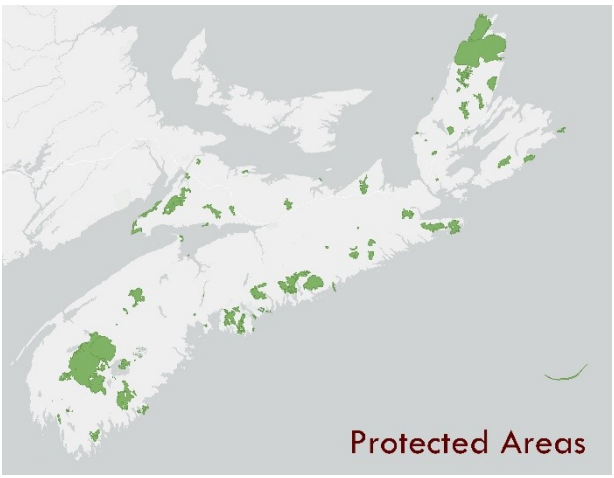

Figure 6. Protected areas in Nova Scotia

Future Research

The results of this research give insight into how connectivity varies in the natural ecosystems, forests and mature forests across the province of Nova Scotia and provide the foundations for future research on the topic. There are opportunities to look at the changes in connectivity between the historic baseline and today, identifying the parts of the province where connectivity has been impacted the most, or remained the most intact. There are also opportunities to investigate further how the road effect zone impacts the different measures of connectivity, and to take a deeper look at how the various metrics analyzed here vary across the province (i.e. where are they highlighting the same or different areas as being the most or least connected).

The broad-scale maps produced in this report can also be used to highlight areas for future, finer-scale research. For example, least-cost path analysis can be applied to these results to identify areas of interest for further investigation, such as areas around major Highways. Figure 7 shows the connectivity of forested areas with a 1 km road effect zone applied and the best path across Cumberland County, running between the Economy River Wilderness Area and the New Brunswick border, highlighting where around Highway 104 further research could be of use. However, it should be noted that this research was solely focused on structural connectivity (the spatial structure of the landscape). How wildlife, of any species, may react to this structure (i.e. functional connectivity), was not considered, but represents an important avenue of future research.

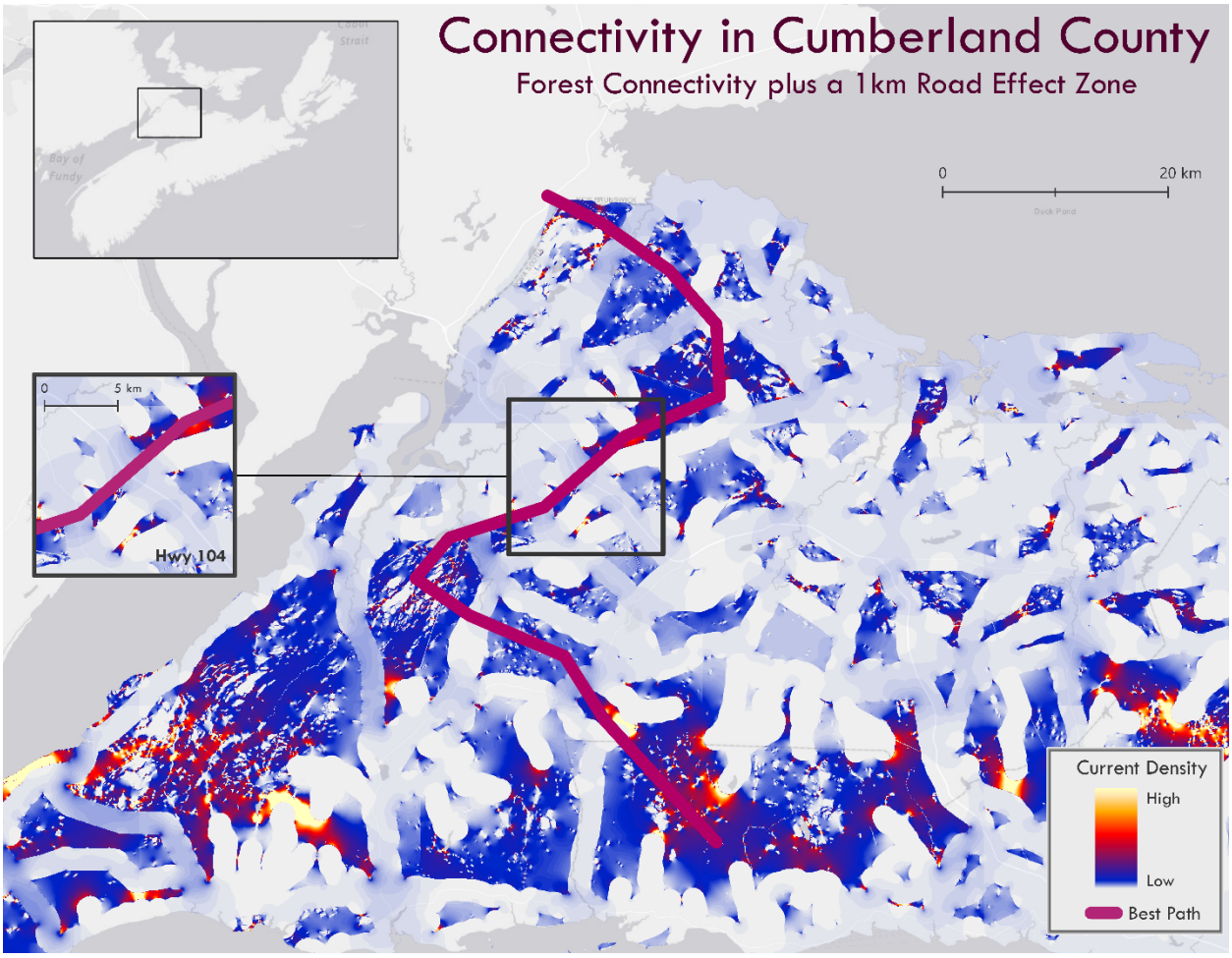

Figure 7. The best path across Cumberland County from the Economy River Wilderness Area to New Brunswick for forests with a 1 km road effect zone applied. Insets show where the path cross the major highways in the province, however there are numerous other, smaller road crossings along the route

REFERENCES

Benítez-López, A., Alkemade, R., & Verweij, P. A. (2010). The impacts of roads and other infrastructure on mammal and bird populations: A meta-analysis. *Biological Conservation*, *143*(6), 1307–1316. https://doi.org/10.1016/j.biocon.2010.02.009

Brooks, C. (2003). A scalar analysis of landscape connectivity. *Oikos*, *102*(2), 433–439.

Dyer, S. J., O'Neill, J. P., Wasel, S. M., & Boutin, S. (2001). Avoidance of industrial development by woodland caribou. *The Journal of Wildlife Management*, *65*(3), 531–542.

Forman, R. T. T. (2000). Estimate of the Area Affected Ecologically by the Road System in the United States. *Conservation Biology*, *14*(1), 31–35.

Forman, R. T. T., Friedman, D. S., Fitzhenry, D., Martin, J. D., Chen, A. S., & Alexander, L. E. (1997). Ecological effects of roads: Toward three summary indices and an overview of North America. In K. Canter (Ed.), *Habitat fragmentation and infrastructure.* (pp. 40–54). Delf, Netherlands: Minister of Transport and Public Works and Water Management.

Jaeger, J. A. G. (2000). Landscape division splitting index and effective mesh size: New measures of landscape fragmentation. *Landscape Ecology*, *15*, 115–130.

Jalkotzy, M. G., Ross, P. I., & Nasserden, M. D. (1997). *The effects of linear developments on wildlife: A review of selected scientific literature*. *Canadian Association of Petroleum Producers*. Calgary, Alberta.

Jelinski, D. E., & Wu, J. (1996). The modifiable areal unit problem and implications for landscape ecology. *Landscape Ecology*, *11*(3), 129–140. https://doi.org/10.1007/BF02447512

Neily, P., Basquill, S., Quigley, E., & Keys, K. (2017). *Ecological land classification for Nova Scotia*. *Report FOR 2017-13*. Truro, Nova Scotia.

Nova Scotia Department of Lands and Forestry. (2016). *Forest Inventory - Current Forest Data*. *Forest Inventory Metadata - Web Version*. https://doi.org/10.1109/ciced.2018.8592188

Openshaw, S. (1984). The modifiable areal unit problem. In *CAT-MOG 38*. Norwich, England: GeoBooks.

Openshaw, S., & Taylor, P. (1981). The modifiable areal unit problem. In N. Wrigley & R. Bennet (Eds.), *Quantitative Geography: A British View* (pp. 60–69). London, UK: Routledge and Kegan Paul.

Pelletier, D., Lapointe, M. É., Wulder, M. A., White, J. C., & Cardille, J. A. (2017). Forest connectivity regions of Canada using circuit theory and image analysis. *PLoS ONE*, *12*(2). https://doi.org/10.1371/journal.pone.0169428

Shah, V. B., & McRae, B. H. (2008). Circuitscape : A Tool for Landscape Ecology. *Proceedings of the 7th Python in Science Conference*, (SciPy), 62–65. https://doi.org/10.1111/j.1523-1739.2008.00942.x

Taylor, P. D., Fahrig, L., Henein, K., & Merriam, G. (1993). Connectivity is a vital element of landscape structure. *Oikos*, *68*(3), 571–573.

Trombulak, S. C., & Frissell, C. A. (2000). Review of Ecological Effects of Roads on Terrestrial and

Aquatic Communities. *Conservation Biology*, *14*(1), 18–30.

Turner, M. G., Gardner, R. H., & O'Neill, R. V. (2001). *Landscape Ecology in Theory and Practice: Pattern and Process*. (M. G. Turner, R. H. Gardner, & R. V O'Neill, Eds.). New York: Springer-Verlag.

APPENDIX I: PERCENTAGE CLASS AREA

Table A1.1. Percentage Class Area for full study area for each forest classification.

	%Natural Ecosystem, No REZ	%Natural Ecosystem, 1km REZ	%Natural Ecosystem, 5km REZ	%Forest, No REZ	%Forest, 1km REZ	%Forest, 5km REZ	%Mature Forest, No REZ	%Mature Forest, 1km REZ	%Mature Forest, 5km REZ	%Natural: Historical Baseline	Percentage Change – Baseline to Today
Total Area	87.0%	94.4%	91.8%	78.1%	82.2%	75.7%	38.7%	40.7%	39.7%	95.9%	-8.9%

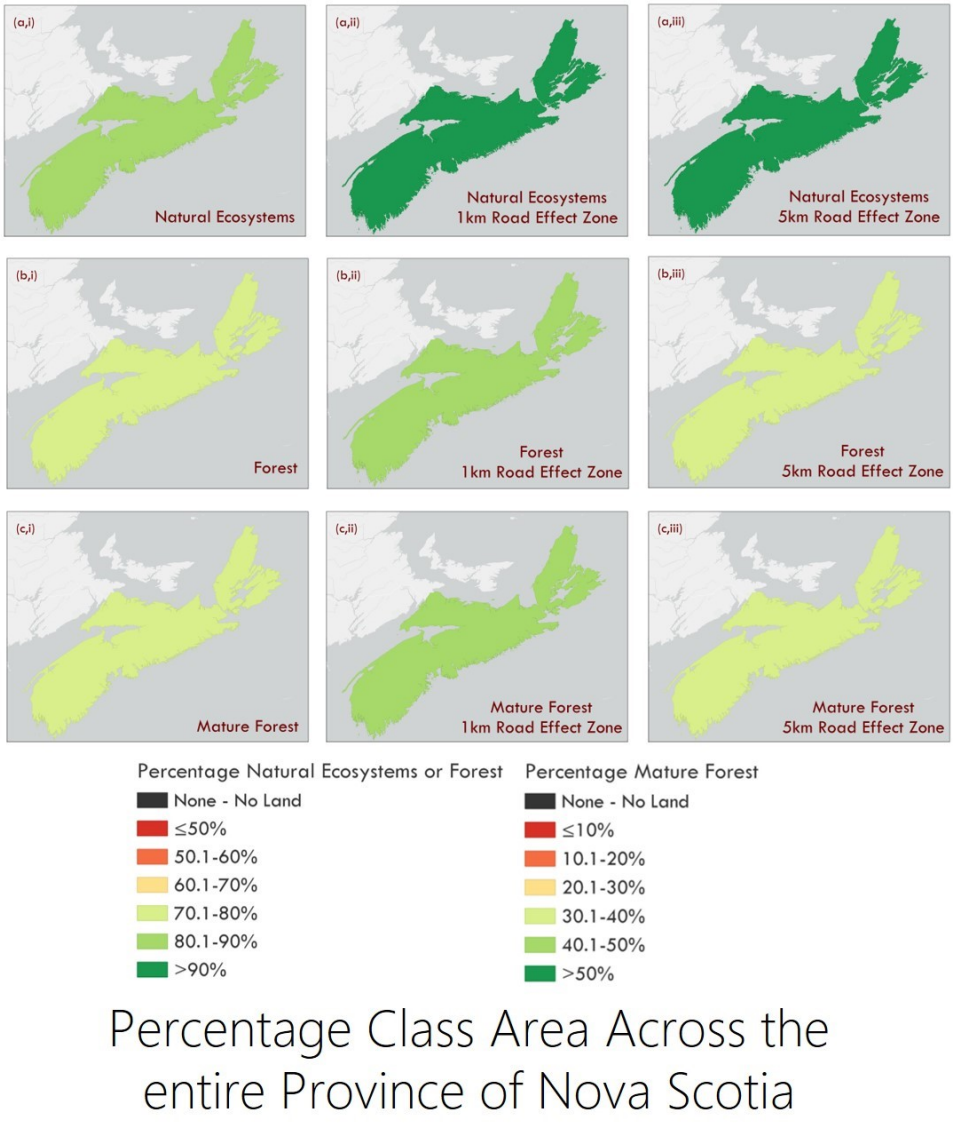

Figure A1.1. Percentage of the class area across the entire province of Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.

Table A1.2. Percentage class area by landmass for each forest classification.

Landmass	%Natural Ecosystem, No REZ	%Natural Ecosystem, 1km REZ	%Natural Ecosystem, 5km REZ	%Forest, No REZ	%Forest, 1km REZ	%Forest, 5km REZ	%Mature Forest, No REZ	%Mature Forest, 1km REZ	%Mature Forest, 5km REZ	%Natural: Historical Baseline	Percentage Change – Baseline to Today
Cape Breton	90.4%	97.1%	98.4%	79.9%	82.0%	69.3%	37.0%	35.6%	16.7%	97.5%	-7.1%
Mainland	86.1%	93.7%	90.4%	77.7%	82.3%	77.1%	39.1%	41.9%	44.6%	95.5%	-9.4%

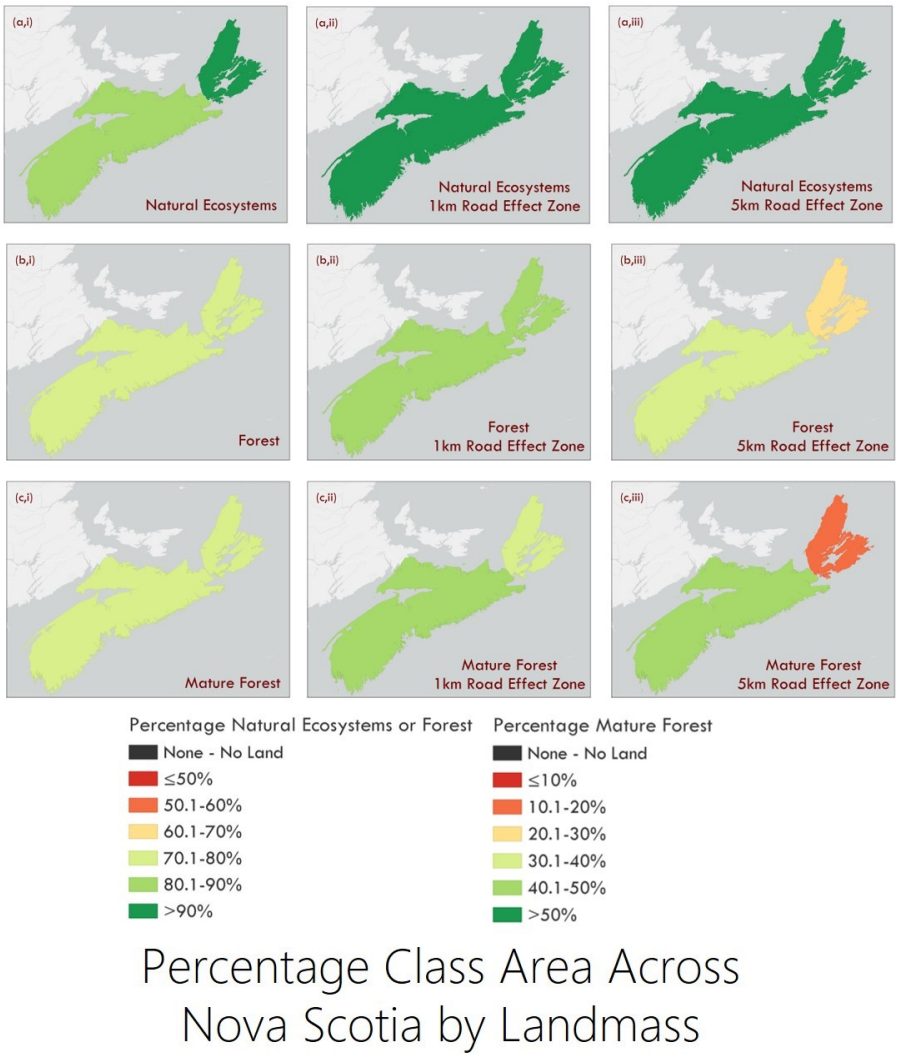

Figure A1.2. Percentage of the class area by landmass across Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.

Table A1.3. Percentage class area by ecoregion for each forest classification.

Ecoregion	%Natural Ecosystem, No REZ	%Natural Ecosystem, 1km REZ	%Natural Ecosystem, 5km REZ	%Forest, No REZ	%Forest, 1km REZ	%Forest, 5km REZ	%Mature Forest, No REZ	%Mature Forest, 1km REZ	%Mature Forest, 5km REZ	%Natural: Historical Baseline	Percentage Change – Baseline to Today
100: Northern Plateau	96.7%	97.3%	97.9%	38.5%	38.9%	34.2%	1.7%	1.6%	0.7%	97.1%	-0.4%
200: Cape Breton Highlands	97.1%	98.7%	98.7%	81.5%	82.0%	76.5%	20.1%	18.1%	11.8%	98.5%	-1.4%
300: Nova Scotia Uplands	92.9%	97.9%	98.0%	89.7%	93.3%	91.9%	44.4%	49.4%	46.8%	98.6%	-5.7%
400: Eastern	87.5%	92.9%	91.2%	77.4%	79.7%	77.6%	29.4%	29.1%	27.6%	93.6%	-6.1%
500: Northumberland/ Bras D'Or	82.5%	97.3%	99.7%	75.7%	86.7%	89.1%	33.7%	40.2%	41.2%	98.4%	-16.0%
600: Valley and Central Lowlands	69.7%	97.6%	99.4%	63.9%	90.3%	92.8%	29.0%	36.8%	36.7%	98.8%	-29.1%
700: Western	88.1%	91.5%	89.9%	80.0%	81.0%	76.6%	50.3%	49.9%	48.1%	92.3%	-4.3%
800: Atlantic Coastal	87.7%	94.2%	95.5%	64.6%	63.2%	44.5%	23.1%	21.3%	7.7%	95.4%	-7.8%
900: Fundy Shore	88.2%	99.2%	99.6%	85.3%	96.1%	91.3%	48.3%	54.7%	28.8%	99.7%	-11.5%

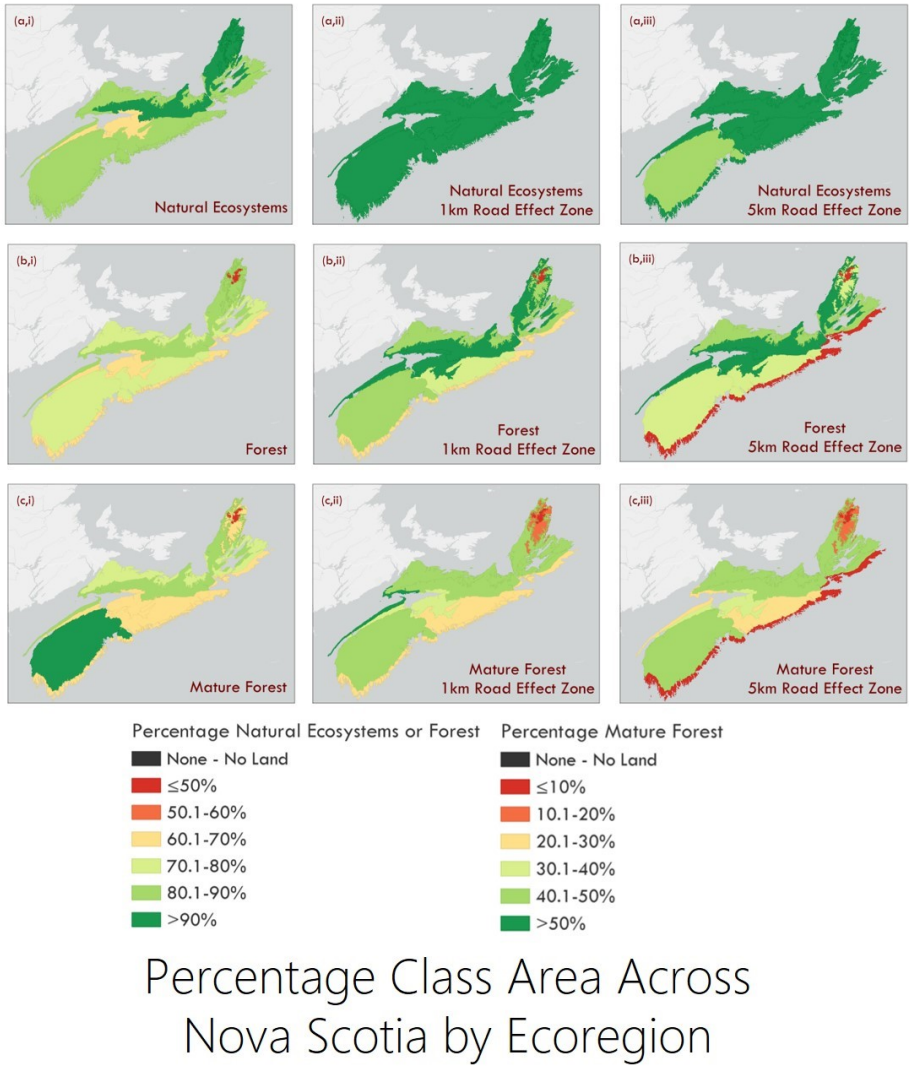

Figure A1.3. Percentage of the class area by ecoregion across Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.

Table A1.4. Percentage class area by ecodistrict for each forest classification.

Ecodistict	%Natural Ecosystem, No REZ	%Natural Ecosystem, 1km REZ	%Natural Ecosystem, 5km REZ	%Forest, No REZ	%Forest, 1km REZ	%Forest, 5km REZ	%Mature Forest, No REZ	%Mature Forest, 1km REZ	%Mature Forest, 5km REZ	%Natural: Historical Baseline	Percentage Change – Baseline to Today
100: Northern Plateau	96.7%	97.3%	97.9%	38.5%	38.9%	34.2%	1.7%	1.6%	0.7%	97.1%	-0.4%
210: Cape Breton Highlands	98.1%	98.8%	98.7%	81.8%	81.9%	76.5%	17.9%	17.7%	11.8%	98.6%	-0.4%
220: Victoria Lowlands	86.7%	95.8%	87.9%	79.3%	85.4%	87.9%	42.8%	46.7%	87.9%	97.8%	-11.0%
310: Cape Breton Hills	96.2%	99.2%	98.8%	93.9%	95.9%	93.1%	60.0%	63.6%	52.7%	99.7%	-3.4%
320: Inverness Lowlands	67.6%	39.7%	88.9%	62.1%	36.7%	83.6%	28.9%	19.5%	73.4%	86.8%	-19.2%
330: Pictou Antigonish Highlands	94.0%	98.6%	0.0%	91.4%	94.8%	0.0%	37.1%	42.6%	0.0%	99.6%	-5.6%
340: Cobequid Hills	93.0%	98.6%	98.1%	91.6%	96.1%	85.6%	53.1%	59.7%	54.4%	99.5%	-6.5%
350: Cobequid Slopes	89.1%	99.0%	0.0%	87.6%	97.5%	0.0%	37.9%	45.5%	0.0%	99.6%	-10.4%
360: Mulgrave Plateau	91.3%	96.0%	99.4%	86.6%	87.0%	88.1%	38.8%	50.9%	44.7%	97.4%	-6.2%
370: St. Mary's River	93.8%	97.9%	100.0%	86.0%	88.5%	95.1%	15.9%	15.9%	4.3%	96.6%	-2.8%
380: Central Uplands	93.0%	98.3%	94.1%	88.7%	92.2%	88.7%	25.6%	25.7%	12.2%	99.5%	-6.6%
410: Rawdon/ Wittenburg Hills	87.5%	98.0%	0.0%	86.5%	96.5%	0.0%	37.6%	38.6%	0.0%	89.0%	-1.5%
430: Eastern Granite Uplands	88.6%	88.4%	80.8%	76.3%	74.9%	71.8%	43.5%	42.5%	47.4%	93.3%	-4.7%
440: Eastern Interior	86.6%	93.3%	93.7%	75.2%	78.9%	79.4%	27.5%	27.6%	25.1%	94.5%	-8.0%
450: Governor Lake	93.2%	93.7%	92.1%	85.1%	84.0%	76.8%	21.6%	20.3%	17.8%	96.9%	-3.6%
510: Bras d'Or Lowlands	83.8%	95.5%	99.8%	74.9%	80.8%	71.0%	34.9%	35.8%	58.6%	99.5%	-15.7%
520: St. George's Bay	76.8%	95.0%	0.0%	74.0%	93.5%	0.0%	24.8%	36.3%	0.0%	99.0%	-22.3%

530: Northumberland Lowlands	78.9%	0.0%	0.0%	73.8%	0.0%	0.0%	32.6%	0.0%	0.0%	99.7%	-20.7%
540: Cumberland Hills	88.2%	98.6%	0.0%	85.4%	96.6%	0.0%	43.5%	50.6%	0.0%	97.0%	-8.9%
550: Cumberland Marshes	59.1%	86.0%	0.0%	30.3%	30.3%	0.0%	10.8%	9.3%	0.0%	99.5%	-40.5%
560: Chignecto Ridges	96.5%	99.5%	99.7%	87.5%	88.6%	89.2%	38.3%	41.0%	41.1%	98.3%	-1.8%
610: Annapolis Valley	46.2%	84.6%	0.0%	41.6%	79.0%	0.0%	27.6%	48.6%	0.0%	99.3%	-53.0%
620: Minas Lowlands	53.1%	90.2%	0.0%	46.8%	83.0%	0.0%	15.1%	25.8%	0.0%	99.3%	-46.2%
630: Central Lowlands	80.4%	98.2%	99.4%	74.2%	90.9%	92.8%	31.7%	36.8%	36.7%	98.9%	-18.5%
710: Valley Slope	83.0%	99.0%	0.0%	81.7%	97.6%	0.0%	57.5%	71.0%	0.0%	99.6%	-16.6%
720: South Mountain	92.2%	92.9%	91.6%	86.0%	86.2%	84.3%	55.5%	56.2%	59.6%	93.0%	-0.8%
730: Clare	84.5%	92.8%	75.8%	78.9%	86.0%	56.4%	50.9%	56.1%	46.9%	91.6%	-7.1%
740: LaHave Drumlins	82.8%	88.4%	93.5%	79.3%	82.9%	85.8%	53.7%	55.9%	75.1%	90.9%	-8.1%
750: Rossignol	78.8%	74.2%	59.3%	71.7%	66.3%	51.1%	52.1%	47.8%	39.7%	80.6%	-1.8%
760: Sable	93.4%	94.8%	95.4%	76.3%	76.7%	73.6%	44.5%	44.0%	42.1%	94.6%	-1.2%
770: Western Barrens	95.1%	95.1%	95.1%	73.7%	74.6%	77.6%	42.8%	43.4%	43.7%	95.3%	-0.2%
780: St. Margaret's Bay	86.4%	91.7%	89.9%	80.2%	84.5%	85.8%	40.1%	39.2%	25.3%	92.9%	-6.5%
810: Cape Breton Coastal	88.2%	94.1%	97.5%	70.8%	71.9%	45.4%	16.3%	17.7%	3.0%	94.5%	-6.3%
820: Eastern Shore	89.3%	93.7%	93.9%	60.8%	56.3%	39.8%	15.4%	14.5%	9.5%	95.8%	-6.5%
830: South Shore	88.9%	94.9%	99.6%	66.5%	66.6%	0.0%	36.1%	35.7%	0.0%	97.3%	-8.3%
840: Tusket Islands	81.8%	97.2%	93.2%	61.3%	63.6%	60.0%	33.0%	37.1%	20.3%	97.5%	-15.6%

910: Parrsboro Shore	86.5%	99.2%	100.0%	82.7%	95.2%	92.3%	37.0%	38.5%	30.6%	99.6%	-13.1%
920: North Mountain	88.9%	99.2%	95.5%	86.4%	96.8%	80.4%	53.3%	65.4%	9.1%	99.7%	-10.8%

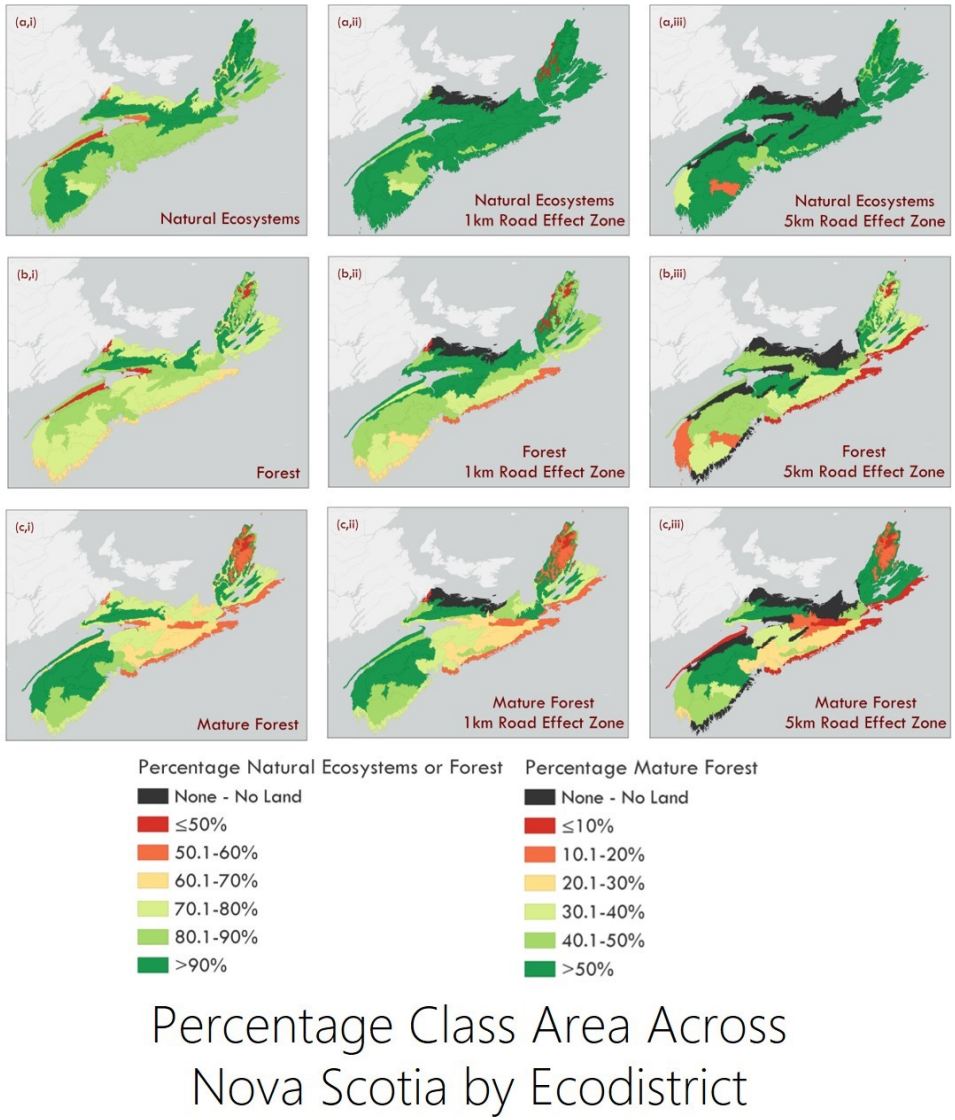

Figure A1.4. Percentage of the class area by ecodistrict across Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.

APPENDIX II: MEDIAN PATCH SIZE

Table A2.1. Median patch size (MedPS) (ha) for full study area for each forest classification.

	MedPS Natural Ecosystem, No REZ	MedPS Natural Ecosystem, 1km REZ	MedPS Natural Ecosystem, 5km REZ	MedPS Forest, No REZ	MedPS Forest, 1km REZ	MedPS Forest, 5km REZ	MedPS Mature Forest, No REZ	MedPS Mature Forest, 1km REZ	MedPS Mature Forest, 5km REZ	MedPS Natural: Historical Baseline	Percentage Change – Baseline to Today
Total Area	1.62	0.66	0.45	2.63	1.60	1.25	3.20	2.59	2.62	2937.79	-99.9%

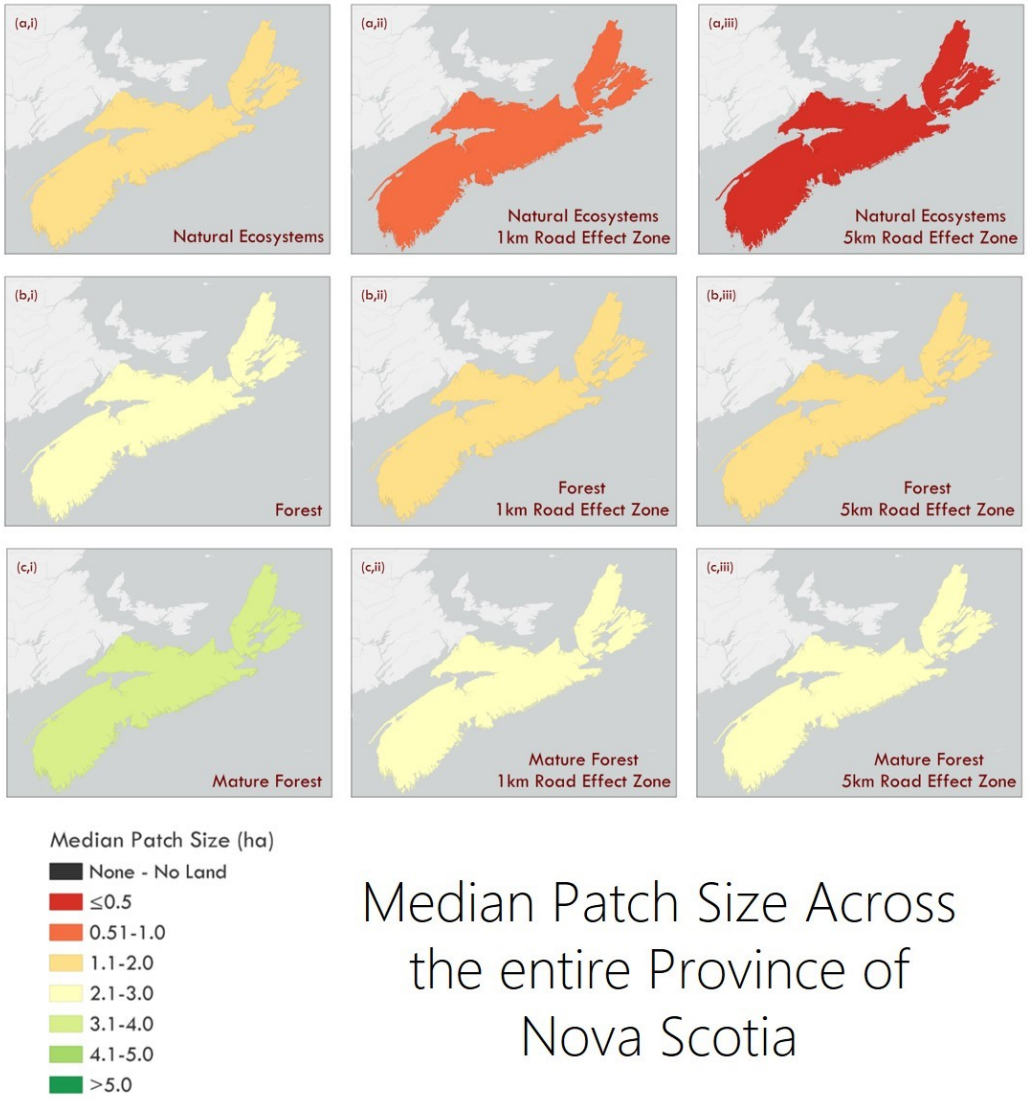

Figure A2.1. Median patch size across the entire province of Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.
Table A2.2. Median patch size (MedPS) (ha) by landmass for each forest classification.

Landmass	MedPS Natural Ecosystem, No REZ	MedPS Natural Ecosystem, 1km REZ	MedPS Natural Ecosystem, 5km REZ	MedPS Forest, No REZ	MedPS Forest, 1km REZ	MedPS Forest, 5km REZ	MedPS Mature Forest, No REZ	MedPS Mature Forest, 1km REZ	MedPS Mature Forest, 5km REZ	MedPS Natural: Historical Baseline	Percentage Change – Baseline to Today
Cape Breton	3.00	1.42	0.30	4.52	2.85	3.11	3.99	3.37	4.70	3770.40	-99.9%
Mainland	1.48	0.64	0.52	2.37	1.46	1.07	3.06	2.50	2.48	1708.87	-99.9%

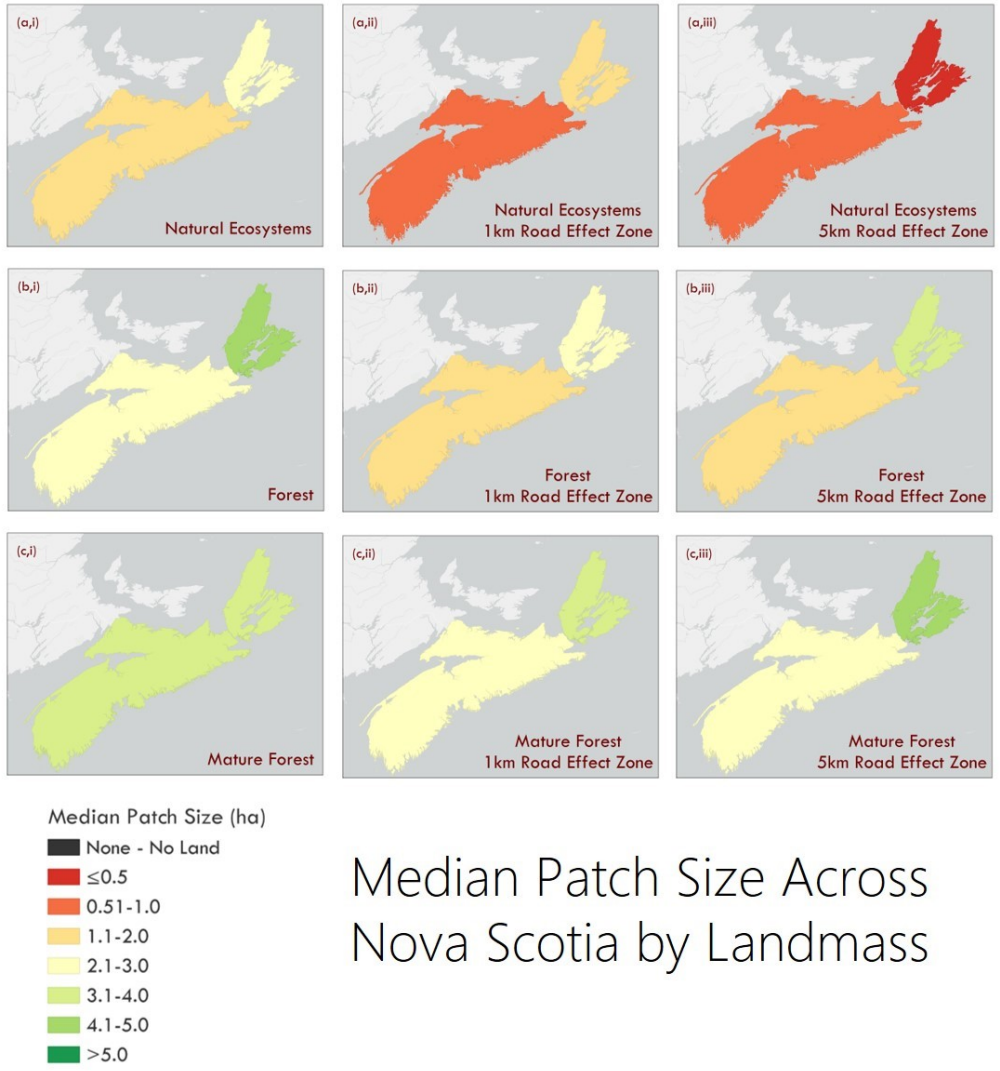

Figure A2.2. Median patch size by landmass across Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.

Table A2.3. Median patch size (MedPS) (ha) by ecoregion for each forest classification.

Ecoregion	MedPS Natural Ecosystem, No REZ	MedPS Natural Ecosystem, 1km REZ	MedPS Natural Ecosystem, 5km REZ	MedPS Forest, No REZ	MedPS Forest, 1km REZ	MedPS Forest, 5km REZ	MedPS Mature Forest, No REZ	MedPS Mature Forest, 1km REZ	MedPS Mature Forest, 5km REZ	MedPS Natural: Historical Baseline	Percentage Change – Baseline to Today
100: Northern Plateau	0.17	0.21	0.11	1.70	1.62	1.60	1.08	0.99	1.35	1081.1	-100.0%
200: Cape Breton Highlands	0.65	0.63	1.91	2.52	2.31	2.34	2.43	2.24	1.94	1222.52	-99.9%
300: Nova Scotia Uplands	2.43	29.60	21.48	2.75	5.37	6.66	2.86	2.51	2.36	1060.17	-99.8%
400: Eastern	0.58	0.22	0.39	1.49	1.03	0.79	3.04	2.89	2.66	1118.57	-99.9%
500: Northumberland/ Bras D'Or	2.84	10.29	7.60	3.73	3.55	2.20	3.12	2.52	3.36	1819.41	-99.8%
600: Valley and Central Lowlands	2.55	7.77	29.99	3.08	3.20	1.20	2.83	2.25	1.74	218.58	-98.8%
700: Western	1.20	0.81	0.61	1.50	1.15	1.06	2.64	2.21	2.42	2455.08	-100.0%
800: Atlantic Coastal	0.29	0.19	0.06	2.24	1.86	2.68	3.19	2.82	3.92	1174.18	-100.0%
900: Fundy Shore	1.74	35.38	0.13	2.82	25.16	45.06	2.91	1.73	10.21	885.278	-99.8%

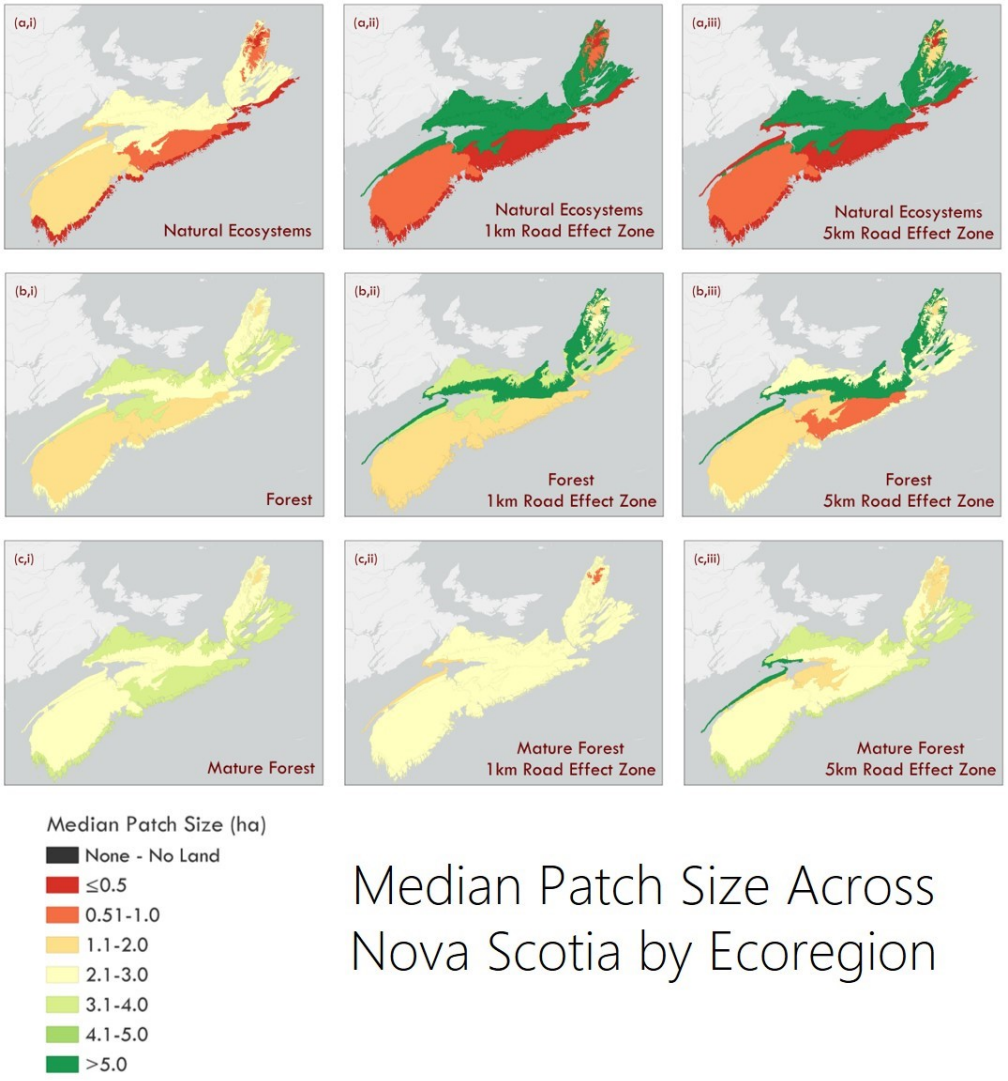

Figure A2.3. Median patch size by ecoregion across Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.

Table A2.4. Median patch size (MedPS) by ecodistrict for each forest classification.

Ecodistict	MedPS Natural Ecosystem, No REZ	MedPS Natural Ecosystem, 1km REZ	MedPS Natural Ecosystem, 5km REZ	MedPS Forest, No REZ	MedPS Forest, 1km REZ	MedPS Forest, 5km REZ	MedPS Mature Forest, No REZ	MedPS Mature Forest, 1km REZ	MedPS Mature Forest, 5km REZ	MedPS Natural: Historical Baseline	Percentage Change – Baseline to Today
100: Northern Plateau	0.17	0.21	0.11	1.70	1.62	1.60	1.08	1.00	1.36	1081.10	-100.0%
210: Cape Breton Highlands	0.20	0.40	1.92	2.56	2.30	2.34	2.35	2.21	1.94	1012.22	-100.0%
220: Victoria Lowttlands	1.13	2.53	2.02	2.42	2.37	2.02	2.84	4.25	2.02	1434.73	-99.9%
310: Cape Breton Hills	1.42	35.27	18.90	1.62	10.24	7.61	2.26	2.26	3.75	2015.52	-99.9%
320: Inverness Lowlands	1.94	3.70	0.40	2.37	2.99	95.87	2.46	2.51	42.09	1183.02	-99.8%
330: Pictou Antigonish Highlands	2.14	151.67	0.00	2.52	56.87	0.00	3.14	2.44	0.00	11.44	-81.3%
340: Cobequid Hills	3.12	22.38	144.51	2.57	3.68	6.67	2.37	2.37	2.82	542.04	-99.4%
350: Cobequid Slopes	3.52	69.37	0.00	3.23	41.21	0.00	2.63	1.96	0.00	57.76	-93.9%
360: Mulgrave Plateau	1.71	5.54	73.52	1.81	1.90	0.51	2.42	2.30	0.76	949.59	-99.8%
370: St. Mary's River	0.59	5.12	7.56	1.42	2.35	1.73	3.23	3.02	0.76	5.96	-90.1%
380: Central Uplands	5.71	24.40	189.66	3.06	3.34	67.94	2.96	2.60	1.62	579.24	-99.0%
410: Rawdon/ Wittenburg Hills	1.71	41.44	0.00	1.56	31.47	0.00	2.07	1.67	0.00	1344.81	-99.9%
430: Eastern Granite Uplands	0.31	0.33	0.26	0.62	0.60	0.38	2.37	2.46	1.91	958.35	-100.0%
440: Eastern Interior	0.46	0.14	0.54	1.46	0.82	0.84	3.03	2.82	2.45	1108.07	-100.0%
450: Governor Lake	0.63	0.17	0.32	1.15	1.10	1.07	2.78	2.76	2.83	2604.43	-100.0%
510: Bras d'Or Lowlands	2.87	6.45	0.08	3.78	2.81	0.08	3.48	2.79	0.08	6337.63	-100.0%
520: St. George's Bay	3.18	12.70	0.00	3.31	10.21	0.00	2.36	1.44	0.00	1689.77	-99.8%

530: Northumberland Lowlands	2.52	23.78	0.00	3.96	6.07	0.00	2.97	2.11	0.00	0.63	300.8%
540: Cumberland Hills	3.05	60.71	0.00	2.64	5.43	0.00	2.50	2.03	0.00	3.71	-17.7%
550: Cumberland Marshes	0.86	0.24	0.00	1.21	2.92	0.00	1.68	2.88	0.00	3158.57	-100.0%
560: Chignecto Ridges	1.21	50.05	121.49	1.97	2.27	2.61	3.67	3.29	3.37	291.63	-99.6%
610: Annapolis Valley	2.09	1.18	0.00	3.05	2.45	0.00	2.91	1.02	0.00	99.55	-97.9%
620: Minas Lowlands	2.99	6.20	0.00	3.04	5.39	0.00	2.39	1.47	0.00	33.72	-91.1%
630: Central Lowlands	2.74	18.00	30.05	2.91	3.11	1.20	2.81	2.31	1.74	340.35	-99.2%
710: Valley Slope	2.75	11.73	0.00	2.97	9.03	0.00	2.59	1.11	0.00	53.46	-94.9%
720: South Mountain	0.12	0.12	0.00	0.61	0.60	0.03	1.89	1.75	1.23	1414.45	-100.0%
730: Clare	1.17	0.14	0.00	1.36	0.28	0.00	2.24	1.33	0.00	639.80	-99.8%
740: LaHave Drumlins	0.32	0.17	0.01	0.71	0.36	0.05	1.96	0.95	0.20	301.14	-99.9%
750: Rossignol	0.49	0.29	0.02	0.70	0.56	0.26	1.18	0.94	0.35	2263.41	-100.0%
760: Sable	0.57	0.56	0.59	1.28	1.26	1.31	2.92	2.92	2.99	1658.66	-100.0%
770: Western Barrens	0.19	0.18	0.16	1.27	1.11	0.86	2.51	2.50	2.81	996.49	-100.0%
780: St. Margaret's Bay	0.63	0.43	0.31	1.19	0.93	0.43	2.41	1.85	1.66	1481.66	-100.0%
810: Cape Breton Coastal	0.87	0.32	0.05	3.45	1.48	2.73	3.80	3.28	2.34	1101.43	-99.9%
820: Eastern Shore	0.14	0.13	0.06	2.45	2.12	2.51	3.29	2.90	4.48	1215.81	-100.0%
830: South Shore	0.32	0.22	8.02	1.88	1.48	0.00	2.91	2.62	0.00	957.69	-100.0%
840: Tusket Islands	1.91	2.27	9.00	1.91	1.66	77.89	2.59	1.56	3.70	4208.11	-100.0%

910: Parrsboro Shore	1.13	43.97	1206.44	2.44	8.96	557.20	3.16	2.06	13.27	995.96	-99.9%
920: North Mountain	2.65	31.63	0.10	3.14	40.37	45.08	2.83	1.57	10.22	835.79	-99.7%

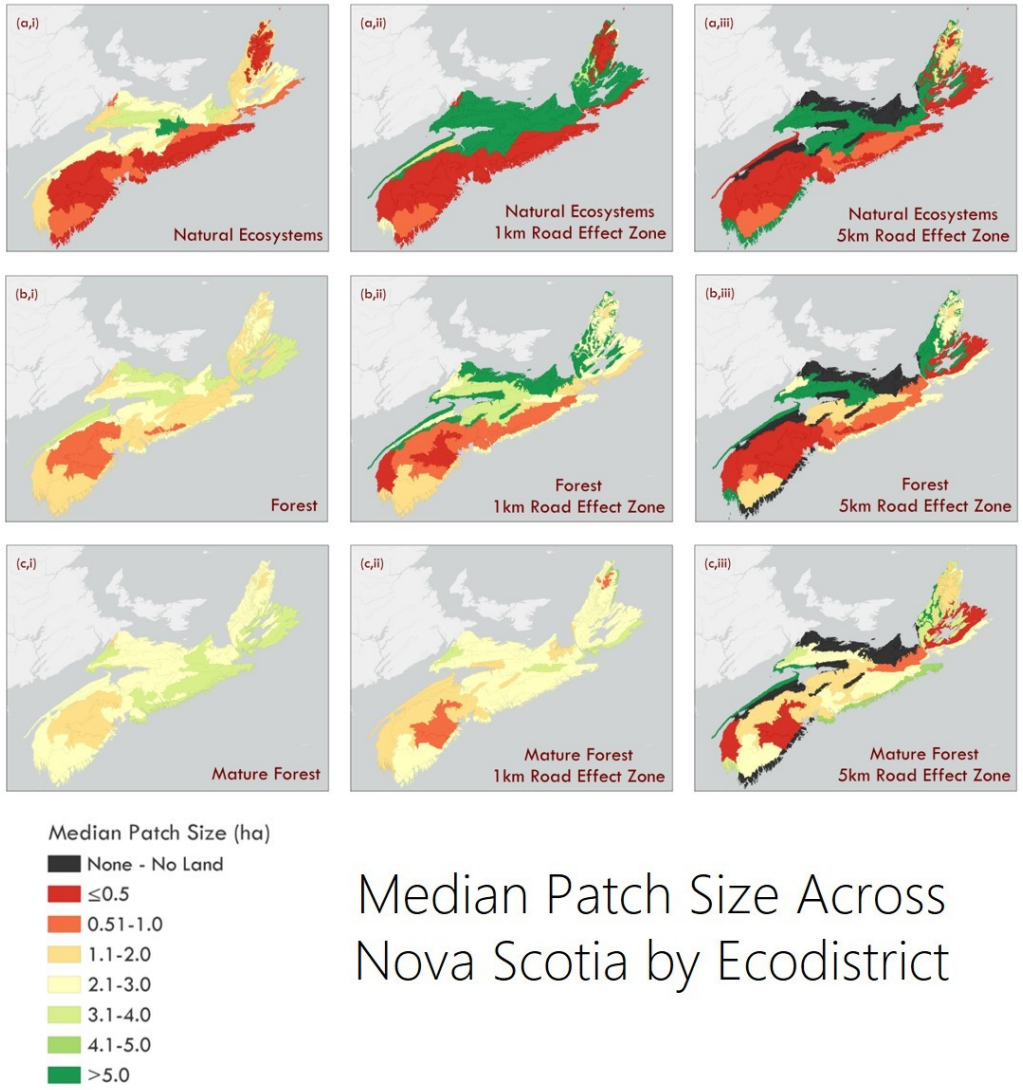

Figure A2.4. Median patch size by ecodistrict across Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.

APPENDIX III: EDGE DENSITY

Table A3.1. Edge density (ED) (m/ha) for full study area for each forest classification.

	ED Natural Ecosystem, No REZ	ED Natural Ecosystem, 1km REZ	ED Natural Ecosystem, 5km REZ	ED Forest, No REZ	ED Forest, 1km REZ	ED Forest, 5km REZ	ED Mature Forest, No REZ	ED Mature Forest, 1km REZ	ED Mature Forest, 5km REZ	ED Natural: Historical Baseline	Percentage Change – Baseline to Today
Total Area	20.85	13.96	11.98	33.74	33.17	34.47	47.30	45.36	42.67	0.001	2601566%

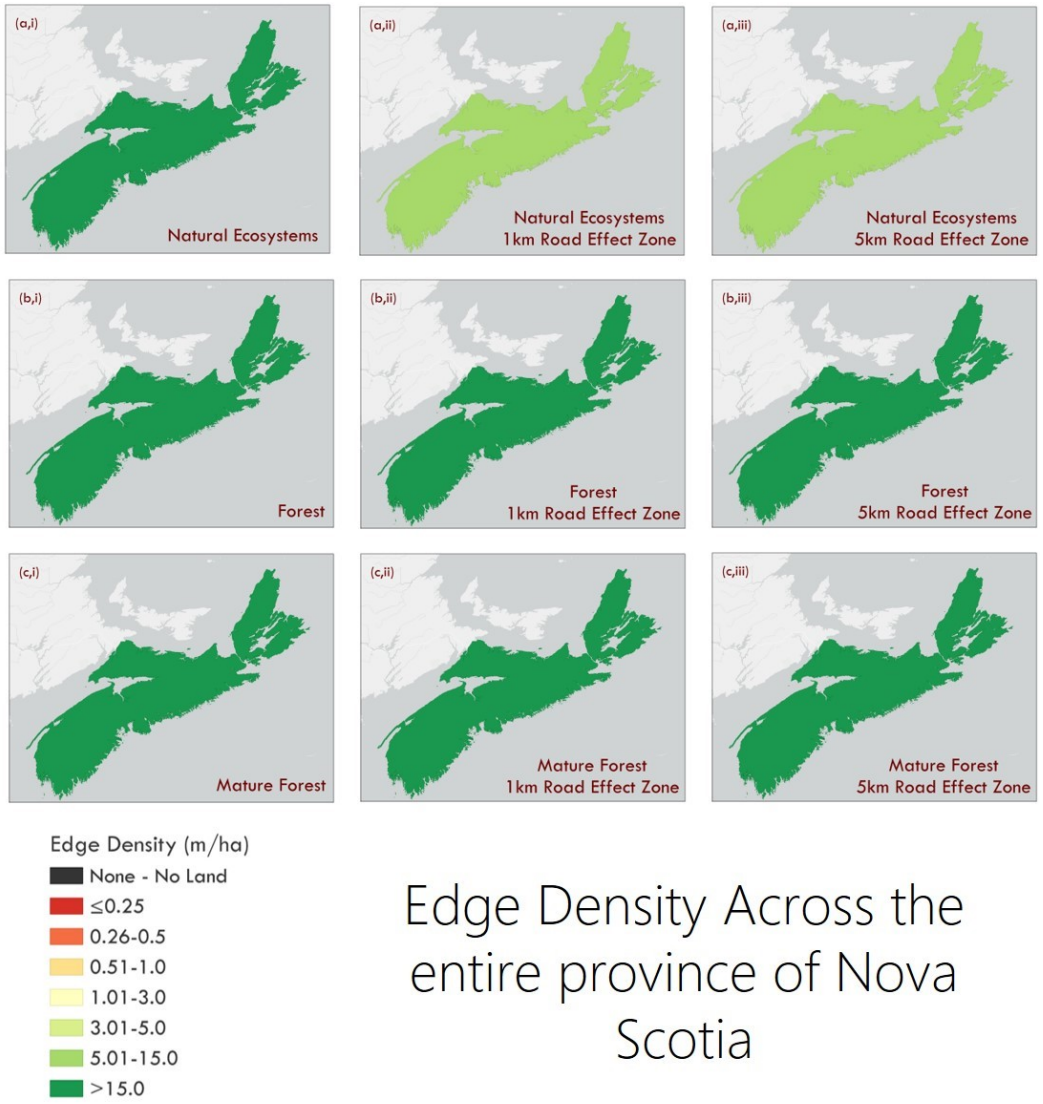

Figure A3.1. Edge Density across the entire province of Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.
Table A3.2. Edge Density (ED) (m/ha) by landmass for each forest classification.

Landmass	ED Natural Ecosystem, No REZ	ED Natural Ecosystem, 1km REZ	ED Natural Ecosystem, 5km REZ	ED Forest, No REZ	ED Forest, 1km REZ	ED Forest, 5km REZ	ED Mature Forest, No REZ	ED Mature Forest, 1km REZ	ED Mature Forest, 5km REZ	ED Natural: Historical Baseline	Percentage Change – Baseline to Today
Cape Breton	3.63	2.17	1.77	6.55	6.26	6.53	8.05	6.65	3.38	0.001	543450%
Mainland	17.21	11.78	10.14	27.19	26.90	27.92	39.26	38.72	39.35	0.001	2012460%

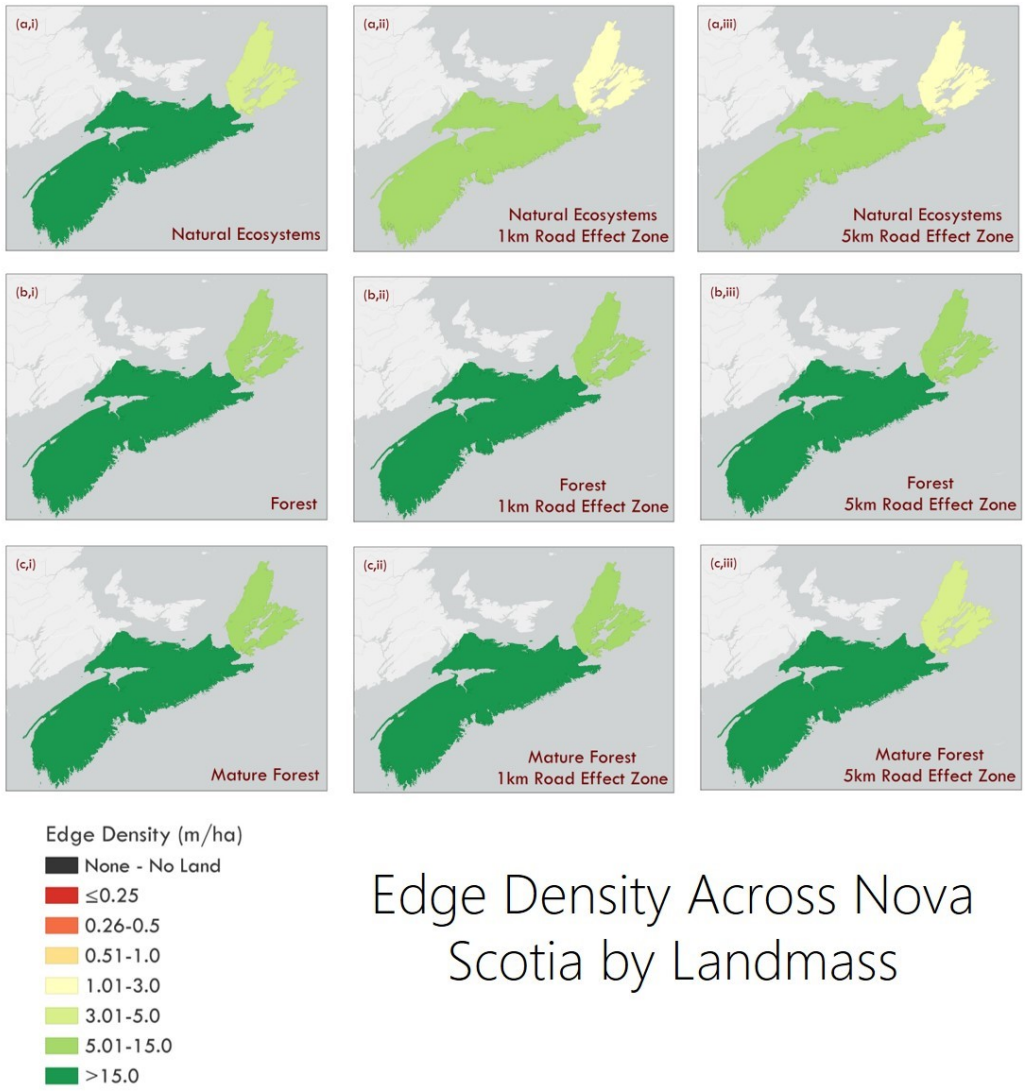

Figure A3.2. Edge density by landmass across Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.
Table A3.3. Edge Denisty (ED) (m/ha) by ecoregion for each forest classification.

Ecoregion	ED Natural Ecosystem, No REZ	ED Natural Ecosystem, 1km REZ	ED Natural Ecosystem, 5km REZ	ED Forest, No REZ	ED Forest, 1km REZ	ED Forest, 5km REZ	ED Mature Forest, No REZ	ED Mature Forest, 1km REZ	ED Mature Forest, 5km REZ	ED Natural: Historical Baseline	Percentage Change – Baseline to Today
100: Northern Plateau	0.12	0.24	0.76	0.36	0.72	1.92	0.03	0.06	0.07	0.002	7930%
200: Cape Breton Highlands	0.80	1.22	2.17	1.67	2.82	4.90	1.12	1.79	2.09	0.002	44960%
300: Nova Scotia Uplands	3.75	3.18	1.84	5.30	5.54	2.14	9.24	8.80	2.16	0.001	486888%
400: Eastern	2.21	2.62	2.30	4.36	6.26	4.96	5.58	7.34	5.35	0.001	179970%
500: Northumberland/ Bras D'Or	4.66	1.55	0.16	6.18	3.10	0.48	7.84	4.26	0.72	0.001	479006%
600: Valley and Central Lowlands	2.33	0.60	0.12	2.63	1.01	0.27	3.47	1.96	0.69	0.001	251366%
700: Western	5.49	4.74	6.96	9.79	11.63	21.47	16.33	19.02	32.00	0.001	616649%
800: Atlantic Coastal	2.91	1.87	0.50	4.90	3.96	0.58	3.49	2.48	0.15	0.002	137012%
900: Fundy Shore	0.68	0.32	0.06	0.76	0.37	0.09	1.39	0.72	0.09	0.001	87787%

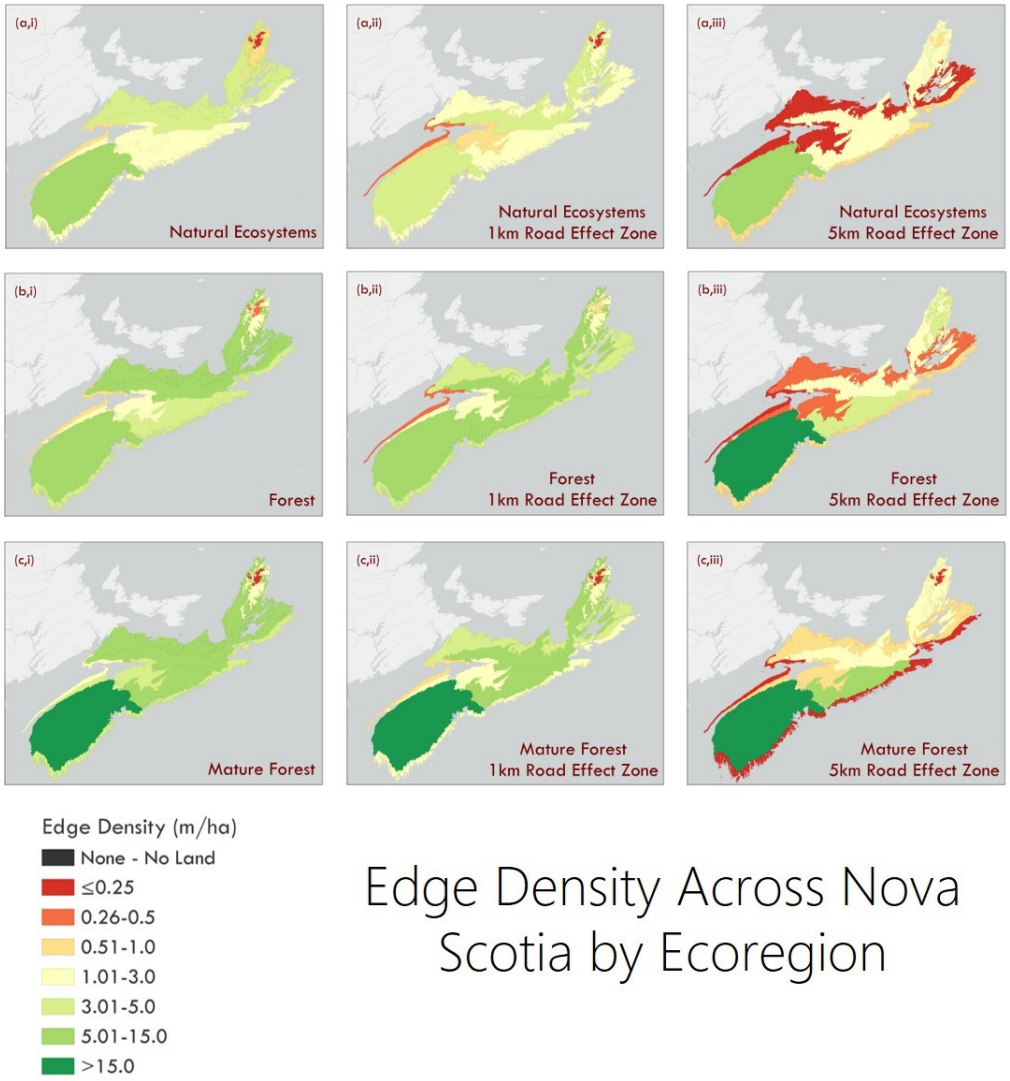

Figure A3.3. Edge density by ecoregion across Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.

Table A3.4. Edge density (ED) (m/ha) by ecodistrict for each forest classification.

Ecodistict	ED Natural Ecosystem, No REZ	ED Natural Ecosystem, 1km REZ	ED Natural Ecosystem, 5km REZ	ED Forest, No REZ	ED Forest, 1km REZ	ED Forest, 5km REZ	ED Mature Forest, No REZ	ED Mature Forest, 1km REZ	ED Mature Forest, 5km REZ	ED Natural: Historical Baseline	Percentage Change – Baseline to Today
100: Northern Plateau	0.12	0.24	0.76	0.36	0.72	1.92	0.03	0.06	0.07	0.002	7927%
210: Cape Breton Highlands	0.61	1.16	2.16	1.46	2.75	4.90	0.91	1.73	2.08	0.002	37443%
220: Victoria Lowttlands	0.19	0.06	0.00	0.21	0.07	0.00	0.19	0.07	0.00	0.003	5581%
310: Cape Breton Hills	1.42	1.66	1.59	1.76	2.17	1.75	3.33	3.46	1.77	0.001	105428%
320: Inverness Lowlands	0.49	0.06	0.03	0.52	0.07	0.02	0.50	0.07	0.02	0.003	17992%
330: Pictou Antigonish Highlands	0.39	0.28	0.00	0.57	0.50	0.00	1.11	0.83	0.00	0.000	109699%
340: Cobequid Hills	0.50	0.40	0.07	0.66	0.68	0.12	1.44	1.48	0.14	0.000	100414%
350: Cobequid Slopes	0.16	0.09	0.00	0.17	0.11	0.00	0.35	0.25	0.00	0.001	16597%
360: Mulgrave Plateau	0.40	0.28	0.02	0.64	0.66	0.03	0.99	1.06	0.03	0.001	52634%
370: St. Mary's River	0.28	0.22	0.02	0.60	0.72	0.02	0.49	0.53	0.01	0.001	28498%
380: Central Uplands	0.42	0.32	0.18	0.67	0.75	0.25	1.06	1.16	0.22	0.001	58663%
410: Rawdon/ Wittenburg Hills	0.26	0.15	0.00	0.29	0.18	0.00	0.59	0.36	0.00	0.003	10453%
430: Eastern Granite Uplands	0.28	0.53	0.66	0.51	0.98	1.02	0.69	1.28	1.27	0.001	20977%
440: Eastern Interior	1.64	1.86	1.45	3.32	4.63	3.22	3.76	4.94	3.36	0.001	135217%
450: Governor Lake	0.18	0.29	0.42	0.37	0.67	0.93	0.52	0.84	0.81	0.001	13533%
510: Bras d'Or Lowlands	1.71	0.60	0.01	2.47	1.30	0.01	2.86	1.44	0.01	0.001	137973%

520: St. George's Bay	0.76	0.14	0.00	0.78	0.14	0.00	0.82	0.18	0.00	0.001	84401%
530: Northumberland Lowlands	1.69	0.42	0.00	2.10	0.70	0.00	2.61	1.02	0.00	0.001	184535%
540: Cumberland Hills	0.38	0.24	0.00	0.46	0.34	0.00	0.79	0.65	0.00	0.003	14480%
550: Cumberland Marshes	0.12	0.08	0.00	0.09	0.06	0.00	0.08	0.05	0.00	0.001	17173%
560: Chignecto Ridges	0.16	0.17	0.15	0.42	0.65	0.47	0.65	0.98	0.71	0.001	12978%
610: Annapolis Valley	0.84	0.06	0.00	0.81	0.05	0.00	0.81	0.07	0.00	0.002	53851%
620: Minas Lowlands	0.33	0.05	0.00	0.31	0.05	0.00	0.26	0.05	0.00	0.001	56261%
630: Central Lowlands	1.17	0.50	0.12	1.53	0.91	0.27	2.35	1.83	0.69	0.001	144788%
710: Valley Slope	0.61	0.19	0.00	0.65	0.21	0.00	0.99	0.37	0.00	0.001	64062%
720: South Mountain	1.07	1.68	3.03	2.14	3.54	6.38	4.27	6.85	11.50	0.001	104762%
730: Clare	0.95	0.43	0.10	1.22	0.63	0.11	2.09	1.17	0.11	0.001	82908%
740: LaHave Drumlins	1.57	0.78	0.34	1.91	1.05	0.46	3.00	1.57	0.56	0.001	126014%
750: Rossignol	0.40	0.54	1.19	0.65	0.93	1.90	0.99	1.40	2.60	0.001	32007%
760: Sable	0.65	0.94	2.05	2.06	3.50	8.60	2.64	4.50	10.48	0.001	81079%
770: Western Barrens	0.14	0.28	1.08	0.58	1.17	4.16	0.76	1.57	5.78	0.001	15139%
780: St. Margaret's Bay	0.73	0.71	0.74	1.14	1.29	1.14	1.74	2.06	1.95	0.001	54737%
810: Cape Breton Coastal	0.58	0.41	0.19	1.16	1.01	0.28	0.75	0.70	0.03	0.002	34602%
820: Eastern Shore	1.01	0.95	0.25	1.80	1.86	0.26	0.89	0.79	0.08	0.003	40006%
830: South Shore	0.90	0.40	0.00	1.46	0.97	0.00	1.33	0.87	0.00	0.002	47435%

840: Tusket Islands	0.42	0.12	0.06	0.48	0.13	0.04	0.47	0.12	0.04	0.003	15613%
910: Parrsboro Shore	0.19	0.12	0.04	0.21	0.15	0.07	0.38	0.27	0.09	0.001	17702%
920: North Mountain	0.50	0.20	0.02	0.55	0.22	0.02	1.00	0.46	0.00	0.001	75423%

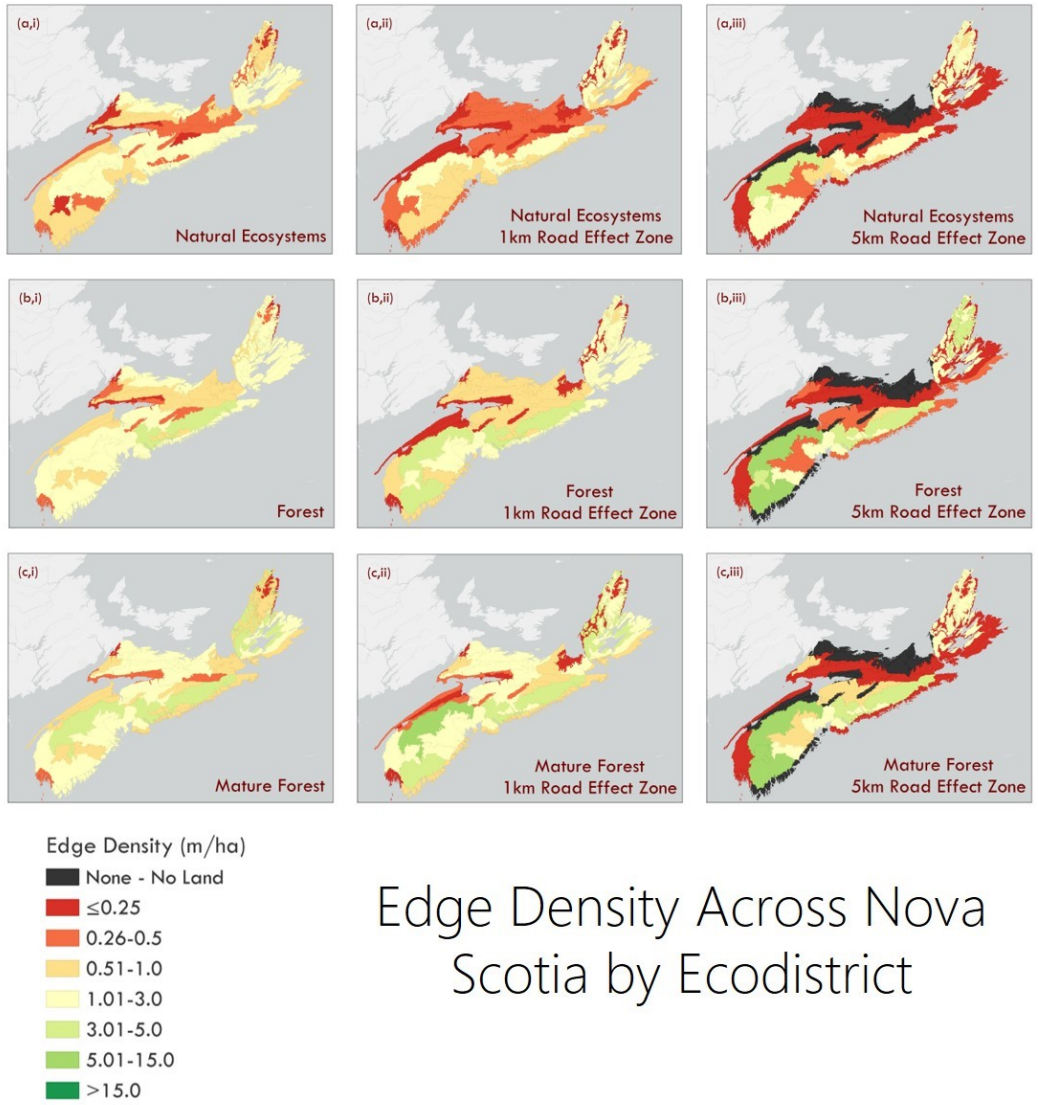

Figure A3.4. Edge density by ecodistrict across Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.

APPENDIX IV: MEAN PERIMETER-AREA RATIO

Table A4.1. Mean perimeter-area ratio (MPAR) for full study area for each forest classification.

	MPAR Natural Ecosystem, No REZ	MPAR Natural Ecosystem, 1km REZ	MPAR Natural Ecosystem, 5km REZ	MPAR Forest, No REZ	MPAR Forest, 1km REZ	MPAR Forest, 5km REZ	MPAR Mature Forest, No REZ	MPAR Mature Forest, 1km REZ	MPAR Mature Forest, 5km REZ	MPAR Natural: Historical Baseline	Percentage Change – Baseline to Today
Total Area	2510.24	2666.16	2543.62	443.09	3069.64	1387.58	420.38	5935.81	4376.68	0.26	960463%

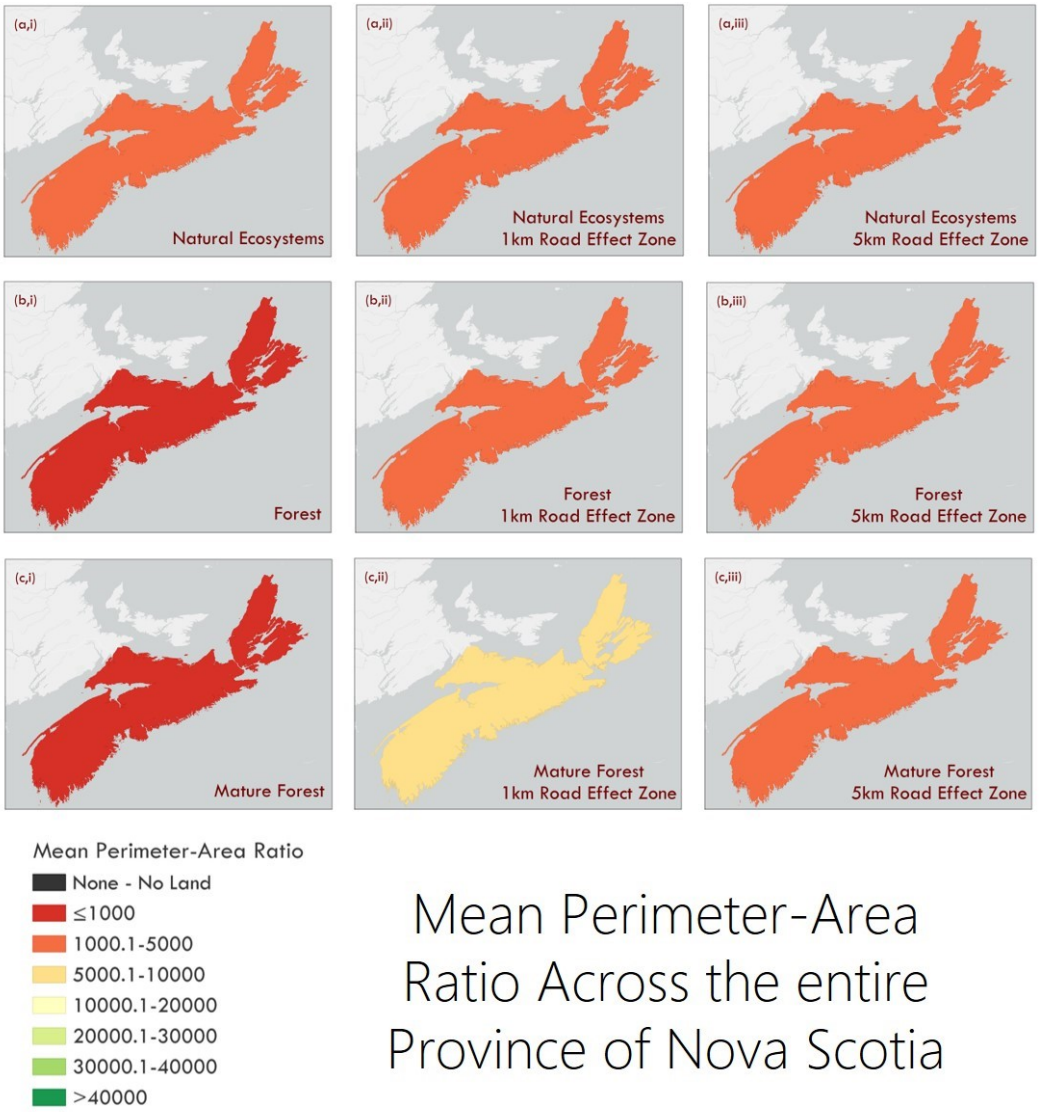

Figure A4.1. Mean perimeter-area ratio across the entire province of Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.

Table A4.2 Mean perimeter-area ratio (MPAR) by landmass for each forest classification.

Landmass	MPAR Natural Ecosystem, No REZ	MPAR Natural Ecosystem, 1km REZ	MPAR Natural Ecosystem, 5km REZ	MPAR Forest, No REZ	MPAR Forest, 1km REZ	MPAR Forest, 5km REZ	MPAR Mature Forest, No REZ	MPAR Mature Forest, 1km REZ	MPAR Mature Forest, 5km REZ	MPAR Natural: Historical Baseline	Percentage Change – Baseline to Today
Cape Breton	881.399	2500.52	1127.18	398.664	3291.47	923.942	344.588	2069.73	778.033	0.11	827645%
Mainland	2794.01	2644.85	2426.59	451.937	3029.77	1495.53	434.884	1952.71	1228.29	0.71	393941%

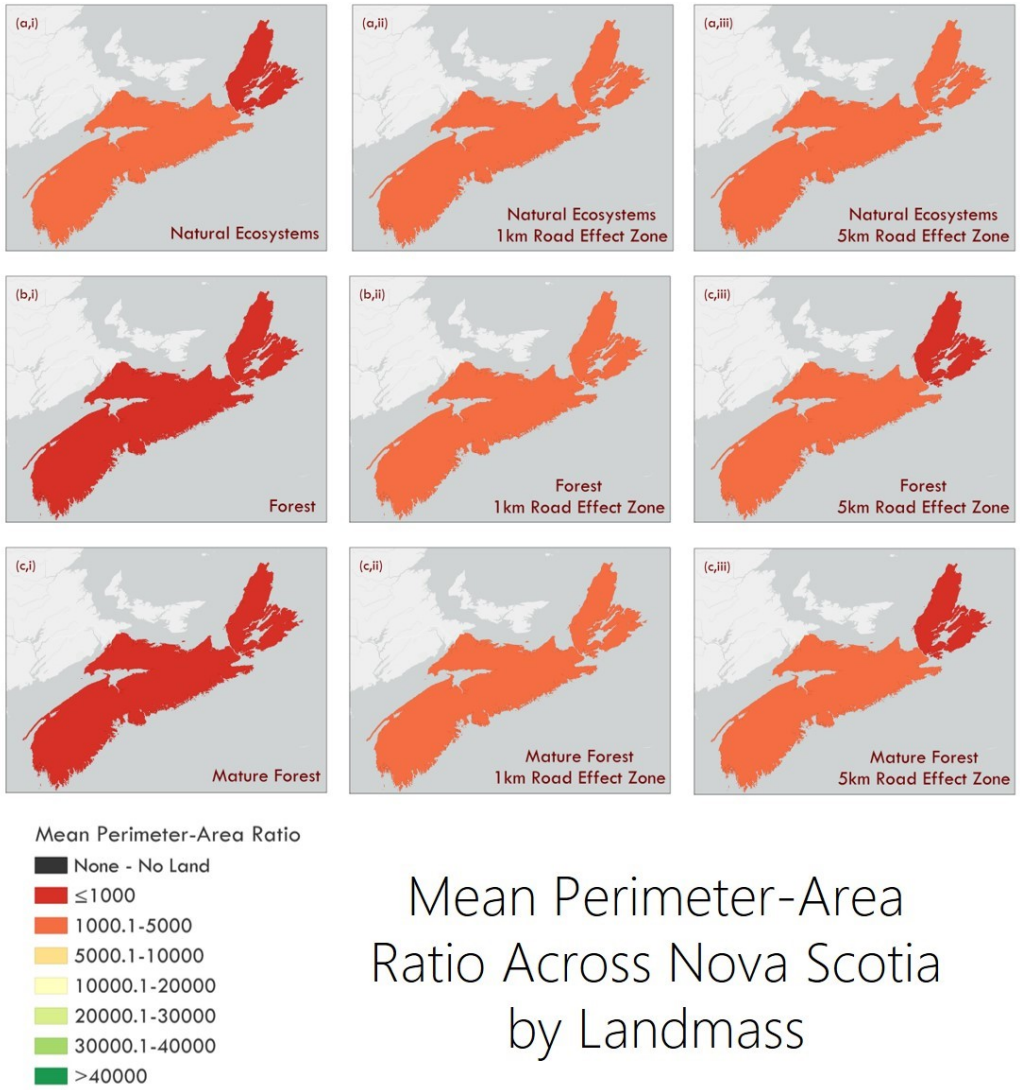

Figure A4.2. Mean perimeter-area ratio by landmass across Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.
Table A4.3. Mean perimeter-area ratio (MPAR) by ecoregion for each forest classification.

Ecoregion	MPAR Natural Ecosystem, No REZ	MPAR Natural Ecosystem, 1km REZ	MPAR Natural Ecosystem, 5km REZ	MPAR Forest, No REZ	MPAR Forest, 1km REZ	MPAR Forest, 5km REZ	MPAR Mature Forest, No REZ	MPAR Mature Forest, 1km REZ	MPAR Mature Forest, 5km REZ	MPAR Natural: Historical Baseline	Percentage Change – Baseline to Today
100: Northern Plateau	17656.8	16715.0	8847.0	3839.1	3942.8	1333.2	4819.6	5619.7	1363.4	2.09	846692%
200: Cape Breton Highlands	128677.0	160237.0	4987.8	66596.7	60279.8	2257.0	13954.5	7842.9	3195.6	1609.33	7896%
300: Nova Scotia Uplands	105290.0	5278.0	1344.9	56359.2	8266.2	2436.1	8957.1	2787.3	9331.7	8227.40	1180%
400: Eastern	156449.0	123407.0	8455.1	77783.8	50601.8	5791.3	7634.9	4676.1	1233.1	11032.80	1318%
500: Northumberland/ Bras D'Or	152403.0	139599.0	1716.9	30592.3	54944.0	802.1	9719.5	15300.5	980.3	16553.00	821%
600: Valley and Central Lowlands	169206.0	249550.0	2860860	54047.4	51662.9	1192490	8792.5	11820.9	107420.0	3686.26	4490%
700: Western	50171.3	9311.7	740.1	15675.6	5199.3	654.5	5456.3	2845.1	536.2	5687.75	782%
800: Atlantic Coastal	335825.0	394926.0	924226.0	45918.3	50287.2	658.0	18946.2	23289.3	538.0	32218.4	942%
900: Fundy Shore	592559.0	1319.9	976.7	26428.1	1081.5	153.5	14746.1	1957.3	185.1	30.42	1948031%

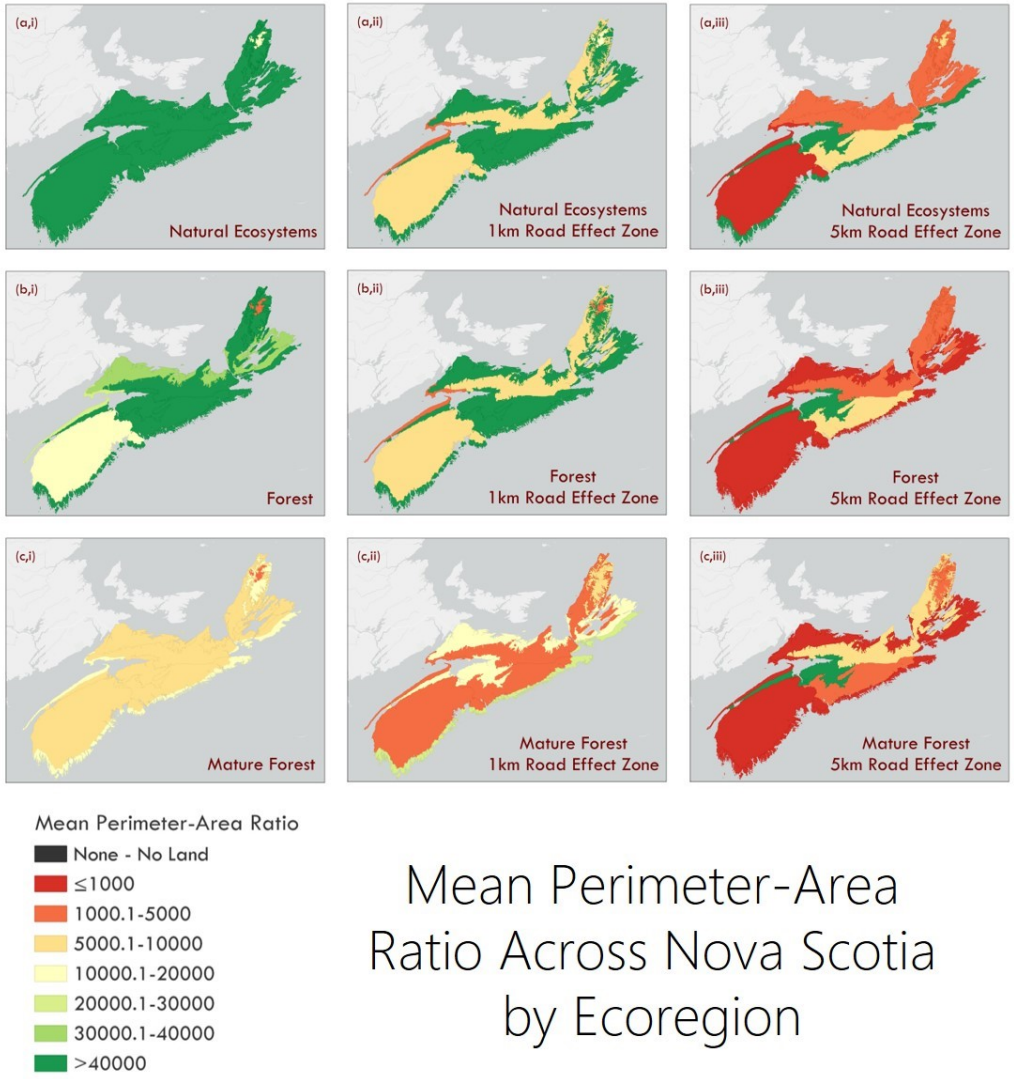

Figure A4.3. Mean perimeter-area ratio by ecoregion across Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.

Table A4.4. Mean perimeter-area ratio (MPAR) by ecodistrict for each forest classification.

Ecodistict	MPAR Natural Ecosystem, No REZ	MPAR Natural Ecosystem, 1km REZ	MPAR Natural Ecosystem, 5km REZ	MPAR Forest, No REZ	MPAR Forest, 1km REZ	MPAR Forest, 5km REZ	MPAR Mature Forest, No REZ	MPAR Mature Forest, 1km REZ	MPAR Mature Forest, 5km REZ	MPAR Natural: Historical Baseline	Percentage Change – Baseline to Today
100: Northern Plateau	17643.2	16702.1	8837.1	3834.8	3938.5	1331.7	4814.4	5613.6	1361.9	2.08	846442%
210: Cape Breton Highlands	223993.0	217038.0	5077.2	64130.4	65400.8	2264.1	8326.2	7981.8	3201.0	52.74	424594%
220: Victoria Lowttlands	69829.8	2982.7	377.0	71270.8	2879.5	377.0	49434.4	2095.1	377.0	17.39	401544%
310: Cape Breton Hills	91610.5	17332.6	1769.8	8511.8	18068.4	3037.6	4135.9	6379.5	3241.9	215.27	42456%
320: Inverness Lowlands	76215.6	891.6	832.0	60103.6	9366.9	118.3	33619.4	1369.3	174.5	52.60	144793%
330: Pictou Antigonish Highlands	133948.0	349.9	0.0	9969.7	13837.5	0.0	689.4	1629.7	0.0	258.48	51721%
340: Cobequid Hills	21252.7	95038.8	168.1	20311.3	74962.5	262.2	3334.5	6384.8	716.7	37.91	55961%
350: Cobequid Slopes	77049.6	150.0	0.0	69120.7	271.3	0.0	22521.7	18536.0	0.0	43.58	176698%
360: Mulgrave Plateau	288849.0	1338.5	204.2	362627.0	1681.0	1530.9	32281.2	2357.2	1200.7	134.12	215269%
370: St. Mary's River	361684.0	50694.1	241.8	485431.0	28408.9	405.7	106684.0	955.2	1044.8	82.80	436723%
380: Central Uplands	45469.4	573.6	237.1	49937.2	51307.6	374.1	5515.7	2114.3	27102.7	124.57	36401%
410: Rawdon/ Wittenburg Hills	126337.0	8706.1	0.0	116491.0	2235.7	0.0	4138.8	6105.7	0.0	13.38	944116%
430: Eastern Granite Uplands	225552.0	73769.9	118071.0	120410.0	53668.7	79822.0	39873.7	14916.4	36087.6	55.74	404572%
440: Eastern Interior	344127.0	482676.0	15499.1	213745.0	230409.0	5260.5	41623.0	46500.1	1629.4	41.89	821319%
450: Governor Lake	36996.9	50125.9	26324.7	24934.5	33280.4	12404.5	3996.1	5461.5	560.7	190.66	19305%
510: Bras d'Or Lowlands	235671.0	342834.0	3161.6	59880.4	78281.5	1946.3	19639.3	26714.1	1967.9	2.47	9522461%

520: St. George's Bay	20359.3	2187.6	0.0	17740.4	136163.0	0.0	7892.9	47941.7	0.0	17.84	114010%
530: Northumberland Lowlands	176335.0	3468.4	0.0	14264.8	3656.2	0.0	4990.6	1899.6	0.0	163.60	107687%
540: Cumberland Hills	135518.0	14513.2	0.0	98700.2	11430.7	0.0	31949.1	3361.9	0.0	93.50	144846%
550: Cumberland Marshes	402120.0	150813.0	0.0	132115.0	105463.0	0.0	89304.2	78767.5	0.0	8.15	4933670%
560: Chignecto Ridges	44053.3	1187.7	268.5	204525.0	1042.9	572.6	4430.7	1386.5	948.6	3.01	1463567%
610: Annapolis Valley	122326.0	68187.7	0.0	1637.5	2046.8	0.0	1678.6	4082.3	0.0	85.10	143648%
620: Minas Lowlands	222242.0	282254.0	0.0	75953.5	34147.1	0.0	41334.4	8110.6	0.0	166.07	133727%
630: Central Lowlands	189056.0	307238.0	2856030.0	97259.9	62927.4	1190470.0	5922.7	12490.1	107241.0	159.51	118426%
710: Valley Slope	22263.8	14963.8	0.0	28065.8	14862.4	0.0	15556.0	14751.4	0.0	20.70	107461%
720: South Mountain	563965.0	583490.0	973095.0	338697.0	311640.0	606361.0	121500.0	110144.0	293735.0	42.66	1322027%
730: Clare	292948.0	419170.0	1387790.0	226242.0	268524.0	1087080.0	79167.3	86046.6	934972.0	61.27	478019%
740: LaHave Drumlins	428730.0	572836.0	677524.0	314773.0	385807.0	289213.0	153219.0	201909.0	177867.0	63.01	680329%
750: Rossignol	283405.0	404906.0	527368.0	191374.0	261795.0	383737.0	121654.0	167793.0	316819.0	30.01	944281%
760: Sable	123192.0	125969.0	149687.0	54845.3	37355.7	29269.1	19616.8	10811.3	7030.4	16.70	737793%
770: Western Barrens	125313.0	144926.0	166154.0	47637.3	55652.1	93337.8	21134.8	23226.1	33982.6	8.50	1474044%
780: St. Margaret's Bay	227679.0	36356.0	795.4	72632.9	15624.1	712.0	25343.9	7783.2	615.6	8.71	2614361%
810: Cape Breton Coastal	45689.8	3593.6	8410.9	707.2	2647.1	509.8	590.7	1094.8	674.0	21.41	213281%
820: Eastern Shore	588225.0	579009.0	1388330.0	35119.4	54652.6	775.7	24864.8	56290.7	587.1	16.38	3590119%
830: South Shore	121127.0	136314.0	538.1	83440.9	79056.6	0.0	28650.0	14910.5	0.0	17.35	698050%

840: Tusket Islands	64317.3	790.9	174.4	27315.1	11313.2	170.9	19429.4	11459.0	279.9	3.28	1963523%
910: Parrsboro Shore	1149500.0	451.7	15.1	62840.6	805.0	207.9	39658.9	903.4	188.0	54.04	2127075%
920: North Mountain	22080.0	1712.0	1136.5	832.9	1272.2	99.1	571.2	2877.2	155.7	0.43	5091270%

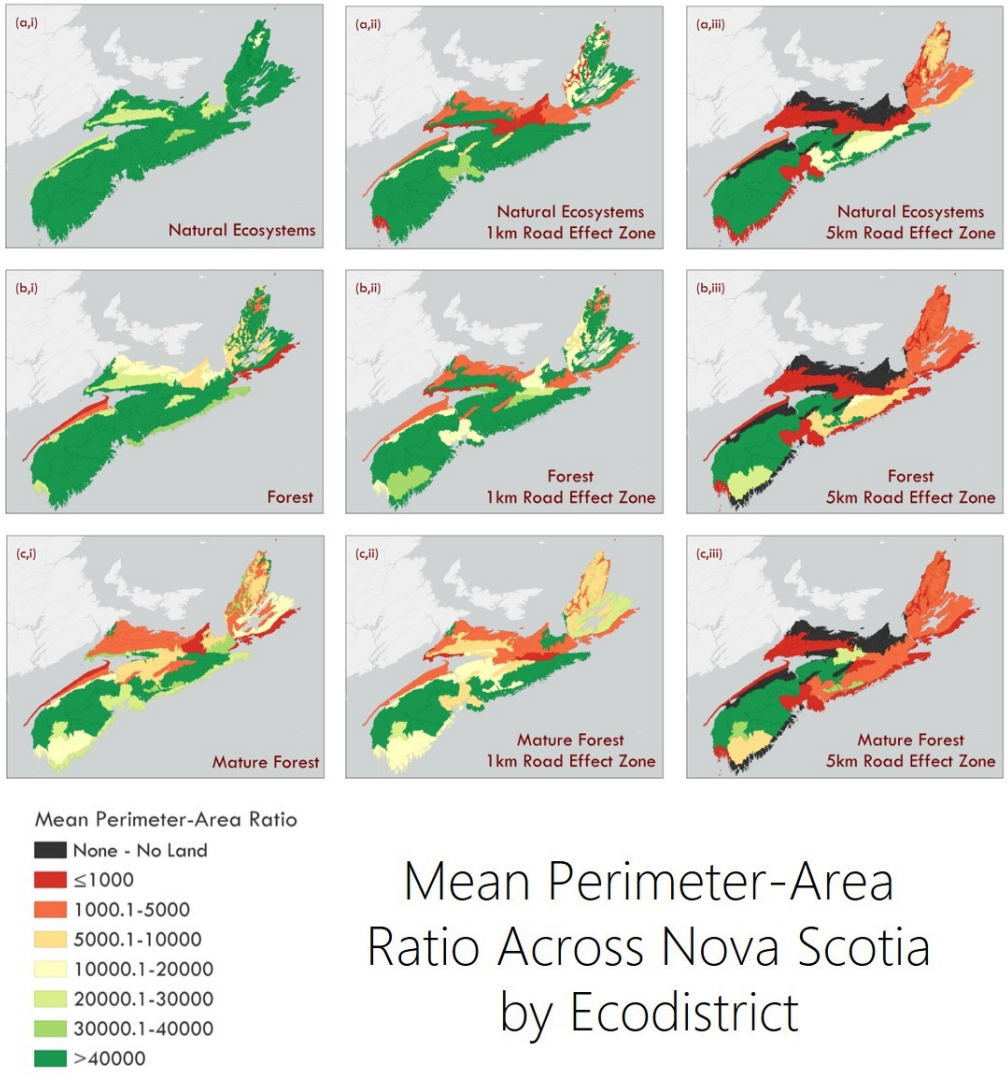

Figure A4.4. Mean perimeter-area ratio by ecodistrict across Nova Scotia occupied by the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) with the different road effect zones: 0km (i), 1km (ii), 5km (iii) applied.

APPENDIX V: EFFECTIVE MESH SIZE RESULTS

Table A5.1. Effective mesh size for full study area for each forest classification. Mesh size values in square kilometers

	Mesh Size: Natural Ecosystems	Mesh Size: Natural Ecosystems, 1km REZ	Mesh Size: Natural Ecosystems, 5km REZ	Mesh Size: Forest	Mesh Size: Forest, 1km REZ	Mesh Size: Forest, 5km REZ	Mesh Size: Mature Forest	Mesh Size: Mature Forest, 1km REZ	Mesh Size: Mature Forest, 5km REZ	Mesh Size: Historical Baseline	Mesh Size: Percentage Change – Baseline to Today
Total Area	435.40	256.49	74.21	208.58	112.48	27.73	20.43	12.44	4.49	49592.34	-99.1%

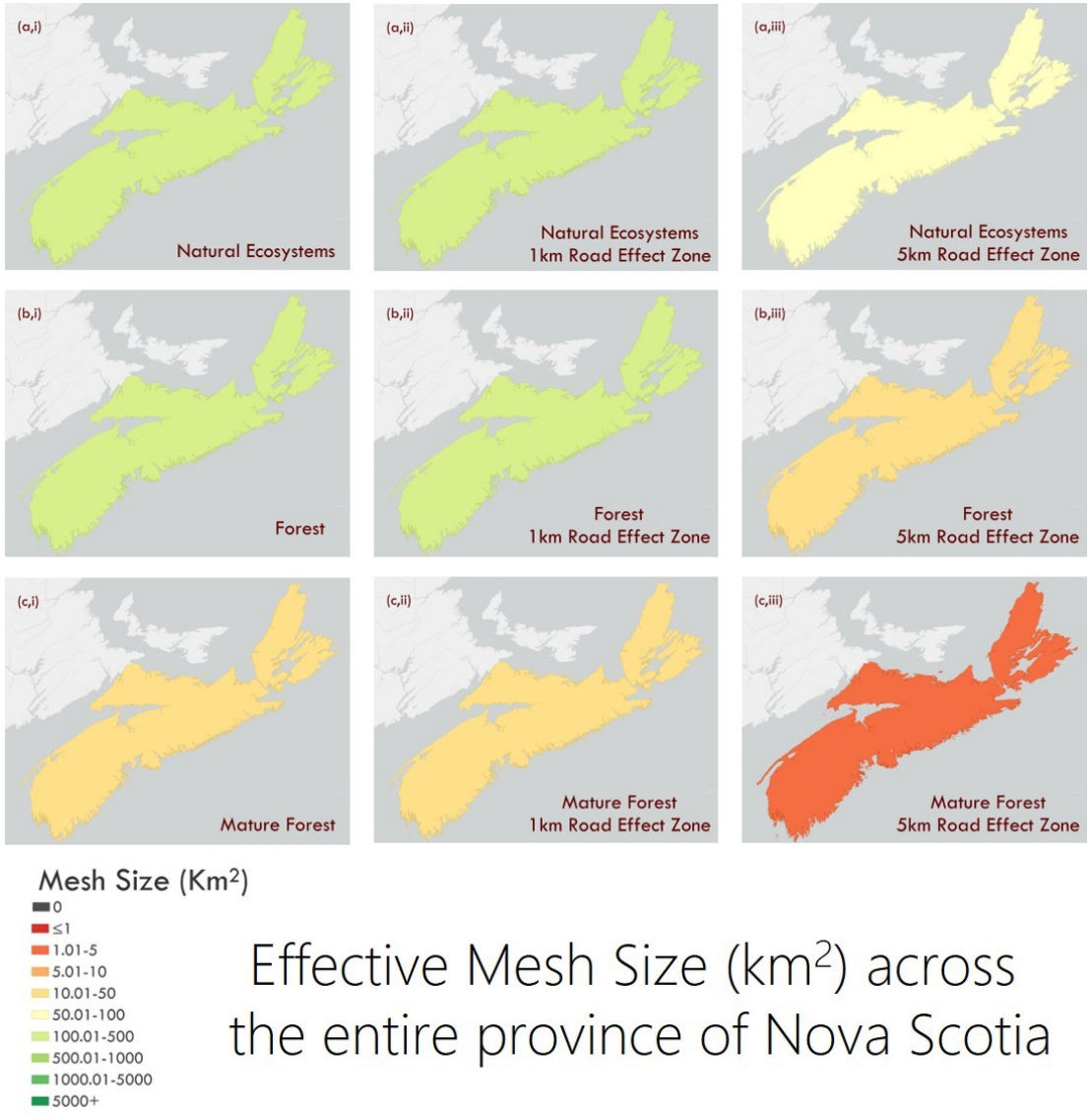

Figure A5.1. Effective Mesh Size across the entire province of Nova Scotia based on the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) and the different road effect zones: 0km (i), 1km (ii), 5km (iii).

Table A5.2. Effective mesh size by landmass for each forest classification. Mesh size values in square kilometers

Landmass	Mesh Size: Natural Ecosystems	Mesh Size: Natural Ecosystems, 1km REZ	Mesh Size: Natural Ecosystems, 5km REZ	Mesh Size: Forest	Mesh Size: Forest, 1km REZ	Mesh Size: Forest, 5km REZ	Mesh Size: Mature Forest	Mesh Size: Mature Forest, 1km REZ	Mesh Size: Mature Forest, 5km REZ	Mesh Size: Historical Baseline	Mesh Size: Percentage Change – Baseline to Today
Cape Breton	351.99	196.17	23.04	172.40	82.09	4.33	16.67	6.62	0.06	9443.31	-96.3%
Mainland	454.39	270.17	85.69	216.83	119.35	32.98	21.29	13.76	5.48	40153.25	-98.9%

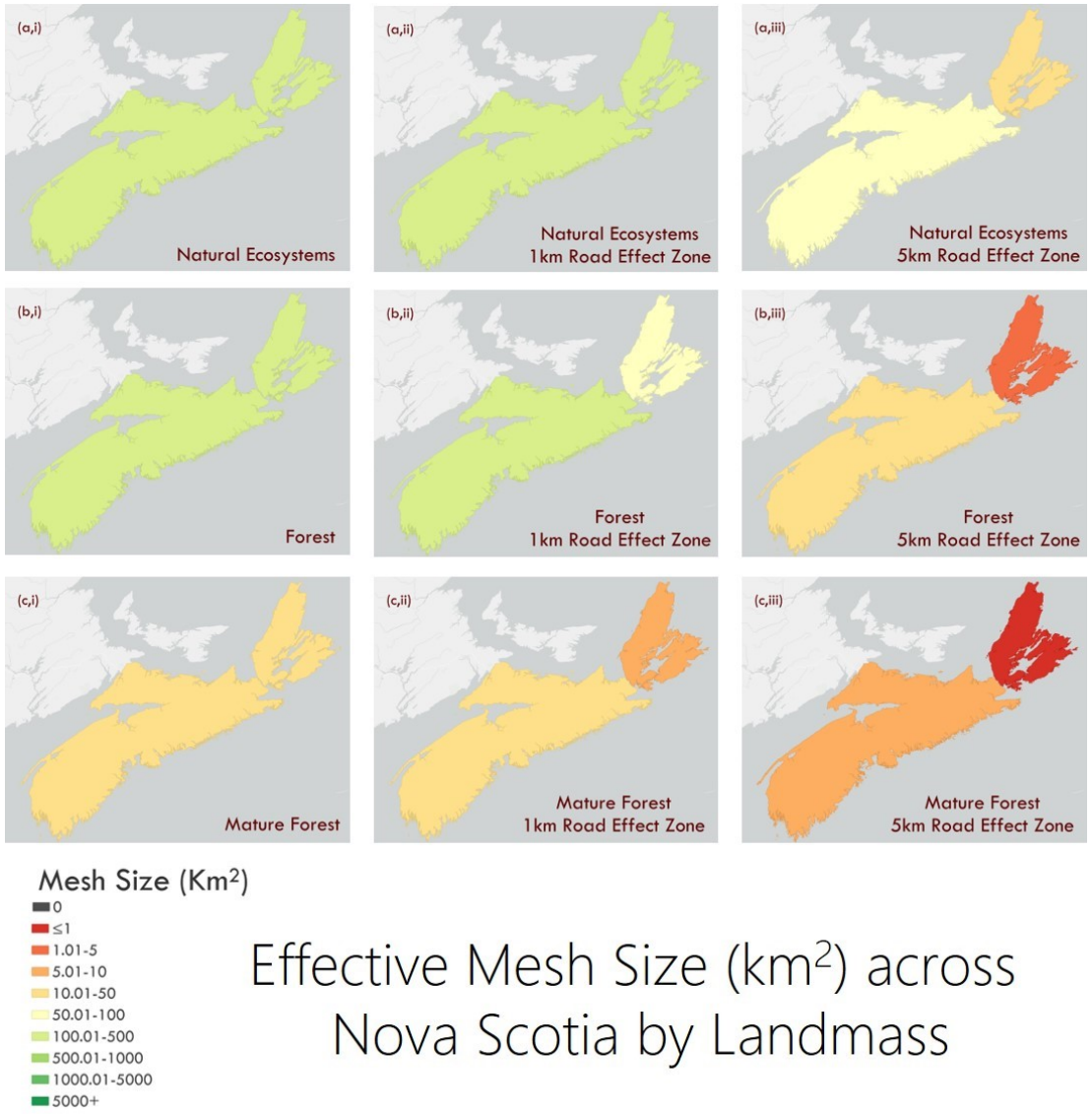

Figure A5.2. Effective Mesh Size by landmass in Nova Scotia based on the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) and the different road effect zones: 0km (i), 1km (ii), 5km

Table A5.3. Effective mesh size by ecoregion for each forest classification. Mesh size values in square kilometers

Ecoregion	Mesh Size: Natural Ecosystems	Mesh Size: Natural Ecosystems, 1km REZ	Mesh Size: Natural Ecosystems, 5km REZ	Mesh Size: Forest	Mesh Size: Forest, 1km REZ	Mesh Size: Forest, 5km REZ	Mesh Size: Mature Forest	Mesh Size: Mature Forest, 1km REZ	Mesh Size: Mature Forest, 5km REZ	Mesh Size: Historical Baseline	Mesh Size: Percentage Change – Baseline to Today
100: Northern Plateau	257.48	3188.88	545.01	1203.97	708.53	78.30	22.06	8.74	0.48	684.75	-62.4%
200: Cape Breton Highlands	217.00	306.42	9.56	456.96	238.82	6.69	62.42	27.43	0.21	1740.55	-87.5%
300: Nova Scotia Uplands	201.09	109.84	0.04	244.62	77.14	0.03	21.23	8.80	0.00	7916.51	-97.5%
400: Eastern	401.50	309.63	6.04	353.47	176.78	4.50	4.46	2.56	0.12	5337.05	-92.5%
500: Northumberland/ Bras D'Or	72.48	11.65	0.72	25.94	6.90	0.40	1.61	0.61	0.02	1008.37	-92.8%
600: Valley and Central Lowlands	90.29	83.51	0.76	113.71	28.51	0.66	19.72	1.18	0.02	2962.93	-97.0%
700: Western	758.82	523.41	238.28	263.11	196.73	90.32	39.68	31.13	15.23	13775.44	-94.5%
800: Atlantic Coastal	44.41	2.60	0.06	2.92	0.78	0.00	0.17	0.04	0.00	250.38	-82.3%
900: Fundy Shore	31.68	0.63	0.00	4.57	0.77	0.09	0.99	0.11	0.00	259.95	-87.8%

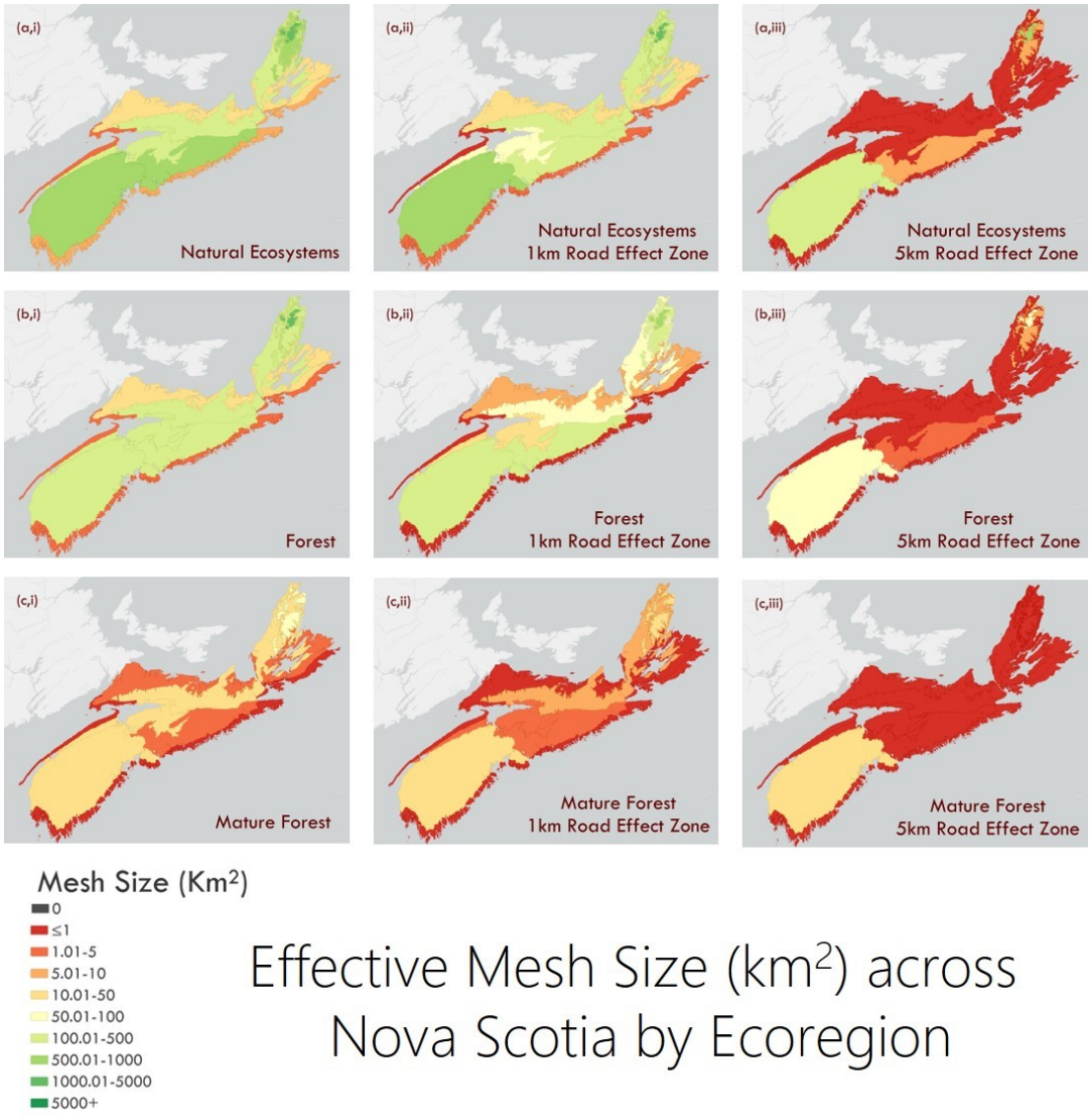

Figure A5.3. Effective Mesh Size by ecoregion in Nova Scotia based on the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) and the different road effect zones: 0km (i), 1km (ii), 5km

Table A5.4. Effective mesh size by ecodistrict for each forest classification. Mesh size values in square kilometers

Ecodistict	Mesh Size: Natural Ecosystems	Mesh Size: Natural Ecosystems, 1km REZ	Mesh Size: Natural Ecosystems, 5km REZ	Mesh Size: Forest	Mesh Size: Forest, 1km REZ	Mesh Size: Forest, 5km REZ	Mesh Size: Mature Forest	Mesh Size: Mature Forest, 1km REZ	Mesh Size: Mature Forest, 5km REZ	Mesh Size: Historical Baseline	Mesh Size: Percentage Change – Baseline to Today
100: Northern Plateau	257.48	3188.88	545.01	1203.97	708.53	78.30	22.07	8.75	0.48	684.75	-62.4%
210: Cape Breton Highlands	234.17	336.56	10.50	501.76	262.32	7.35	68.54	30.13	0.23	154.38	51.7%
220: Victoria Lowttlands	9.83	0.12	0.00	1.80	0.07	0.00	0.22	0.00	0.00	12.31	-20.2%
310: Cape Breton Hills	128.14	21.07	0.00	81.71	16.86	0.00	10.62	2.83	0.00	1885.89	-93.2%
320: Inverness Lowlands	3.87	0.00	0.00	0.45	0.00	0.00	0.03	0.00	0.00	7.54	-48.7%
330: Pictou Antigonish Highlands	155.15	27.11	0.00	131.46	15.95	0.00	8.43	2.24	0.00	1150.54	-86.5%
340: Cobequid Hills	328.51	407.66	0.06	873.29	299.02	0.05	93.41	42.32	0.01	1360.14	-75.8%
350: Cobequid Slopes	36.11	0.07	0.00	2.95	0.04	0.00	0.59	0.15	0.00	81.88	-55.9%
360: Mulgrave Plateau	92.27	37.70	0.00	142.66	28.93	0.00	6.07	3.31	0.00	1099.69	-91.6%
370: St. Mary's River	172.15	258.16	0.26	278.33	131.53	0.24	0.19	0.09	0.00	646.62	-73.4%
380: Central Uplands	177.81	51.31	0.05	139.29	45.80	0.04	0.30	0.15	0.00	1243.22	-85.7%
410: Rawdon/ Wittenburg Hills	53.99	859.39	0.00	896.21	125.95	0.00	14.97	5.64	0.00	361.78	-85.1%
430: Eastern Granite Uplands	102.63	1529.19	27.87	2207.76	1137.79	22.15	26.37	18.58	1.15	208.89	-50.9%
440: Eastern Interior	245.43	117.89	4.63	85.15	81.56	3.28	0.77	0.38	0.01	2126.52	-88.5%
450: Governor Lake	197.43	0.00	1.35	0.00	0.00	0.95	0.10	0.11	0.03	665.05	-70.3%
510: Bras d'Or Lowlands	33.19	22.09	0.00	33.93	10.21	0.00	0.54	0.13	0.00	890.36	-96.3%

520: St. George's Bay	6.55	0.14	0.00	3.04	0.14	0.00	0.07	0.01	0.00	207.34	-96.8%
530: Northumberland Lowlands	30.41	7.39	0.00	27.65	5.27	0.00	1.84	0.45	0.00	828.93	-96.3%
540: Cumberland Hills	58.56	15.98	0.00	42.11	15.02	0.00	6.13	3.25	0.00	609.72	-90.4%
550: Cumberland Marshes	16.80	1.37	0.00	9.07	1.24	0.00	2.26	1.14	0.00	98.31	-82.9%
560: Chignecto Ridges	266.05	0.00	8.14	1.34	0.39	4.49	0.87	0.40	0.20	360.98	-26.3%
610: Annapolis Valley	1.64	4.42	0.00	217.03	4.32	0.00	72.73	2.12	0.00	990.74	-99.8%
620: Minas Lowlands	2.69	610.24	0.00	547.37	0.78	0.00	0.69	0.00	0.00	319.09	-99.2%
630: Central Lowlands	132.46	26.51	1.14	8.91	41.25	1.00	4.55	1.05	0.03	1620.71	-91.8%
710: Valley Slope	13.02	8419.58	0.00	3429.89	2485.50	0.00	143.30	63.00	0.00	95.40	-86.3%
720: South Mountain	399.37	77.79	869.24	76.30	114.94	295.22	97.08	94.30	55.49	1115.69	-64.2%
730: Clare	68.40	421.13	22.76	224.99	113.74	8.01	10.25	1.80	0.00	1326.50	-94.8%
740: LaHave Drumlins	56.23	13.75	0.00	74.35	18.17	0.00	18.37	6.42	0.00	1634.53	-96.6%
750: Rossignol	73.11	88.68	3.11	268.34	242.59	129.95	13.05	8.27	0.91	288.69	-74.7%
760: Sable	659.57	17.39	5.45	20.25	9.90	3.85	4.74	2.91	1.00	2656.32	-75.2%
770: Western Barrens	381.33	0.00	0.00	0.03	0.02	0.00	0.09	0.09	0.09	432.74	-11.9%
780: St. Margaret's Bay	282.37	13.44	0.01	24.06	7.03	0.01	0.64	0.34	0.13	1381.12	-79.6%
810: Cape Breton Coastal	44.57	2.84	0.16	6.46	1.77	0.01	0.05	0.02	0.00	368.25	-87.9%
820: Eastern Shore	55.65	4.57	0.05	1.27	0.65	0.00	0.06	0.07	0.00	216.77	-74.3%
830: South Shore	42.01	0.76	0.00	2.22	0.35	0.00	0.42	0.05	0.00	88.34	-52.4%

840: Tusket Islands	7.99	0.09	0.00	2.12	0.02	0.00	0.21	0.01	0.00	252.41	-96.8%
910: Parrsboro Shore	43.51	0.04	0.00	3.37	0.71	0.28	0.28	0.05	0.01	373.75	-88.4%
920: North Mountain	26.40	0.90	0.00	5.11	0.79	0.00	1.31	0.14	0.00	236.63	-88.8%

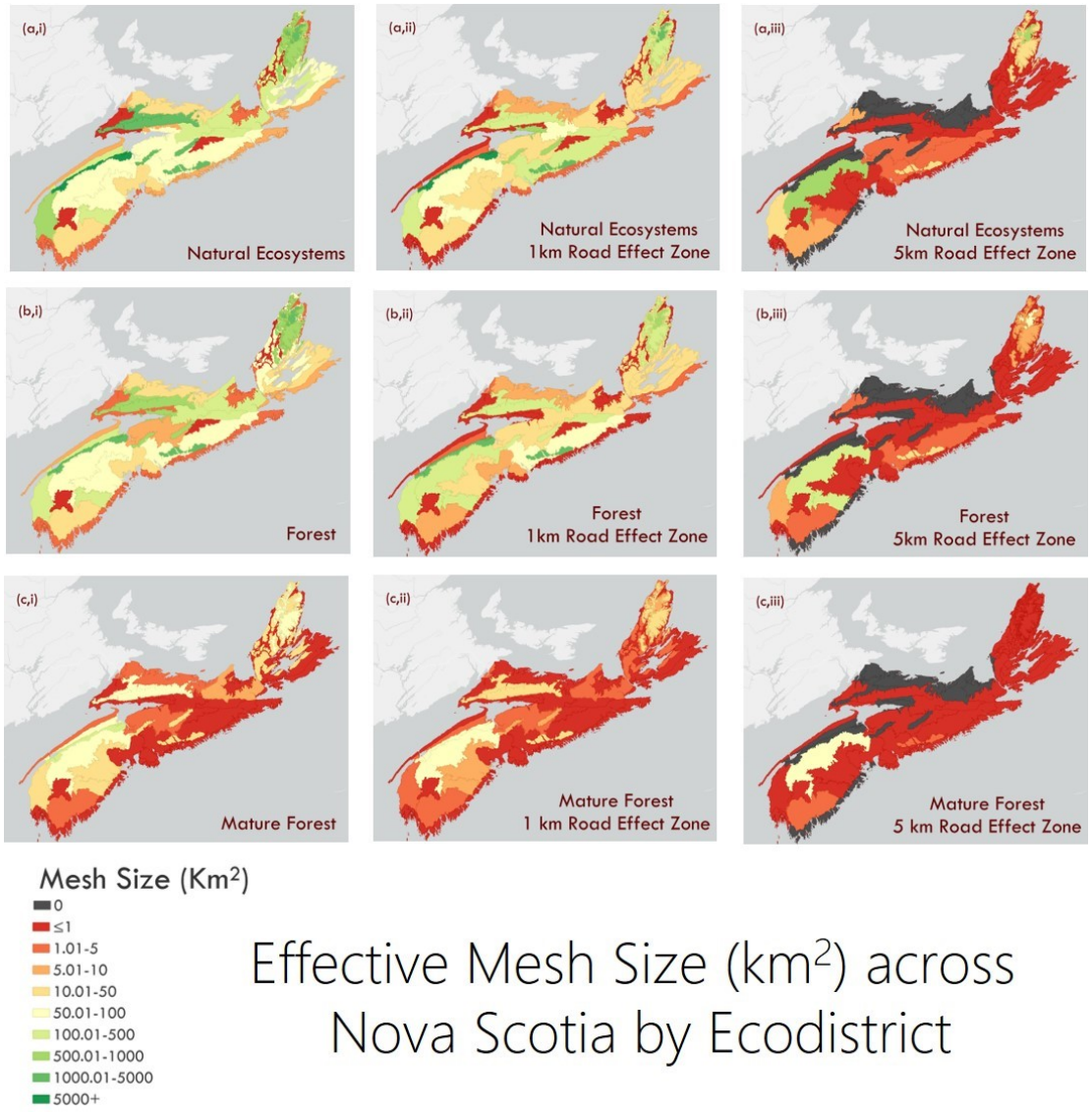

Figure A5.4. Effective Mesh Size by ecodistrict in Nova Scotia based on the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) and the different road effect zones: 0km (i), 1km (ii), 5km

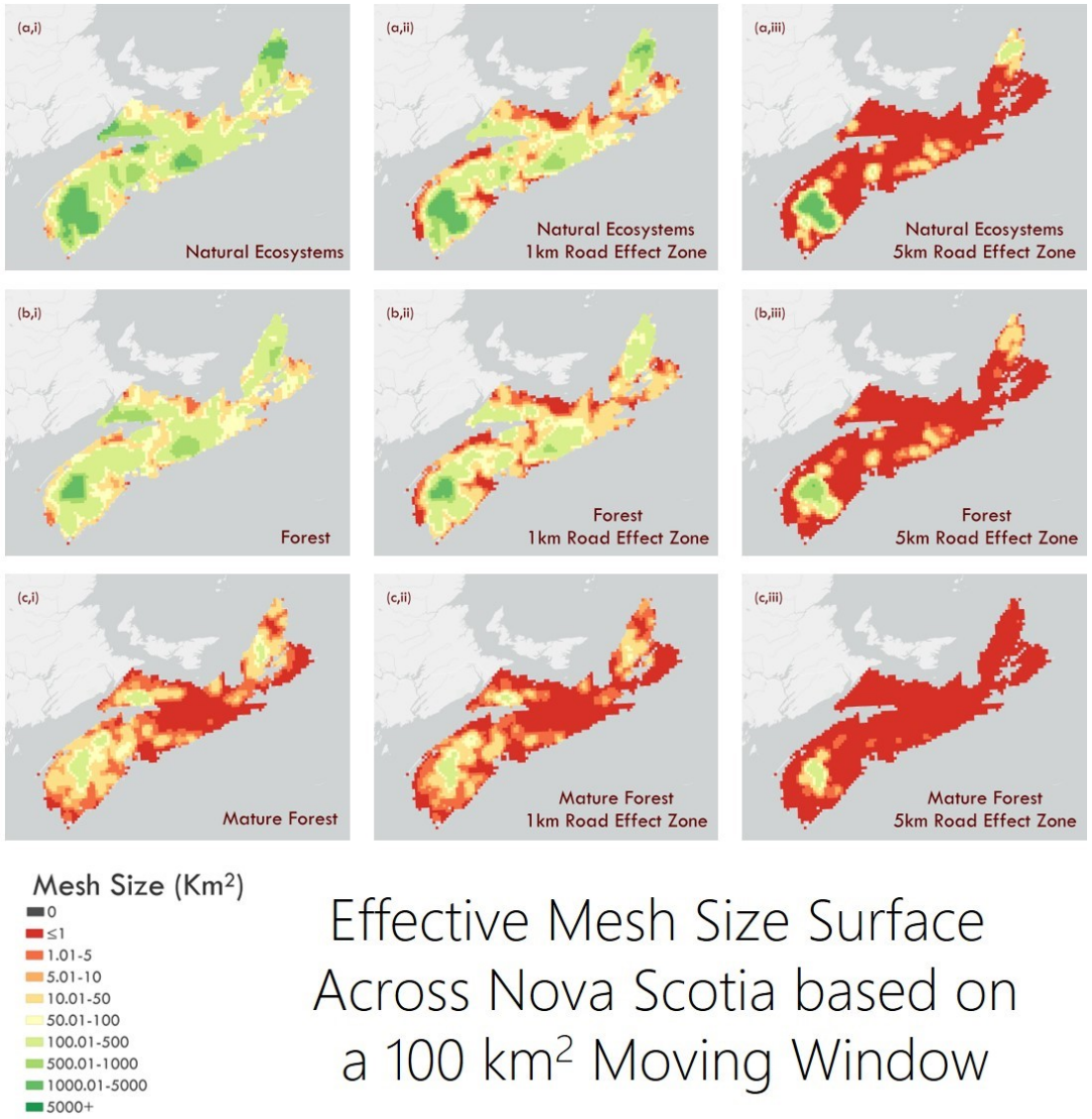

Figure A5.5 Effective Mesh Size surface across the entire province of Nova Scotia using a 100 km^2 moving window based on the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) and the different road effect zones: 0km (i), 1km (ii), 5km

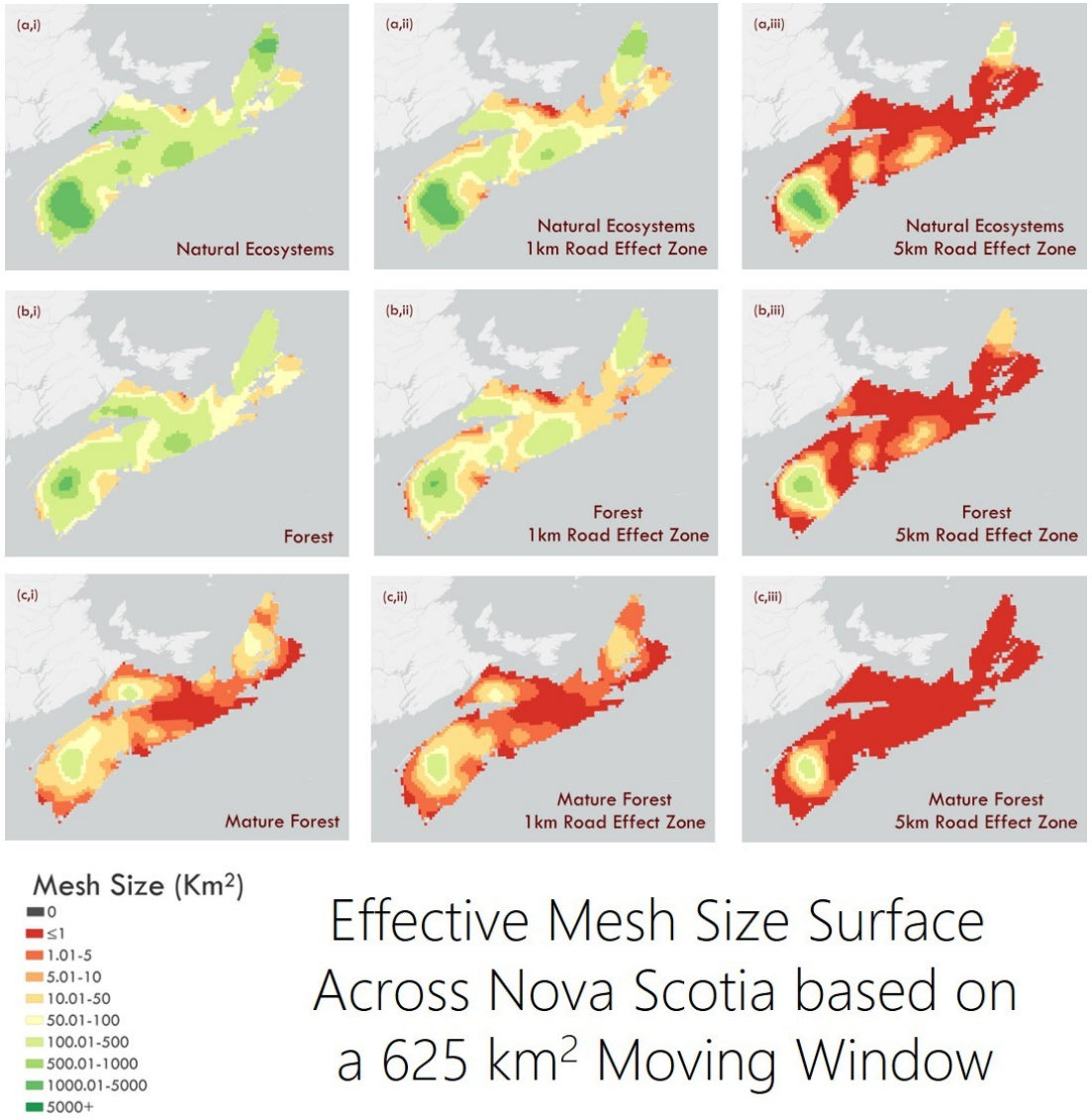

Figure A5.6. Effective Mesh Size surface across the entire province of Nova Scotia using a 625 km^2 moving window based on the different classifications of the landscape described above: natural ecosystems (a), forest (b) and mature forest (c) and the different road effect zones: 0km (i), 1km (ii), 5km

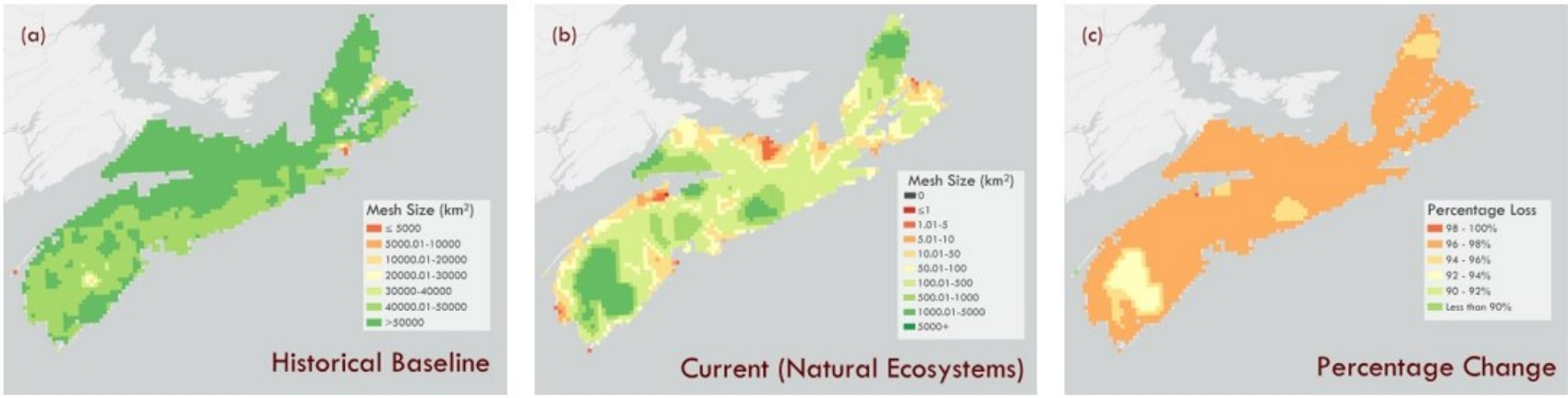

Figure A5.7. Changes in effective mesh size (c) between the historical baseline (a) and today (b) based on a 100 km² moving window

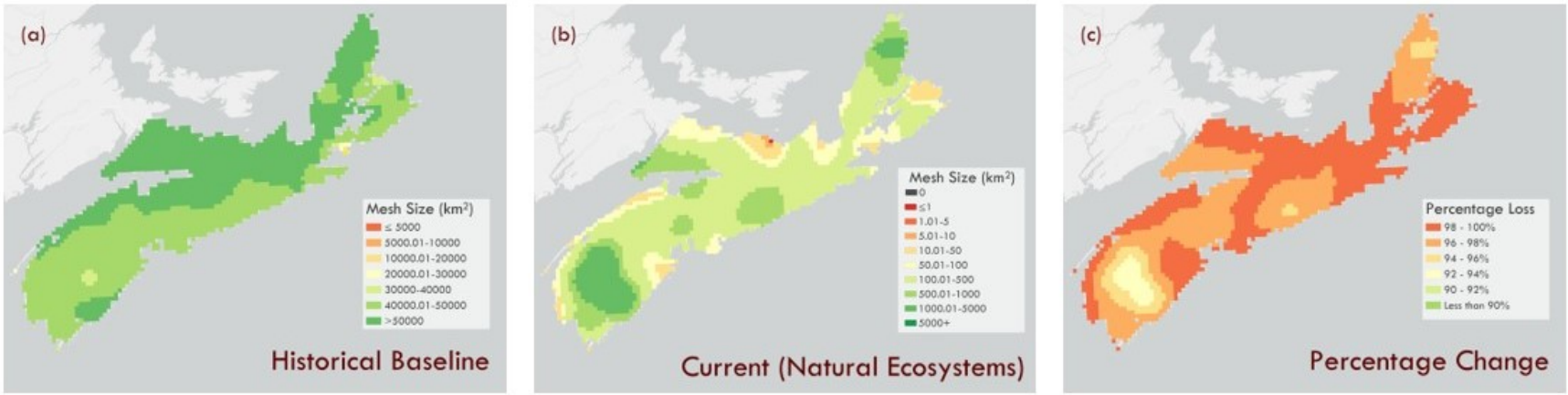

Figure A5.8. Changes in effective mesh size (c) between the historical baseline (a) and today (b) based on a 625 km² moving window

APPENDIX VI: CIRCUITSCAPE

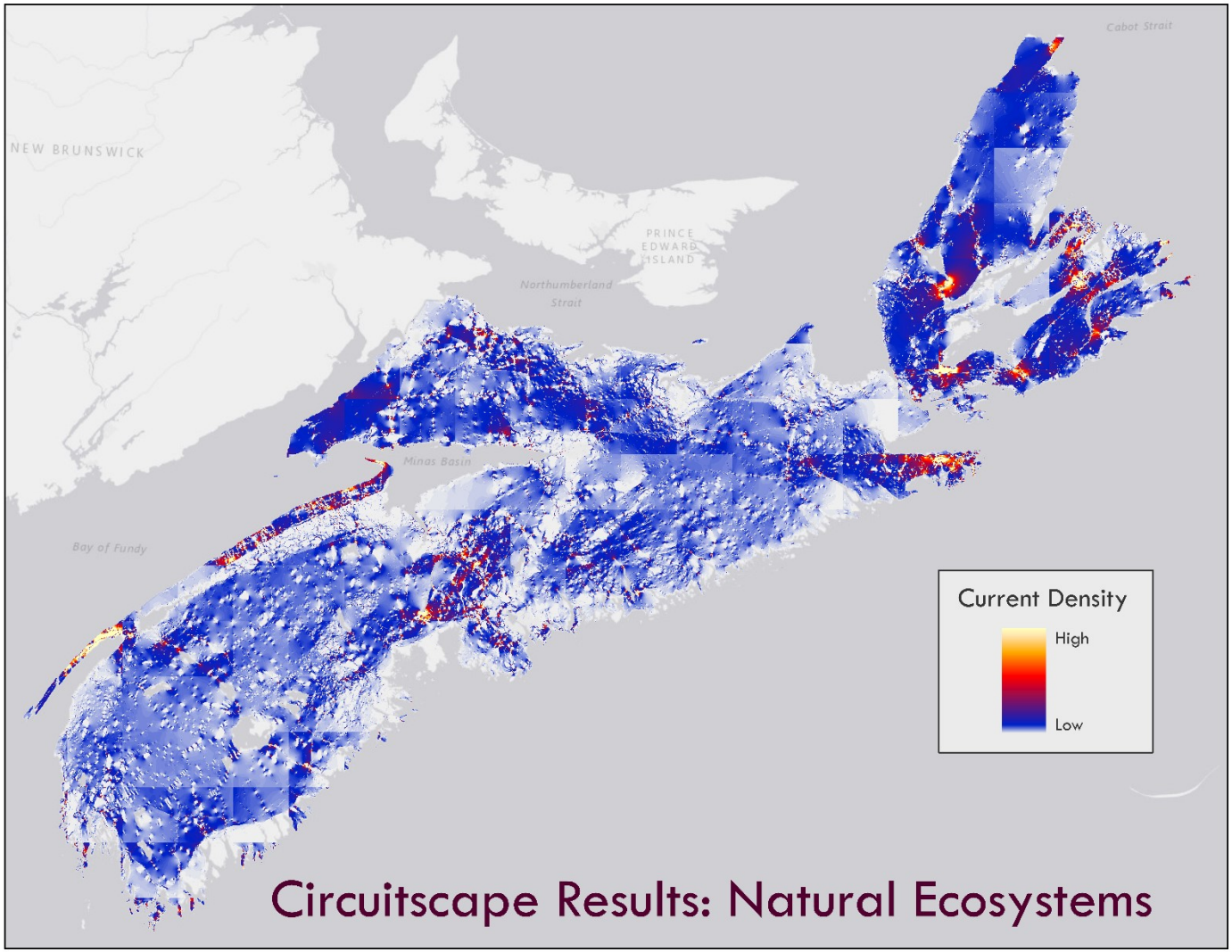

Figure A6.1 Results for the Circuitscape analysis for natural ecosystems across the province

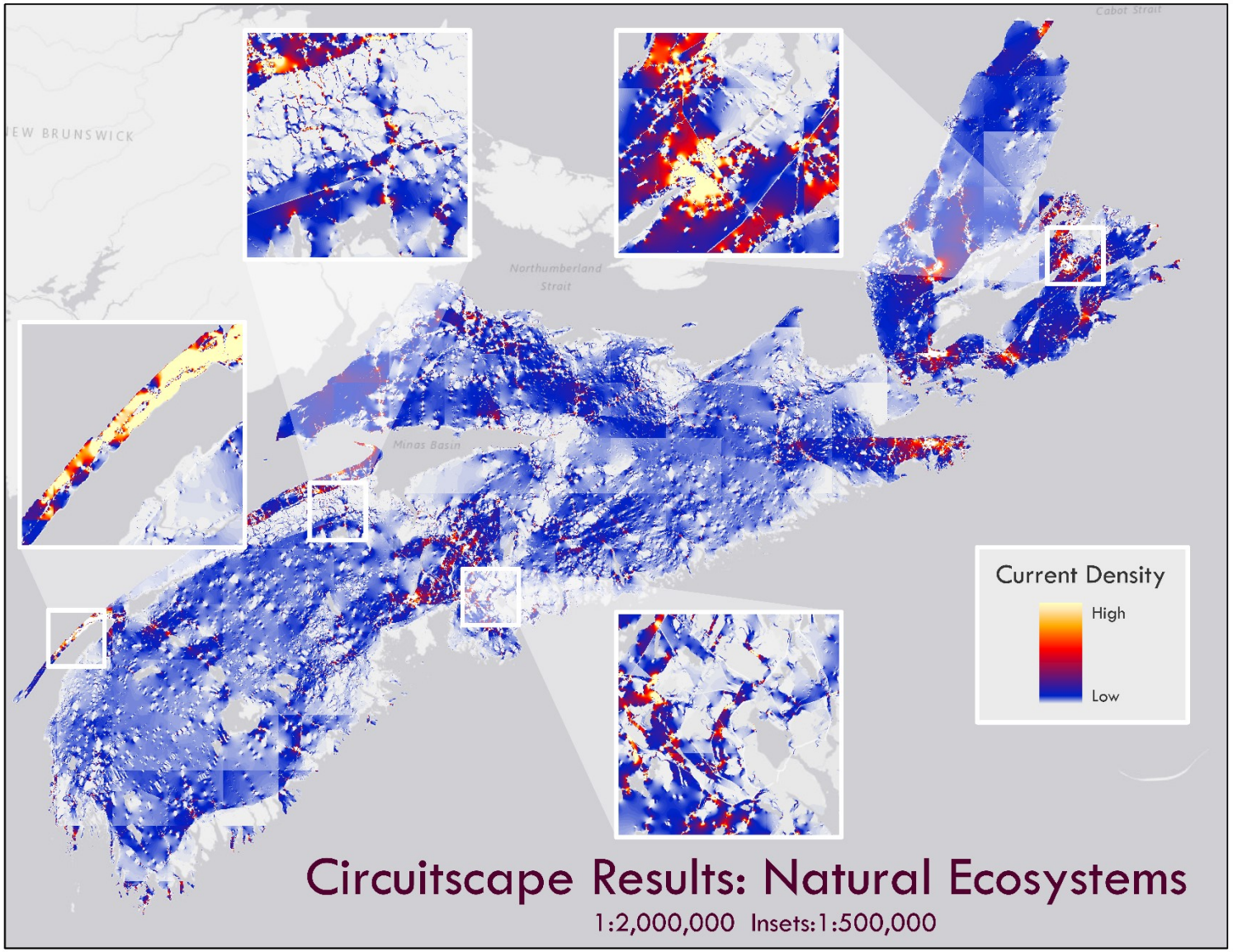

Figure A6.2 Results for the Circuitscape analysis for natural ecosystems across the province including insets detailing the Dgby neck, Annalpolis Valley, Halifax and Sydney areas.

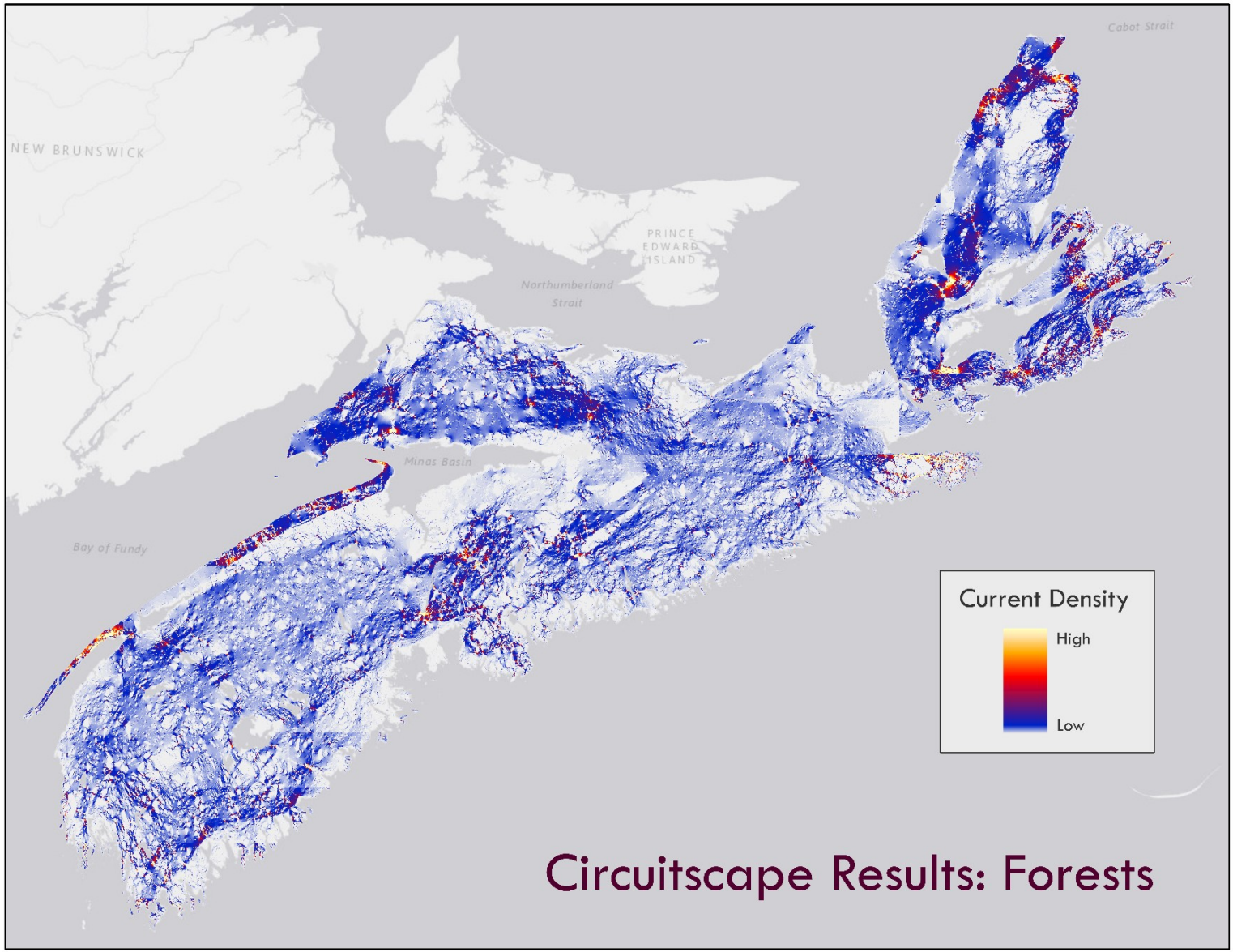

Figure A6.3 Results for the Circuitscape analysis for forests across the province

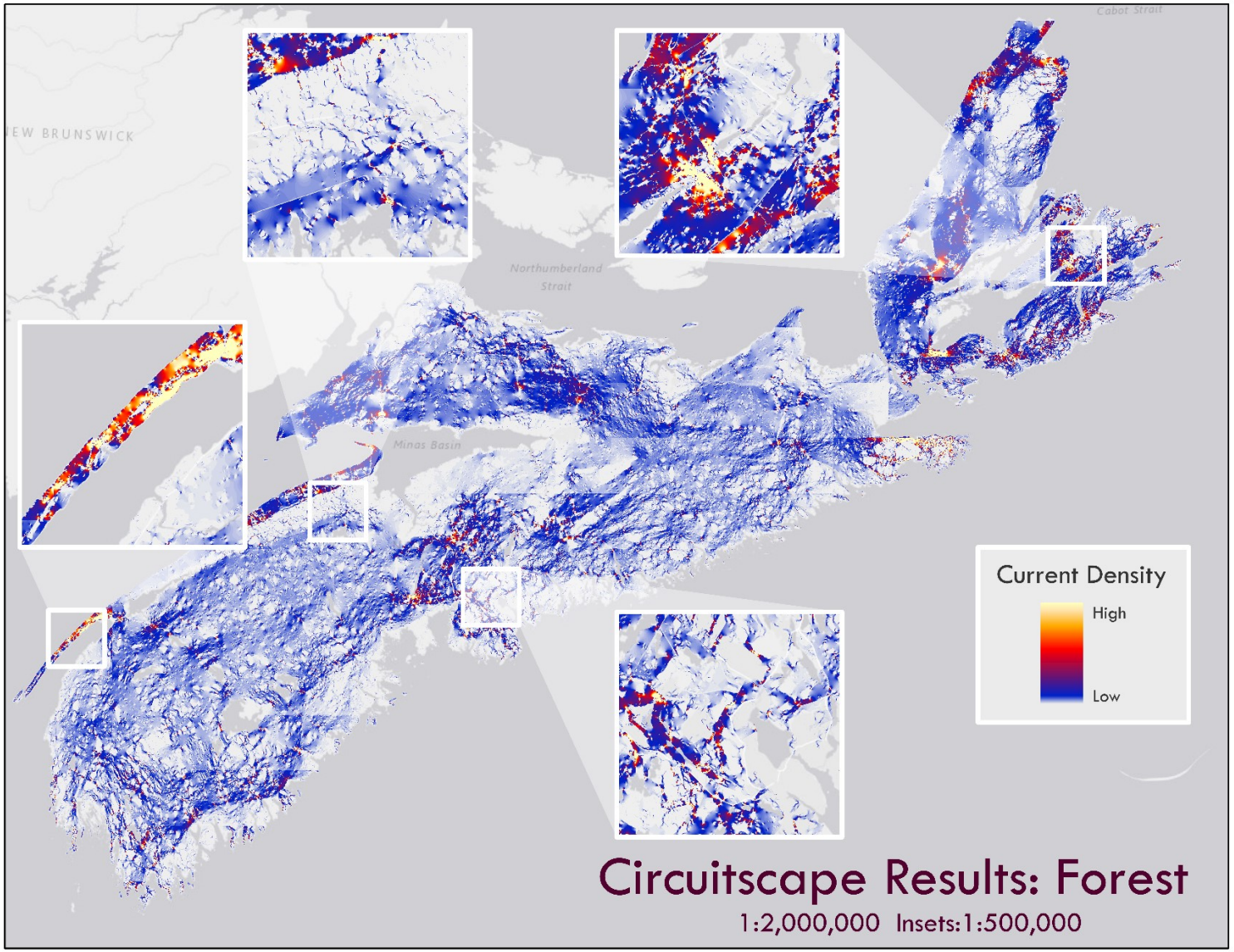

Figure A6.4 Results for the Circuitscape analysis for forests across the province including insets detailing the Dgby neck, Annalpolis Valley, Halifax and Sydney areas.

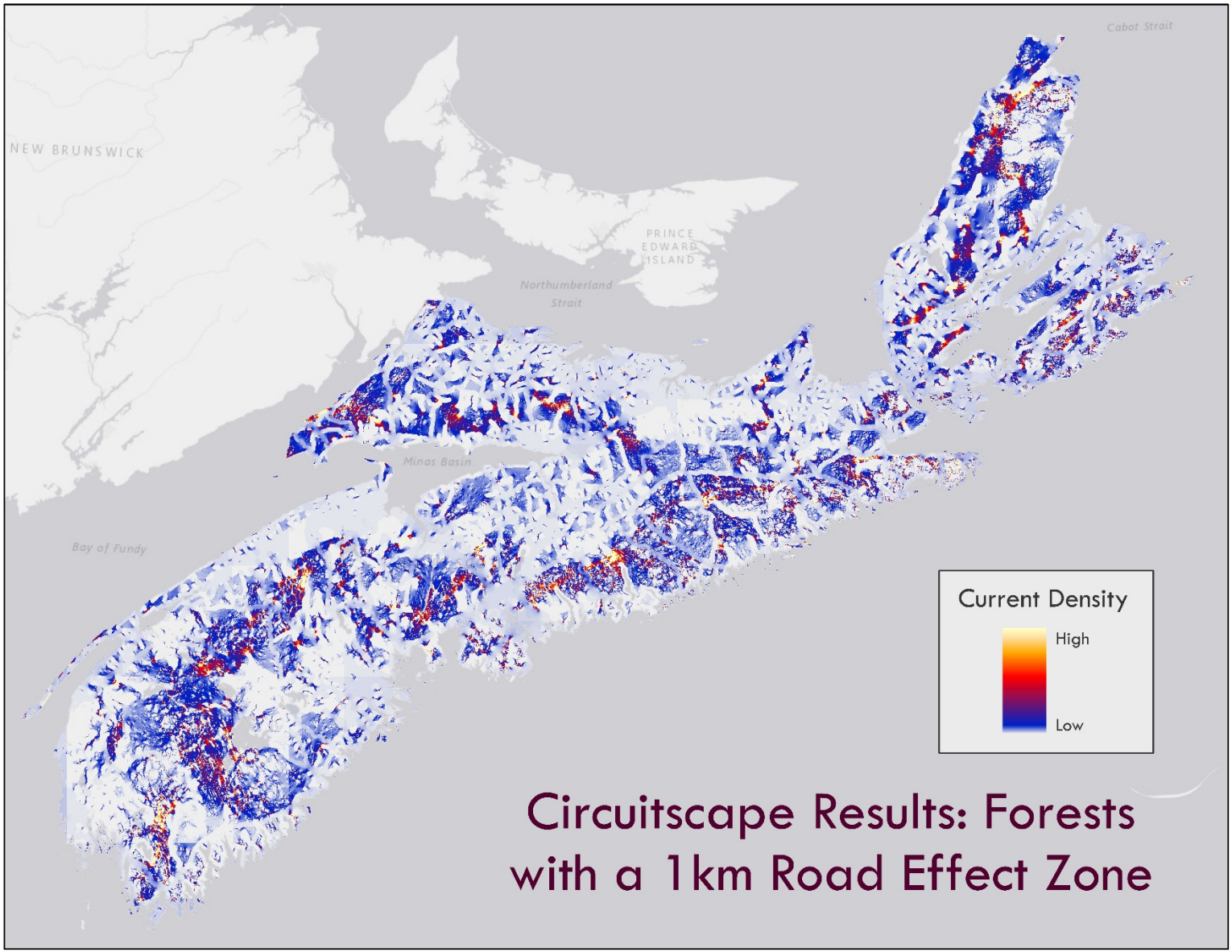

Figure A6.5 Results for the Circuitscape analysis for forests with a 1 km road effect zone across the province

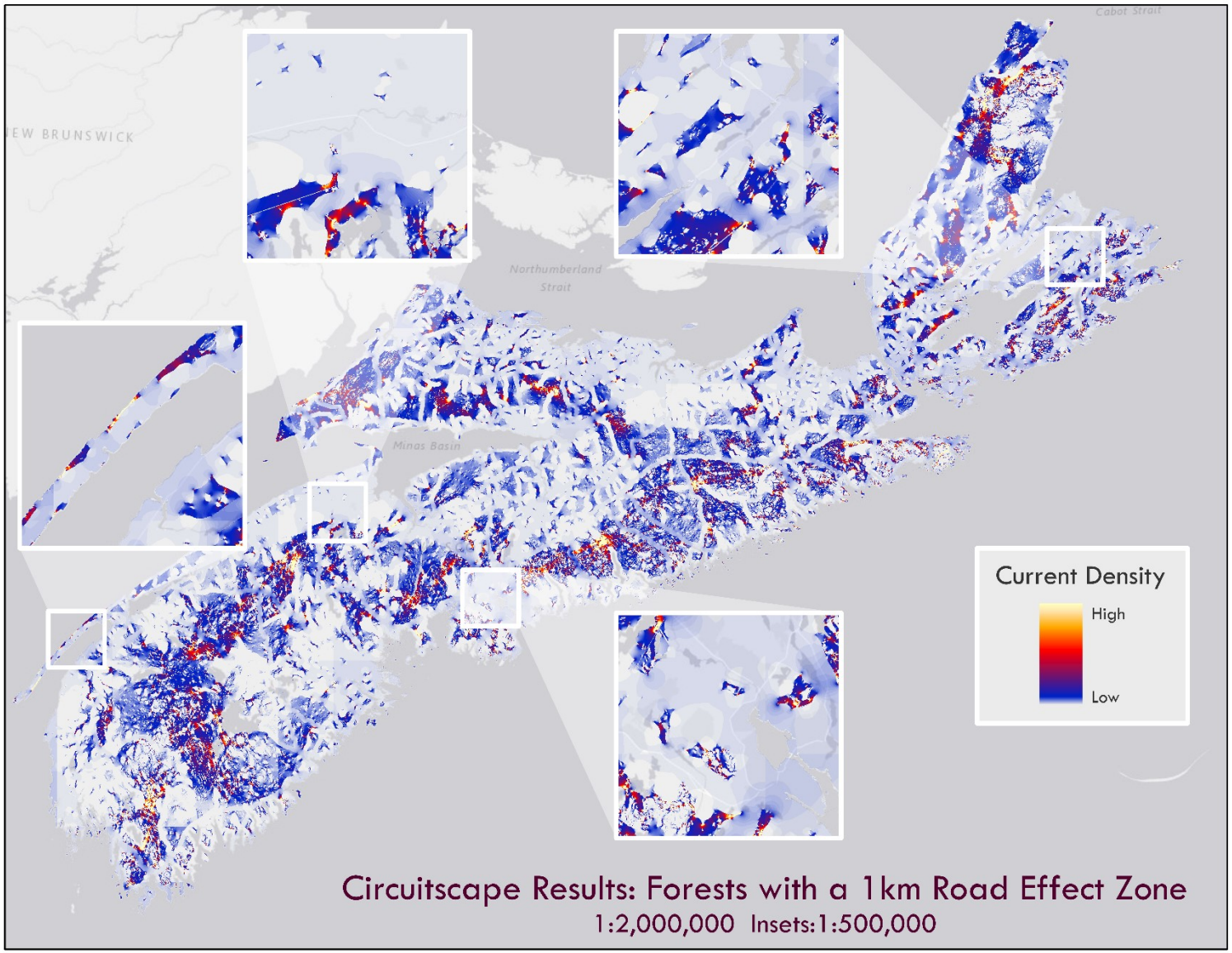

Figure A6.6 Results for the Circuitscape analysis for forests with a 1km road effect zone across the province including insets detailing the Dgby neck, Annalpolis Valley, Halifax and Sydney areas.

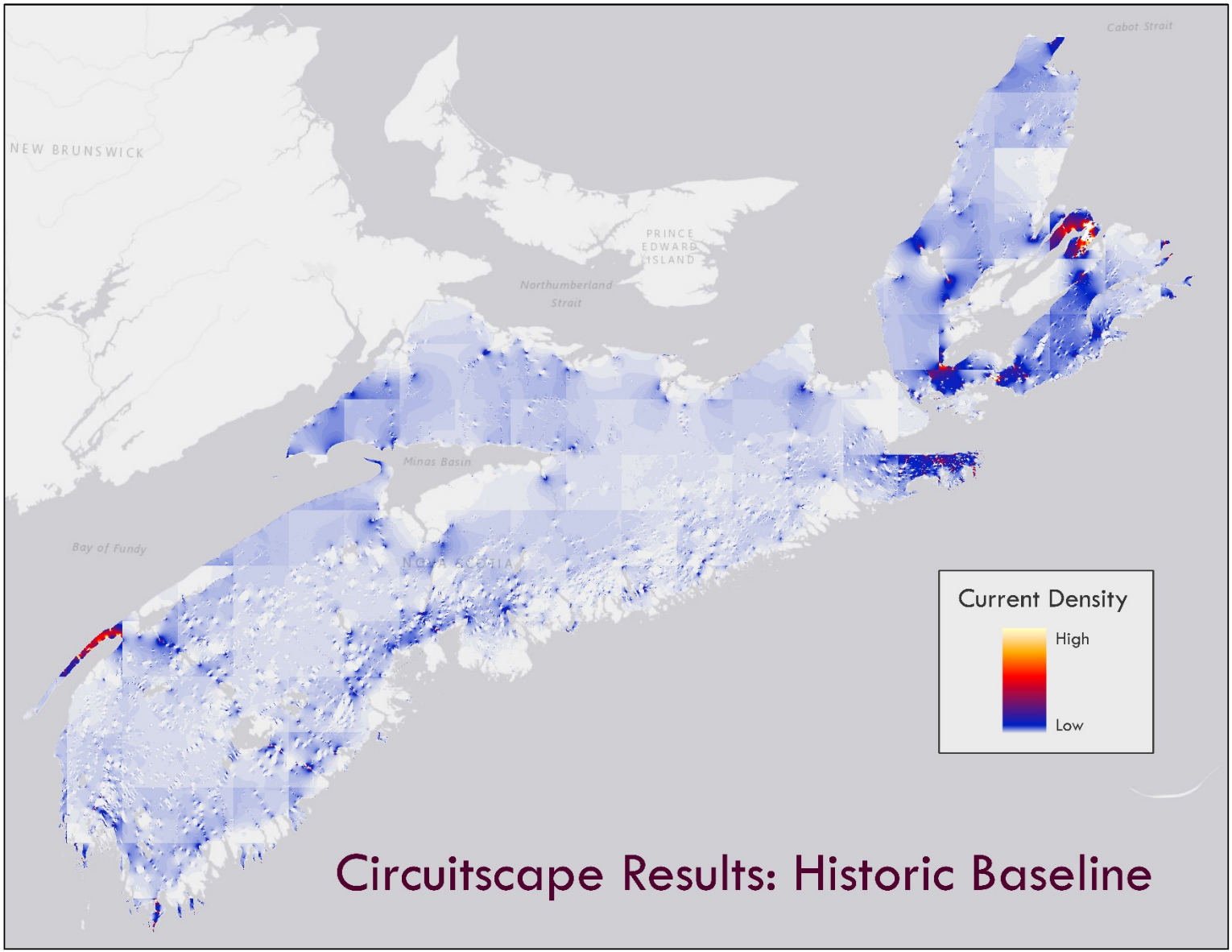

Figure A6.7 Results for the Circuitscape analysis the historic baseline across the province

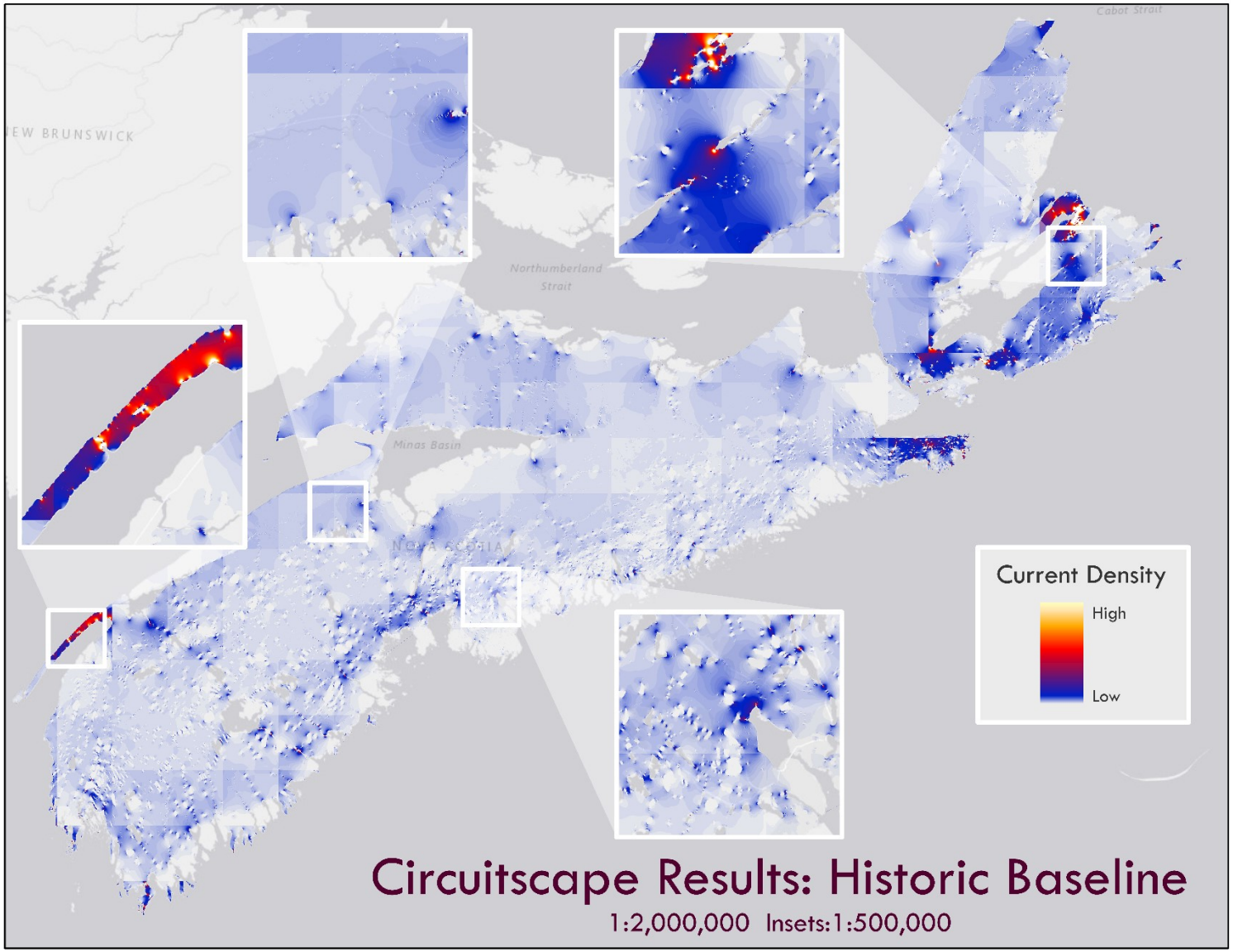

Figure A6.8 Results for the Circuitscape analysis for the historic baseline across the province including insets detailing the Dgby neck, Annalpolis Valley, Halifax and Sydney areas.