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Plant species composition across several natural edge types in Nova Scotia

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Abstract

Forest edges, anthropogenic and natural, experience edge effects which influence the surrounding species and abiotic factors. The amount of effect on the forest depends on a variety of factors including how the edge was made (or if it exists naturally), severity of contrast between adjacent habitat and forest, forest type and age. Many studies have looked in depth on anthropogenic edges but there is a lack of knowledge about natural edges, specifically looking at multiple natural edges and comparing them. My objectives were 1) to compare different edge types in Nova Scotia and 2) look at differences in species composition between the edge, forested and non-forested areas of each study. The data set used in this study spans a ten-year period and includes lakeshore, bog, barren, coastal, insect and fire edges. Cover estimates of vascular plants were taken within quadrats along a transects perpendicular to the edges and varied in length from 100 to 200m. I conducted a correspondence analysis to compare species composition.

The bog, lakeshore and barren edges had patterns of distinction between the edge, forested and non-forested categories. The coastal, insect and fire sites had a lack of distinction in species composition at these three distance categories. This was related to disturbance with coastal, insect and fire being frequently/previously disturbed and thus with less complex species composition. Overlap in species composition were seen between forest and edge at all six edge types and there was also overlap with the edge and non-forested area, less so. The natural inherent sites shared more similarities to each other. The naturally created sites were not like each other nor to the naturally inherent sites. The edge and forested sites had similar species composition, as did non-forested and edge sites. The non-forested and forested species composition was distinct from each other.

April 30, 2020

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1. Introduction

The most general definition of an edge can be considered a section of land significantly different to the systems adjacent to it (British Columbia Ministry of Forests Research Program 1998). Edge influence, also known as edge effects, is the impact and change to forest structure and composition from the edge compared to the interior forest (Harper and Macdonald 2001). Edge vary significantly based on edge type, ecosystem, time of creation, severity of edge and the amount of contrast between systems (Harper and Macdonald 2002; Harper et al. 2005 and Harper et al. 2015). Edge effects can result in changes in light, wind exposure, litter amounts, soil humidity, temperature and storm exposure at the forest next to the edge (Luczaj and Sadowska 1997). There are two main types of edges: anthropogenic edges and natural edges.

Anthropogenic edges are human created edges. Some examples of this could be a forest that has been clear cut, a fire started by an ignition source, or destruction of trees through pollution. These types of edges experience amplified damage to trees from increased exposure to wind and this leads to increased coarse woody debris (Harper et al. 2004). There is also increased light exposure at the exposed forest next to the edge which leads to increased production in this area and growth that often manifests in shrubs, development of the herbaceous understory, invasion of non-native plants and tree regeneration and growth (Harper et al. 2004).

Natural forest edges can be explained as the boundary between a forest and its adjacent non-forested area (Harper et al. 2015). Natural edges exist because the landscape is heterogeneous with different ecosystems existing next to one another. Natural edge boundaries are often complex and highly developed from years of existence due to natural landscape heterogeneity (Harper and Macdonald 2001). Edge influence is understood to be less drastic at undisturbed natural edges compared to anthropogenic edges (Harper and Macdonald 2001).

Edge effects differ between anthropogenic edges and naturally existing edges. The difference between these two types of edges can be understood by how each edge affects a forest. Both types of edges, natural or man-made experience changes in light, wind, litter amounts, etc. (Luczaj and Sadowska 1997). These effects can be more or less drastic and penetrate different distances into the forest depending on the edge type (Harper et al. 2004). Edge influence also depends on forest type. When it comes to man-made edges, it has been noted that the effect of the edge at temperate and tropical forests is greater than the effect at boreal forests (Harper et al. 2004). This is thought to be because of the existence of many natural edges in the landscape and the boreal system being disturbance adapted (Harper et al. 2004). When it comes to tree debris in the forest around anthropogenic edges compared to natural edges there is a distinct difference in that clearcutting is removing part of the ecosystem and this is often in a uniform pattern (Pykälä 2004). If a tree falls in a natural edge environment it is left as debris and able to host other species and can also be used for nutrients as it decays. When it comes to diversity around created anthropogenic edges and disturbed natural edges there is thought to be an increase in diversity for the first 1-2 years after being disturbed (or otherwise anthropogenically modified) (Pykälä 2004). Following this, the diversity gradually declines and overall is lower than the previously forested ecosystem before it was changed (Pykälä 2004). At natural edges without disturbance Erdős et al. (2013) found the most diversity located on the edge rather than the adjacent forest or grassland system.

Overall the understanding of species composition and diversity around natural edges is muddy at best. Previous studies have looked at cut edges, or cut edges compared to natural edges, but little has been studied in terms of different types of natural edges (Harper and Macdonald 2001; Harper and Macdonald 2002; Guirado et al. 2006).

Natural edge types include inherent edges and naturally created edges. Inherent edges are natural systems like lakeshore, wetland, barren and coastal edges that are relatively permanent in time and do not change unless disturbed (Harper et al. 2005). Naturally created edges are a result of a natural disturbance like a fire or an insect outbreak (Harper et al. 2005). These two natural edge types tend to differ in that naturally created edges can share similarities in patterns of diversity with anthropogenic created edges, while natural inherent edges are without disturbance and do not change over time (Pykälä 2004, Harper et al. 2005).

Inherent edges, although undisturbed, differ vastly in composition and function. Lakeshore edges form complex edges as the interaction of the topography, hydrology, light, and wind are very intertwined and complicated (Harper and Macdonald 2001). These edges can also experience small intermittent disturbances when the water table fluctuates causing floods, wind disturbance or disturbance from animals like beavers which can lead to gaps in the canopy and woody debris (Harper and Macdonald 2001; Komonen 2001). Such disturbances, frequent and small, are expected to enrich species coexistence and increase diversity (Komonen 2009). Many studies have previously considered forest edges near streams and rivers; thus, little is known about lakeshore edge characteristics (Komonen 2009). It is recognized that the forest-water interface has great contrast and therefore, great potential for diversity (Komonen 2009). Wetland bog forest edges consist of mainly low shrubs and have low diversity in vascular plants but high diversity for mosses, lichens, and fungi (Moen and Jonsson 2003). This type of system also usually exists as pockets of forests situated in wetland areas and contains specific water tolerant species (Moen and Jonsson 2003). Bog edges are highly developed from years of coexistence; thus, it is expected that the forest is sheltered from the increased wind and light and expected to have stronger but less extensive edge influence when compared to a fragmented landscape (Moen and Jonsson 2003). Barren edges are characterized by open communities with the dominant species being low growing shrubs and thinly dispersed tree cover (Burley et al. 2010). The open habitat of barrens next to the forest provides a gradient of successional species with the barrens containing rare plant species typically only found in the barren habitat (Burley et al. 2010). The influence of the trees into the barrens side of the edge has been recognized in changing shading, soil moisture and nutrient availability in the adjacent soil (Burley et al. 2010). Finally, the coastal edge is not widely studied but it is usually characterized by its proximity to the ocean which result in high erosion areas inflicted with salt spray. Some have claimed that the existence of certain vegetation at these coastlines prevent erosion and thus are quite beneficial; *Spartina alterniflora* has been studied for this trait (Feagin et al. 2009). These coasts can often contain unique tolerant species that are most likely not characteristic of an adjacent forest (Feagin et al. 2009).

Naturally created edges result from disturbance occurring without human influence. Fire edges can be human created but are also naturally part of ecological processes in some forests (Coop et al. 2010). These fire disturbances are recognized as having a central role in providing a unique habitat for some species and resetting the landscape for early-successional species (Harper et al. 2004). The typical edge effects of wind and light exposure are thought to be less drastic at this type of edge due to the presence of snags and remnant trees blocking some entry (Harper et al. 2004). At fire edges, we tend to see greater nutrient availability, seedbed exposure and the establishment of plant species that otherwise may have struggled to compete in the forest before the disturbance (Lantz et al. 2010). Created edges can also be made by insect disturbance and are often created by native species such as the western spruce budworm (*Choristoneura occidentalis*) or occasionally non-natives such as the gypsy moth (*Lymantria dispar*) (Radeloff et al. 2003). These outbreaks have scattered patterns and thus varying amounts of edge exposure that can lead to edge effects at different distances in the intact forest (Franklin et al. 2015). We also see an increase in tree mortality, reduced tree growth and an increase in fire frequency and longevity with increased fuel load (Franklin et al. 2015; Radeloff et al. 2003). It is also worth noting that certain types of insect outbreaks often facilitate forest succession when the competition is reduced, and new openings are created (Morin 1994).

I used data from six natural edge types (lakeshore, bog, barren, coastal, fire and insect) from years of collection by Karen Harper and her lab in Nova Scotia, Canada. My objectives were 1) look between studies and compare species composition and 2) look at species composition differences between the edge, forested and non-forested areas of each individual study. This information will guide our understanding of edge influence as well as species composition in natural systems, which could provide important information for conservation when it comes to conserving natural edges. Understanding these natural edges and their processes will provide key information for when choosing land to protect and maintain.

2. Methods

2.1 Study Sites

I worked with 8 data sets on 6 different edge types (Table 1). There were two ecoregions present in this study, temperate broadleaf and mixed forests or boreal forest/taiga (Table 1). The taiga forest is a scrub forest with a mix of rocky barren and bog and characterized by dwarfed vegetation and shrubby black spruce (Parks Canada, 2018a). The boreal forest has dense shading, acidic soil and characteristic species such as balsam fir and white birch (Parks Canada 2019). Temperate broadleaf and mixed forests experience wide variability in temperature and precipitation and are characterized by tree species such as oak, beech, birch, and maple (World Wildlife Fund, 2019). All studies are within Nova Scotia and conducted between the months of June-August over approximately a 10-year period. The most northern point of Nova Scotia, Cape Breton, had temperature averages from 9 to 23°C (Meteoblue 2019) while the most southern part, Yarmouth, had 11 to 24 °C from the months June to August (Meteoblue 2019). Nova Scotia on average had about 75mm of rain per month during these months (World Weather Online 2020).

Different forest communities were opposite the edge such as mixed forest, Acadian forest, old-growth hemlock forest or Picea dominated stands (Table 1). All edge types were studied in one type of forest except for lakeshore edge, in which there were two studies next to the old growth hemlock and spruce forests. The mixed forest can consist of several tree species such as balsam fir, birch, sugar maple, American beech, and spruce, among others (Nature Conservancy Canada, 2019). This forest type provides habitat to a variety of species and contains rare forest groups (Nature Conservancy Canada, 2019). Acadian forests are composed of mixed hardwoods and softwoods occur in lowland coastal areas and sheltered valleys (Parks Canadab, 2018). Species that grow in this forest, specifically in the Cape Breton region, include sugar maple, yellow birch, American beech, balsam fir, and eastern hemlock while in other regions red spruce, red oak, white ash, white pine, and ironwood are also common (Parks Canadab, 2018). The old-growth hemlock forest is dominated by eastern hemlocks and requires consistent moisture year-round due to the hemlocks shallow root system. They are shade-tolerant trees that are home to a wide variety of species due to their unique habitat of moist and shaded (National Wildlife Federation, 2019). *Picea* dominated stands are simply areas with uniform species composition, in this case, spruce dominated. There were also coastal barrens present opposite the edge. Coastal barrens will consist of sparse tree cover and be dominated by shrub vegetation (Burley 2009).

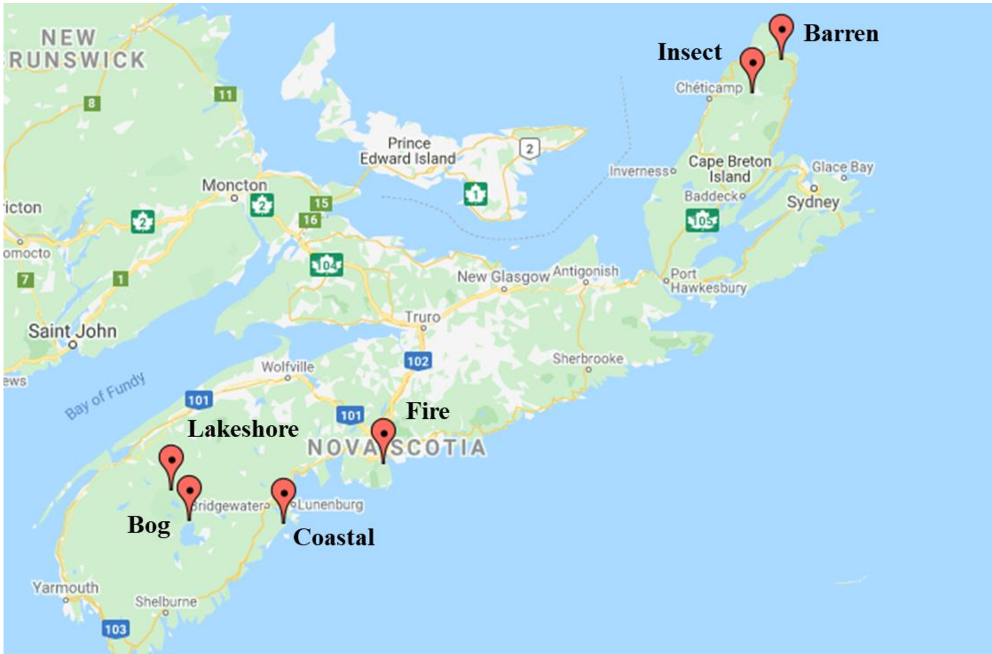

Figure 1 Map indicating study site locations across Nova Scotia

2.2 Data Collection

Each study site had from 3 to 8 transects with lengths from 100 to 360m (Table 1). Transects were perpendicular to the edge with some running half the distance on either side of the edge while others were only on one side of the edge. Data were collected using 1x1m contiguous quadrats and cover percent was estimated for all vascular plant species within each quadrat. The edge was defined at the -20 to 20m distance, the forested as any distance above 20m and non-forested as the area below -20m.

Table 1. Different edge types with their associated data on forest type and transect as well as coordinate range for approximate location

Edge Type	Forest Type	Transect Length (m)	Number of Transects	Coordinate Range (Latitude, Longitude)
Coastal	Temperate broadleaf and mixed forest	200	3	44.2633 to 44.2806, -64.385 to -64.40541
Barren	Boreal forest/taiga	140	4	46.82841 to 46.84365, -60.43374 to -60.43673
Fire	Temperate broadleaf and mixed forest	100	5	44.59463 to 49.62, -63.58913 to -79
Insect	Boreal forest/taiga	120	6	46.64642 to 46.81108, -60.66134 to -60.892
Lakeshore (Old gorwth forest)	Temperate broadleaf and mixed forest	100	5	44.45089 to 44.56049, -65.19546 to -65.27487
Lakeshore (Spruce forest)	Temperate broadleaf and mixed forest	120	4	44.46933 to 44.58428, -65.07047, -65.16519
Bog (Spruce forest)	Temperate broadleaf and mixed forest	120	4	44.27898 to 44.51986, -65.12362, -65.23232

2.3 Data Analysis

Data for the six edge types were analyzed using Past 3.26 software (Hammer Ø 2019). A correspondence analysis was conducted using the cover of individual plant species from all quadrats from all studies together. Species with 20% frequency or higher were labelled on the plotted species ordination graph, separate from the original ordination. Each study was presented on a separate biplot from the same ordination results, first using axis 1 and 2 and then also with axis 3 and 4. Only axis 1-4 were used as they provided to most representation for the data. This allowed for a better examination of trends and overall a better representation of the data. The scores along the first axis were averaged for each study to examine similarity and differences of scores among and within studies. Quadrats were grouped into three distance categories: the edge, forested and non-forested.

3. Results

The CA ordination plot had no obvious evidence of a curve so detrending was not necessary. Axis 1 had an Eigenvalue of 0.80 and Axis 2 had a value of 0.75 which tells us how much variation is represented in our data. The bog, insect and fire sites were separated along the first axis from the coastal, lakeshore and barren sites.

3.1 Inherent edges

For the coastal plots in ordination using axes 1 and 2, there was much overlap and lack of distinction between quadrats of the forested side of the transect and the edge. (Figure 2). For axis 3 and 4 there was a similar trend with large amounts of overlap between the edge and forested sites (Figure 3). For the barren sites using axis 1 and 2, there was much overlap present between the non-forested side of the transect and the edge (Figure 4). The edge also appears to share a large amount of overlap with the forested side of the transect but notably, the non-forested and forested quadrats appear to lie, mostly, on opposite sides of the axis (Figure 4). Using axis 3 and 4 the same trend appears again; the edge has much overlap with both the forested and non-forested sites but forested and non-forested do not share much overlap (Figure 5). When looking at the coastal and barren graphs together, the forested sites and edge sites appear to share similar layout and similar species and the barren non-forested sites were similar to the coastal forested sites (Figure 2 and 3). With the lakeshore sites using axis 1 and 2, the forested side of the transect has some overlap with the edge but each section appears to concentrate slightly separate from the other (Figure 6). It can also be noted that the lakeshore and the barren edge and forested sites appeared similar to each other (Figure 4 and 5). On axis 3 and 4 of the lakeshores sites there is the same pattern with overlap occurring between the edge and forested sites, but each distance category was still a separate cloud of points (Figure 7). The spread of the bog sites appears differentiated with some clear spots of overlap along axis 1 and 2 (Figure 8). The bog sites had much overlap between the edge and the non-forested side of the transect as well as between the edge and the forested side of the transect (Figure 8). There seemed to be only a small amount of overlap between the forested and non-forested quadrats (Figure 8). There was also similarity that can be seen between the bog forested and the lakeshore forested quadrats (Figure 6 and 7). There were the same trends for axis 3 and 4 (Figure 9).

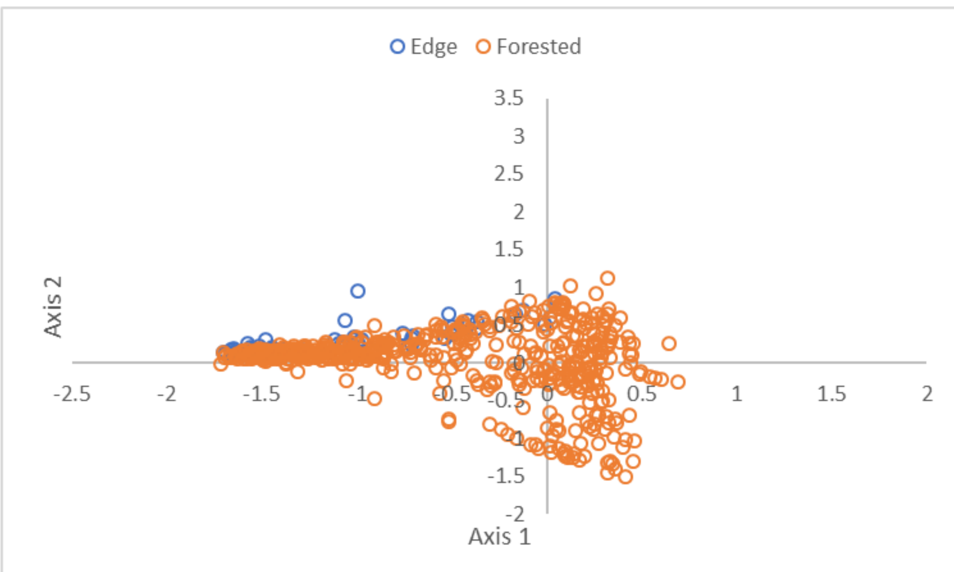

Figure 2 CA ordination plot using axis 1 and 2 displaying coastal site scores. The forested quadrats along the transects are represented with orange circles and the edge quadrats as blue circles.

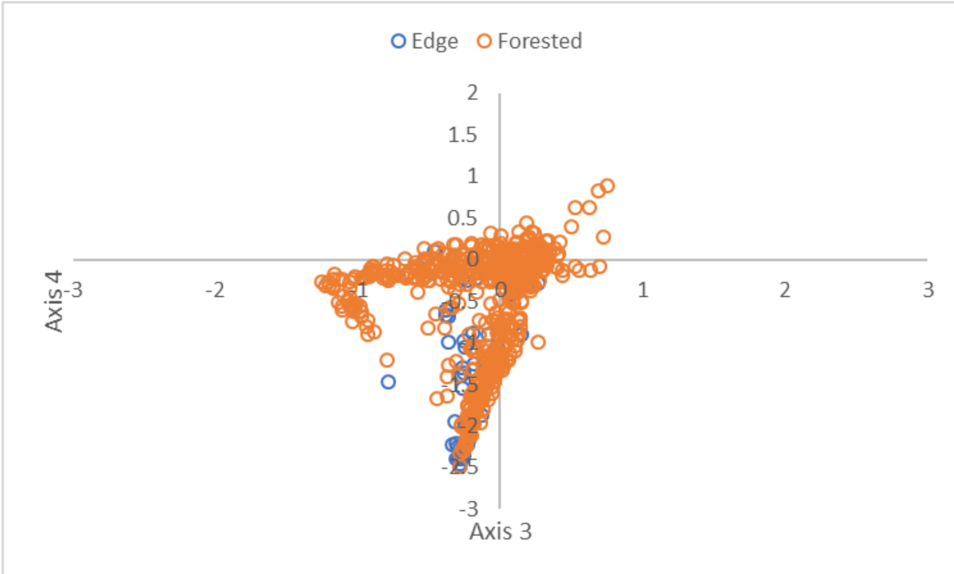

Figure 3 CA ordination plot using axis 3 and 4 displaying coastal site scores using. The forested quadrats along the transect were represented with orange circles and the edge quadrats as blue circles.

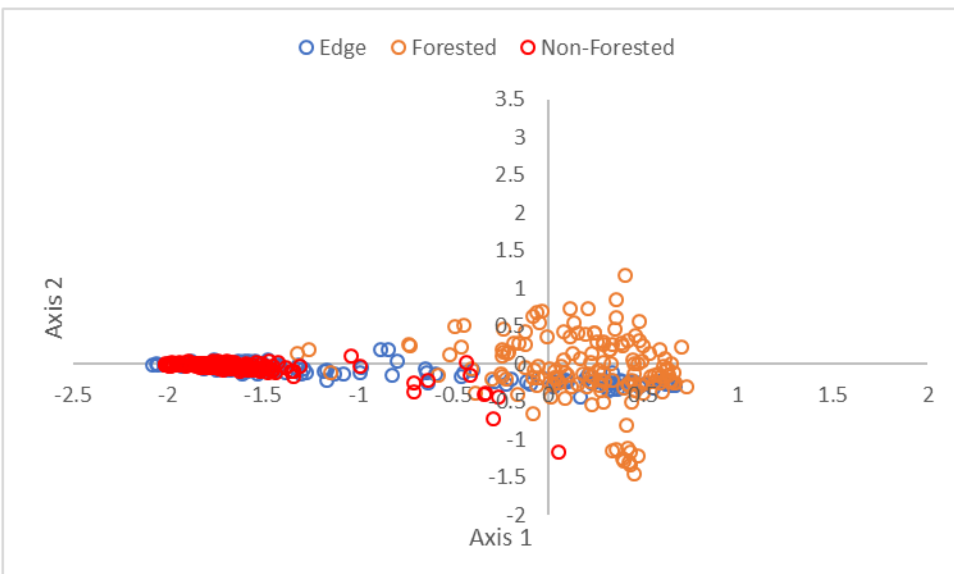

Figure 4 CA ordination plot using axis 1 and 2 displaying barren site scores. The non-forested quadrats along the transects are represented with red circles, the forested quadrats as orange circles and the edge quadrats as blue circles.

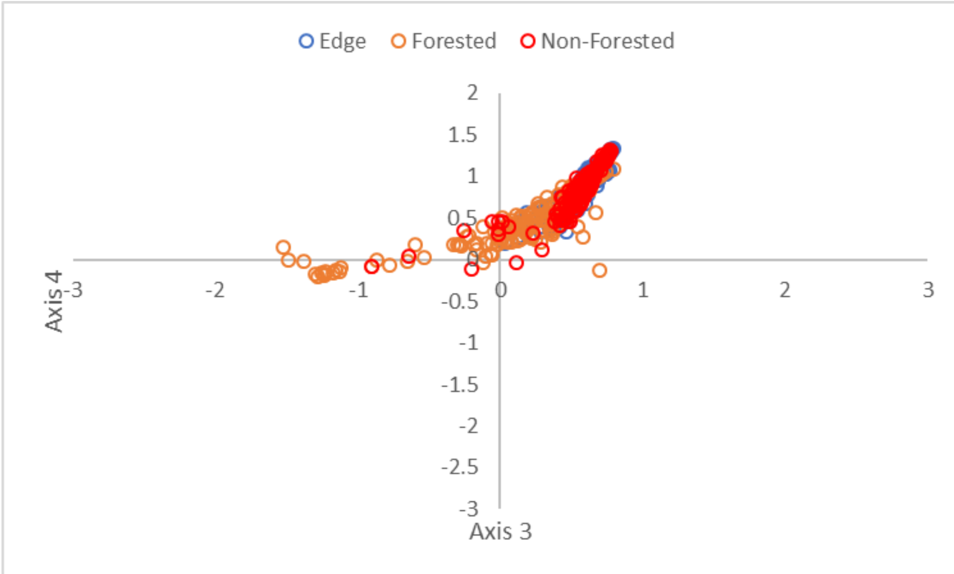

Figure 5 CA ordination plot using axis 3 and 4 displaying barren site scores. The non-forested quadrats along the transects are represented with red circles, the forested quadrats as orange circles and the edge quadrats as blue circles.

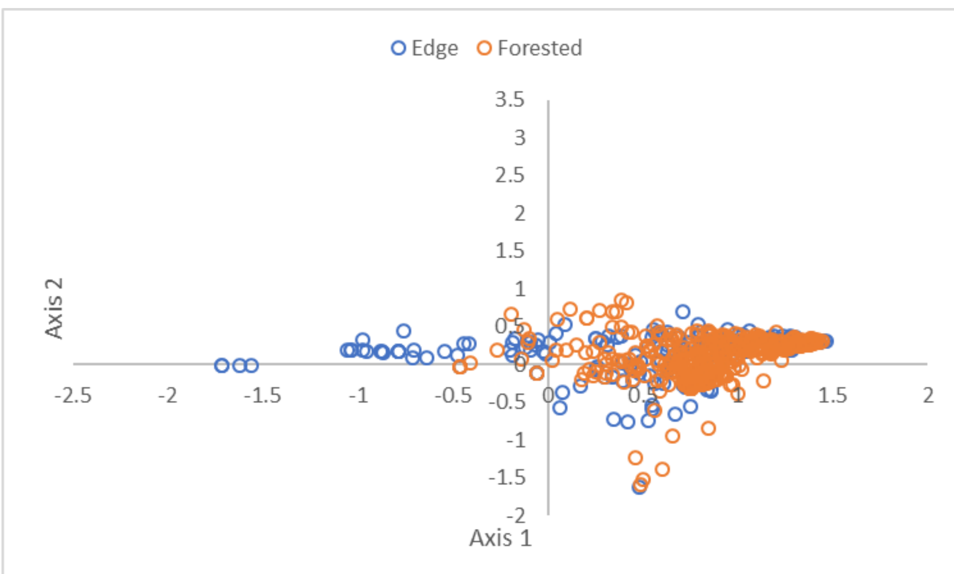

Figure 6 CA ordination plot using axis 1 and 2 displaying lakeshore site scores. The forested quadrats along the transect are represented with orange circles and the edge quadrats as blue circles.

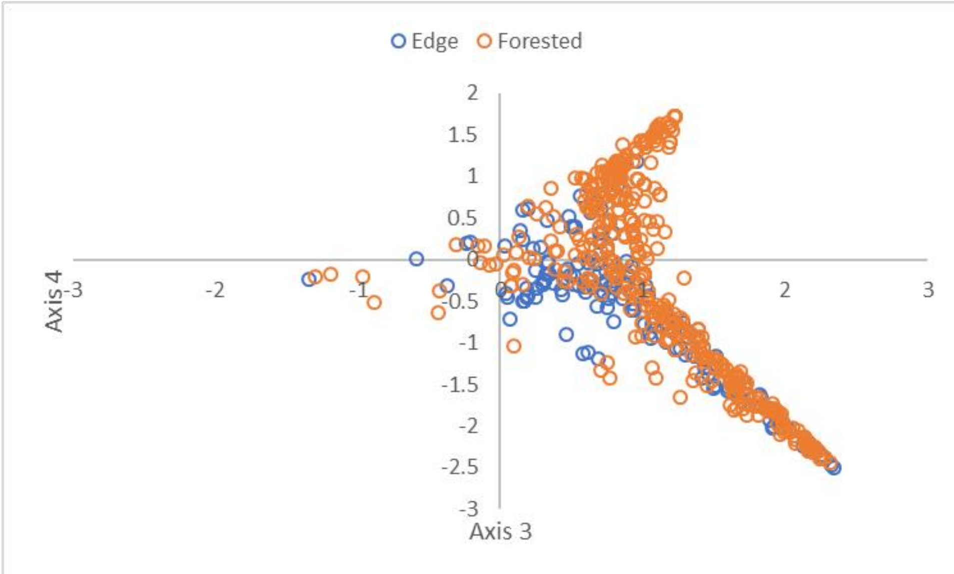

Figure 7 CA ordination plot using axis 3 and 4 displaying lakeshore site scores. The forested quadrats are represented with orange circles and the edge quadrats as blue circles.

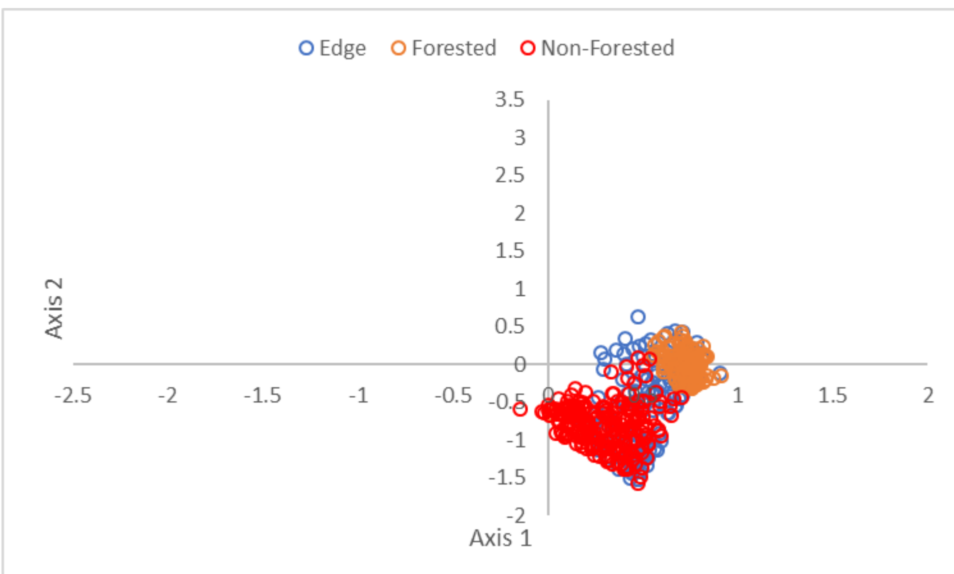

Figure 8 CA ordination plot using axis 1 and 2 displaying bog site scores. The non-forested quadrats are represented with red circles, the forested quadrats as orange circles and the edge quadrats as blue circles.

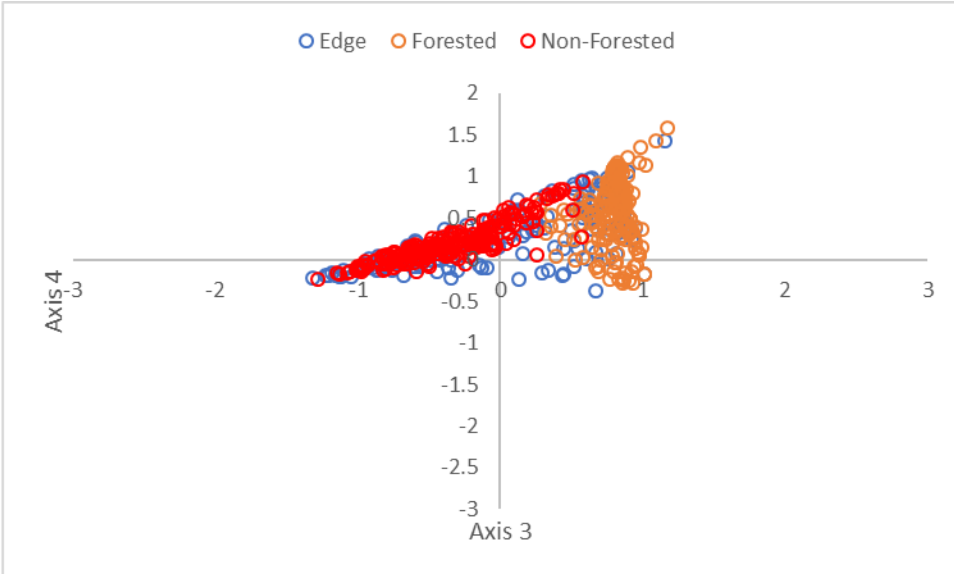

Figure 9 CA ordination plot using axis 3 and 4 displaying bog site scores. The non-forested quadrats are represented with red circles, the forested quadrats as orange circles and the edge quadrats as blue circles.

3.2 Naturally Created Edges

For the fire edge a lack of distinction is apparent between the edge, forested and non-forested distances along axis 1 and 2 (Figure 10). There appears to be a lack of a pattern in the spread and overlap of the quadrats aside from much overlap of all three distances (Figure 10). Using axis 3 and 4 there is the same lack of distinction between the three distances (Figure 11). In the insect edge using, axis 1 and 2, there appears to be a lack of major distinction between the edge, forested and non-forested section of the transect for this edge as well (Figure 12). The non-forested and forested side of the transect had some overlap but also appears to have some separation and concentration away from each other on the graph while the edge is distributed underneath them both (Figure 12). Using axis 3 and 4 there is a slightly different trend with much overlap under all three distances (Figure 13).

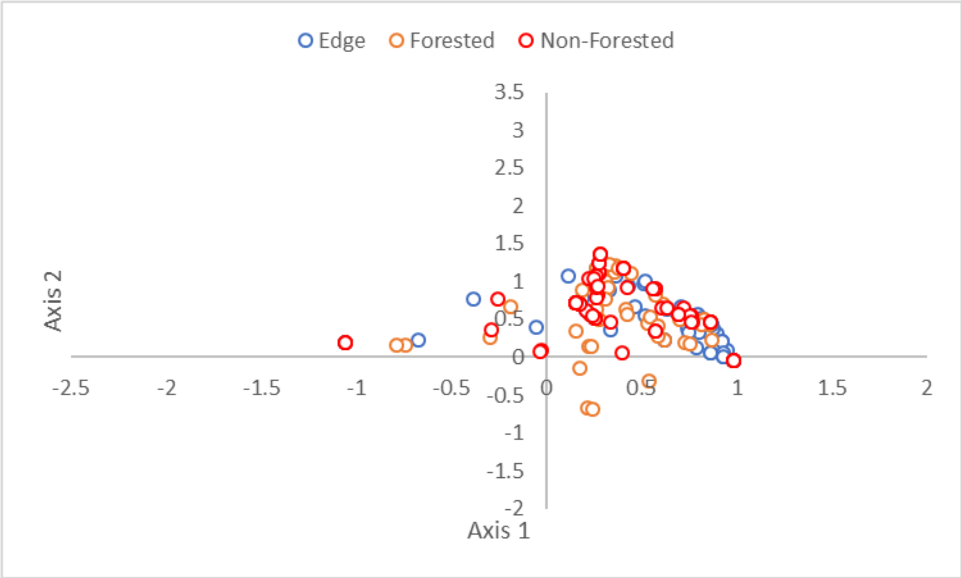

Figure 10 CA ordination plot using axis 1 and 2 displaying fire site scores. The non-forested quadrats are represented with red circles, the forested quadrats as orange circles and the edge quadrats as blue circles.

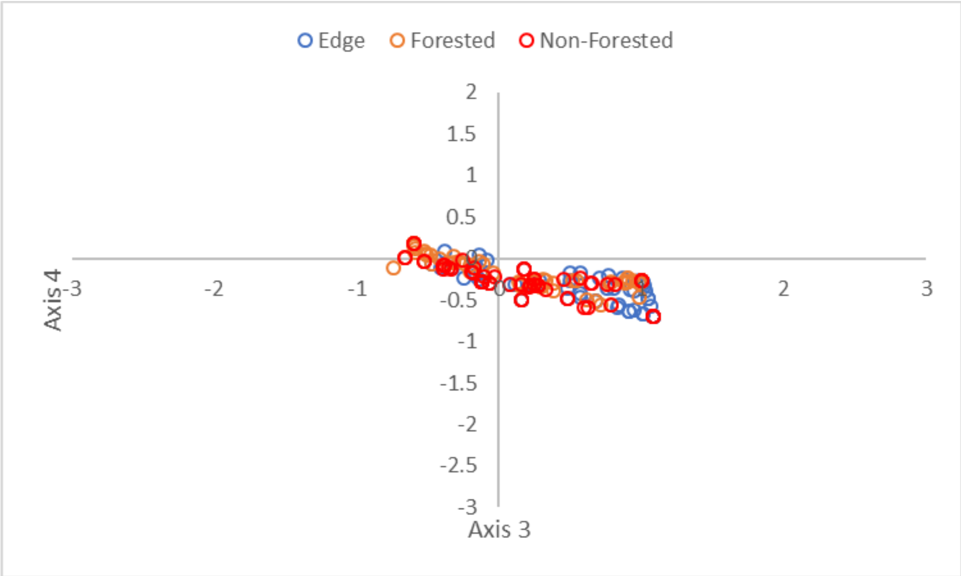

Figure 11 CA ordination plot using axis 3 and 4 displaying fire site scores. The non-forested quadrats are represented with red circles, the forested quadrats as orange circles and the edge quadrats as blue circles.

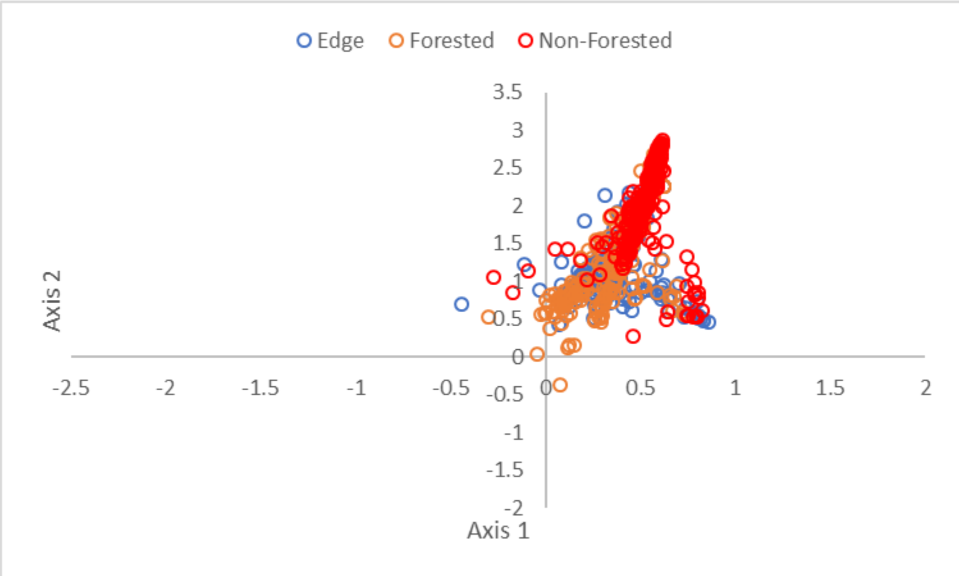

Figure 12 CA ordination plot using axis 1 and 2 displaying insect site scores. The non-forested quadrats are represented with red circles, the forested quadrats as orange circles and the edge quadrats as blue circles.

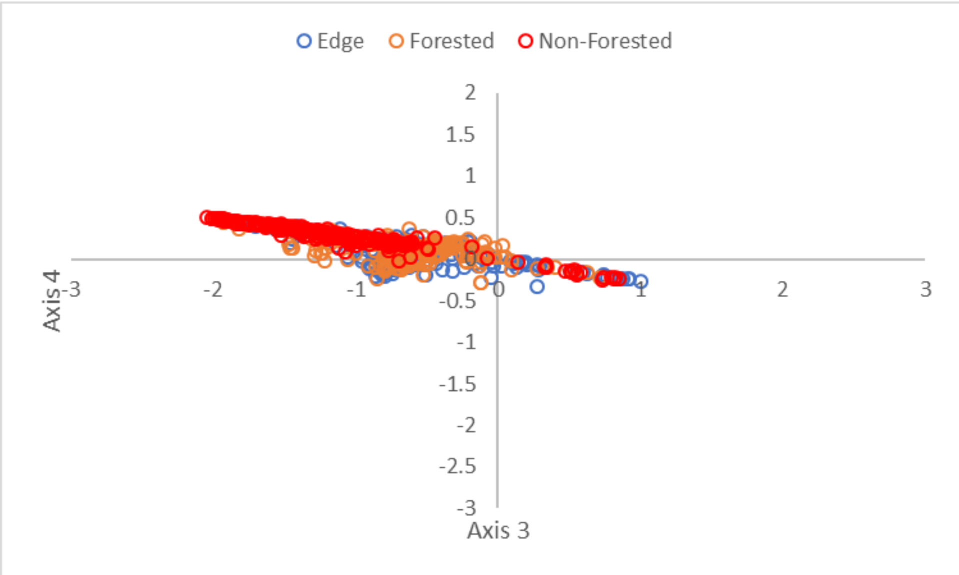

Figure 13 CA ordination plot using axis 3 and 4 displaying insect site scores. The non-forested quadrats are represented with red circles represent, the forested quadrats as orange circles and the edge quadrats as blue circles.

Average axis 1 values show that species composition was very similar between edge and forest for most study sites except the coastal and barren edge types (Table 2). The non-forested area and edge were similar between fire and insect edges but not the other study sites. The fire and insect study sites had similar species composition between the edge, forest and non-forest. The widest variation in species composition was for barren edge, lakeshore edge and coastal forest as shown by the standard deviation.

Table 2 Average axis 1 values and their associated standard deviation for all six natural edge types split into edge, forested and non-forested quadrats. N/A means the non-forested side was water.

	Forested Average	Forested Standard Deviation (+/-)	Edge Average	Edge Standard Deviation (+/-)	Non-Forested Average	Non-Forested Standard Deviation (+/-)
Coastal	-0.560	0.682	-1.110	0.536	N/A	N/A
Barren	0.180	0.376	-0.845	0.960	-1.627	0.370
Lakeshore	0.820	0.319	0.503	0.688	N/A	N/A
Bog	0.732	0.079	0.564	0.154	0.300	0.166
Fire	0.402	0.366	0.533	0.471	0.344	0.384
Insect	0.335	0.167	0.395	0.189	0.520	0.133

3.3 Species

Species associated with the coastal sites included *Trientalis borealis, Maianthemum canadense, Cornus canadensis, Pteridium aquilinum,* and *Dicranum* sp (Figure 14). The barren sites had species including *Vaccinium angustifolium, Gaultheria procumbens, Kalmia angustifolia,* and *Pleurozium schreberi* (Figure 14). The lakeshore sites had associated species *Pteridium aquilinum, Trientalis borealis, Dicranum sp, Vaccinium myrtilloides,* and *Pleurozium schreberi* associated (Figure 14). The bog allied species were *Sphagnum sp, Pleurozium schreberi, Kalmia angustifolia, Vaccinium* *myrtilloides*, and *Trientalis borealis* (Figure 14). The fire sites had species *Trientalis borealis*, *Maianthemum canadense*, *Cornus canadensis*, *Pteridium aquilinum*, and *Dicranum sp* associated while the insect sites were accompanied by *Maianthemum canadense*, *Cornus canadensis*, *Pteridium aquilinum*, and *Trientalis borealis* (Figure 14). These were obtained by overlaying each edge biplot to see species composition.

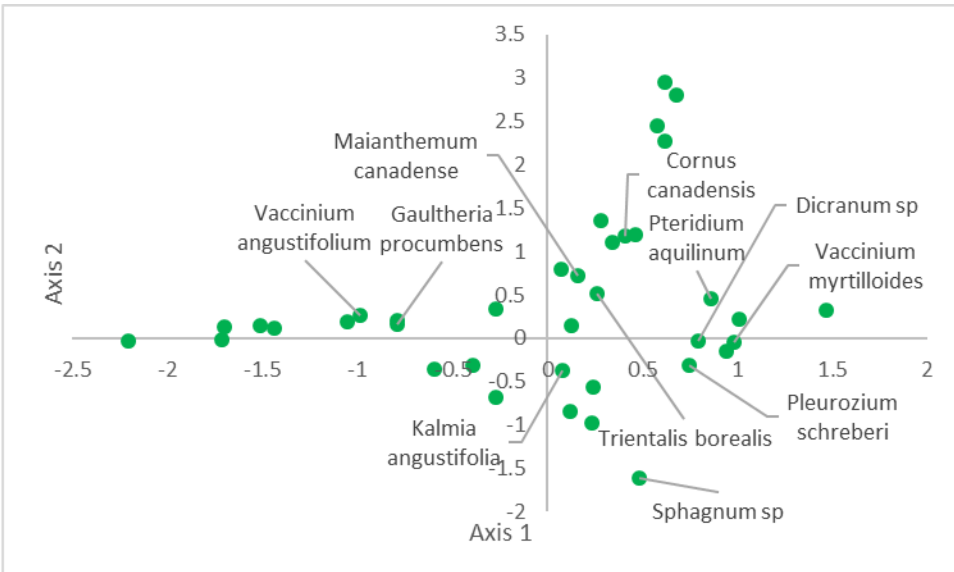

Figure 14 Species scores for the correspondence analysis of all sites. The species graph was utilized to determine what major species was at each site and for simplicity only species with a 20% frequency or higher were labelled as the major species.

4. Discussion

4.1 Differences between studies

The most prominent trend is the lack of distinction and high overlap between the three distance categories for coastal, fire and insect edges. This lack of distinction appears to be tied to disturbance level. While coastal edges are considered an inherent, undisturbed edge, they can be exposed to storms and wave surges that would introduce an element of disturbance. The opposite of this is the distinction between distance categories for the lakeshore, bog and barren sites. For these edge types the lack of disturbance allows for the development of more complex boundaries and different species composition. The importance of natural disturbances on ecosystems is already recognized as drivers of forest ecosystem dynamics and the cause of changes to structure and function of the disturbed forest (Thom and Seidl 2015). These natural disturbances are thought to stimulate biodiversity and restore ecosystem functioning to its original state (Thom and Seidl 2015). In other studies that looked at disturbance regimes it was noted that areas of disturbance often see a ‘reset’ in species where those with opportunistic nature exploit the recently altered area and as time passes complexity can develop as other species move and compete in the area (Fleming 2000). This ‘reset’ in species could explain the lack of apparent complexity and high overlap we seen in the coastal, insect and fire disturbed edges.

The forested side for barrens and coastal edge types was very similar. This can be explained because the coastal forested area was a forest/barrens system so there would be similar species overlap. Burley et al (2010) noted that coastal barrens can host rare plant species. The high similarities in these two forested systems suggest that both study types may be supporting the same rare species.

The lakeshore and barren study shared high similarity and overlap between the forested side of each study type and also between each studies’ edge. This lakeshore would have Atlantic coastal plain flora (ACPF) habitat. This habitat has characteristic species depending on if its lakeshore, salt marsh, wetland, etc. (Mersey Tobeatic Research Institute, 2011). ACPF is found not only at lakeshores but also in rocky barrens areas when near a wet ecosystem (MTRI, 2011). The forest and the edge at these two edge types may have had high similarity and similar species as they both possess ACPF.

The bog and lakeshore forested areas were also similar. This could be related to the similar water content and similar location. The areas sampled for both these edge types were extremely close together and thus would share similar forest, weather conditions and soil type.

4.2 Species composition differences at the edge, forested and non-forested areas

There was a high amount of edge-forest overlap at the barren, bog and insect edge types and a smaller amount of overlap at the coastal, lakeshore and fire edges. All six edge types in this study did see some amount of overlap between the edge and the forest meaning some amount of similarity in species composition. This has been supported by others (Harper and MacDonald, 2001) who also found that understory species at lakeshore edges had similar cover in the interior forest. They also found greater herb diversity at the edge but not richness (Harper and MacDonald, 2001). These findings could explain how some of the edges only experienced moderate overlap between the forest and the edge. Some species had similar cover at both the edge and forest, but it has also been found the edge has greater diversity then the forest meaning there would not be complete overlap. Previous studies have found edge influence extending up to 40 meters into the forest at natural burned edges (Harper et al 2004). Edge effects can cause changes in soil, light, wind and other factors which help to define the edge (Luczaj and Sadowska 1997). Many studies recognize the possible influence edges have in changing the surrounding abiotic factors (Moen and Jonsson, 2003; Cooper et al. 2012; Murcia

1995). The forest quadrats are far enough away to not experience edge influence which means that the edge and forest may be compositionally similar in microclimate and thus the edge may not have experienced much influence and change in its abiotic factors.

Edge types with high amounts of edge and non-forested overlap included barren, bog and insect as well as fire had a lesser amount of overlap in this region as well. The barren, bog, insect and fire edge consist of partially patchy landscape as well as sections of developed forest. Natural landscapes such as these do not always have clear boundaries. In the barren, for example, forest encroachment makes defining the edge a somewhat arbitrary task (Burley et al. 2010). Species composition forms a gradient and is not an abrupt switch between barren and forest (Burley et al. 2010). This kind of gradient may explain the species overlap seen between the non-forest and the edge as well as the overlap between the edge and the forest.

The only edge type with any notable amount of overlap was the fire edge, which had overlap between all three distance categories, but no defining pattern. The fire edge used in this paper was a more recent fire with a well-defined edge. The crown fire boundary was distinct, but the ground fire boundary was less discrete. In a study by Harper et al (2004) that looked at young fires they noted that the influence of the edge did not extend far for cover of individual species except those that would be directly influenced by burning, like mosses and snags created by the fire. In older fires in the boreal forest edge influence rarely penetrated past 5m into the nearby forest and the gradient between the forest and edge was structurally and also compositionally similar (Harper et al. 2014). A previous study that looked at species composition at this fire edge also found a lack of difference which is quite unusual (Heathcote 2010). The lack of distinction between edge, forest and non-forest is therefore uncertain and could be the result of rapid re-sprouting but further analysis would be needed to determine the exact cause.

In conclusion we do see differences between sites but, we also see similarities between different sites. The reason for these differences and similarities between sites is possibly linked to disturbance level at each study site. This is not yet completely understood and should be researched further. Species composition at the edge, forest and non-forest was unique for each site. The forested and edge quadrats had similarity and overlap in all six edge types. The edge and non-forested quadrats had the same trend in all edge types with non-forested distance category. There was not much overlap in species composition between the forested area and the non-forested area which could be related to unstudied abiotic factors. There seems to be a gradient in species composition from the non-forested to the forested quadrats. These results provide insight for conservation in understanding species composition and potential effects of conserving natural forest edges. Understanding that species composition is not entirely the same, and can possibly be quite different, across the edge might influence decisions in creating protected areas in the future.

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