SUCCESSIONAL RESPONSES OF A BLACK SPRUCE ECOSYSTEM TO WILDFIRE IN THE NORTHWEST TERRITORIES

FINAL REPORT

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ABSTRACT

Wildlife and vegetation abundance data were collected in 14 burns of increasing age in areas originally dominated by black spruce to establish the successional process and time-frames in this particular ecosystem. Almost all vegetation species were present within a few years of the fires and the successional process was an increasing/decreasing of abundance and dominance rather than an actual replacement of species. Stands returned eventually to black spruce but only after other shrubs and plants first held sway. Vegetative species richness and diversity reached their maxima early in the succession. Total small mammals appeared to recover almost immediately but species differences occurred. Snowshoe hares recovered substantially after about 10 years. Marten recovered to reasonable numbers after about a decade but were present within the first couple of years. Much Coarse Woody Debris appears to be left after burns in black spruce forests which would provide good cover for furbearers and their prey for many years. Moose populations used burns after about 5 years and then continued to increase in density at least into the 20th year after a burn. Several smaller studies are recommended which should further clarify successional patterns, especially of the mammal populations.

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INTRODUCTION

The impact of fire on populations of furbearers and large game is a major concern to the people of the NWT who live below the treeline. Logistically and economically, total suppression is not possible. Governments and others also see fire as a necessary part of the boreal forest ecosystem (NWT Forest Fire Management Policy 1990). From a wildlife perspective, total suppression is not always desirable, as some species prefer the earlier stages of post-fire succession (Kelsall et al. 1977).

For government to discuss fire management of a trapper's trapline or a community's hunting area, users must have the best data possible regarding the chronology of post-fire succession in vegetation, furbearers, large game, and furbearer prey species. We should be able to tell them with some confidence the sequence of events that will happen after fire (wild or prescribed) goes through an area.

As we move into an era of Integrated Resource Management plans, knowing the length of time required for succession to occur will be of considerable importance for other land management decisions besides fire fighting. Whether areas are to be used for timber harvesting, trapping or hunting, a large fire can dramatically affect their usefulness for that particular activity. Just as trappers must consider how long an area will require to full production, so must our foresters know how long an area will take to return to the state of development suitable for timber harvesting. Unfortunately, we have little data to show how or over what period the vegetation and wildlife responds to large fires.

This lack of data regarding the impact of fire on populations of furbearers has been reported by many authors (Kelsall et al. 1977; Bunnell 1980; Stephenson 1984; Magoun and Vernam 1986; Bob Bailey- application to CCFFM 1989). Stephenson (1984) interviewed 62 Alaskan trappers regarding their observations of furbearer populations in 44 different burns. Most trappers generally felt that fires were beneficial in the short term, especially for marten, and that lynx generally took longer to respond, i.e. 15-20 years. The most dramatic conclusion was that the areas regarded as exceptionally good habitat for furbearers generally had the shortest fire cycles. Although the trappers attributed the short-term response of the furbearers to increased abundance of small mammals, there is no field data to support this reasonable contention.

Yeager (1950) and others reported that marten required mature, closed canopy, conifer forest for habitat. They suggested that large burns are detrimental to marten populations for many years (Lensink 1953, Murphy et al. 1980; Koehler and Hornocker 1977). They believed marten would only use edges of burns in winter and perhaps hunt in the summer in open areas. However, Magoun and Vernam (1986) found some radio-collared marten were living entirely within a seven year old burn in Alaska. Similar results have been found in Norman Wells (Latour et al. 1994). We have had several trappers in the South Slave report good marten abundance in the middle of large 10-15 year old burns, while other trappers using similar aged burns have reported no marten sign at all.

The response of marten and other furbearers to fires will depend greatly, but not entirely, on how the vegetation regenerates. In the boreal forest, it has been suggested that there is no succession in the classical sense of the term, only a cycling of the forest by fire (Kelsall et al. 1977). A mature forest in the South Slave is usually black spruce or jack pine but white spruce may predominate along river and lake edges. In the majority of cases, a mature forest that is burned should regenerate immediately back to the pine or black spruce that was there before the fire (Rick Lanoville, pers.comm.). The full successional sequence should only occur over a burn when a second fire eradicates a young, regenerated forest that has not yet produced seeds. The response of the herbivores, both large and small, will likely be controlled by the response of the vegetation. The response of the predators that feed upon those herbivores should depend upon their preys' response.

Most hunters and biologists agree that moose prefer early successional stages following fires (Kelsall et al. 1977). In the Slave River Lowlands this is particularly evident where the vegetation appears to be following a multi-stage regeneration process (Graf, unpubl. data). We have no data to suggest how the moose respond to a one-stage regeneration process.

Therefore, to be able to discuss the impact of fire on furbearers and large game with trappers, hunters and other stakeholders, we must first determine and understand the impact of fire on the vegetation and the herbivores. Most trappers have indicated that the majority of their fur harvesting occurs in black spruce stands and so they would be most interested in the response of that ecosystem to fire.

The general questions that will be addressed are listed here and the more specific research hypotheses are listed in Appendix A, Table 4:

1. What is the pattern of post-fire vegetation succession? Will black spruce forests regenerate as a monoculture?
2. How will the populations of small mammals respond, specifically *Microtus, Peromyscus* and *Clethrionomys* species? Will they respond at the same rate?
3. How will snowshoe hares respond?
4. How long will it take for marten and lynx to return in numbers?
5. How soon will moose populations respond?
6. How much and what type of Coarse Woody Debris is left after fires in black spruce stands?

This study will address the above questions by gathering wildlife and vegetation abundance data in burns of increasing age that occurred in areas originally dominated by black spruce.

METHODS

Study Sites

Fourteen burns were chosen as study sites: 2 each at burn ages of 0, 2, 5, 12 and 106 years, as well as one each at burn ages of 20, 22, 139 and 249 years (Fig. 1). To be considered, each burn had to be at least 5,000 hectares, and had to have been a black spruce stand prior to burning which we determined by the species of the logs on the ground and the standing snags. With the older burns (i.e. older than 25 years), it was not possible to ascertain stand type prior to burning with any great confidence so we chose stands of live black spruce.

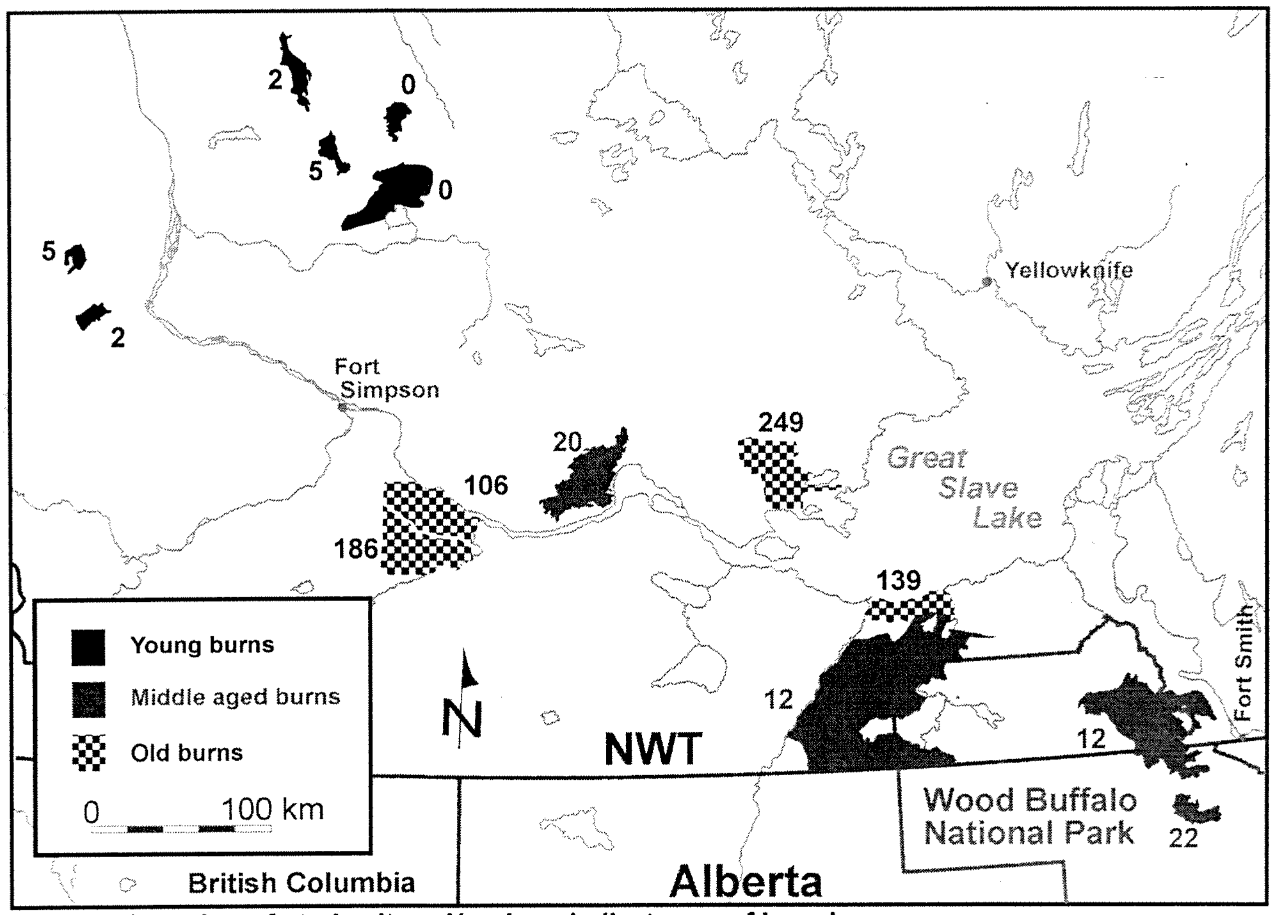


Figure 1 Location of study sites. Numbers indicate age of burn in years.

Forest Aging

Within each burn, several trees were aged by counting annuli, either from cross sections or core samples. Samples were taken at DBH (diameter at breast height) or at the stump. In the younger burns (< 25 years) we chose trees killed in the fire, and in the older burns live trees were used. When possible, live trees with fire scars were chosen.

Vegetation

Vegetation Sampling

We measured the abundance of live mosses, lichens, forbes, graminoids, shrubs and trees. The 1 m^2 study plots were arranged in 2 transects of 15 plots each, with 25m between each plot, and 50m between transects, giving a total of 30 plots within each burn. Three types of vegetation data were collected in each plot: percent cover, number of stems, and stem heights.

Percent cover was visually estimated for each species occupying space above the 1 m^2 plot as well as the amount of unvegetated space or bare ground. Numbers of stems of each woody species were counted if they were rooted within the plot. The first 20 black spruce stem heights were measured using a meter stick or a clinometer. Stems of all other woody species were counted at four height classes: $x < 1$ m, $1 \leq x < 1.5$ m, 1.5 m $\leq x < 2$ m, $x \geq 2$ m. The stems were re-counted as they passed through each height class, i.e. a stem that was 1.75 m tall was counted three times; once for each of the first three height classes.

For the four oldest burns, we used the T-Square technique (Besag and Gleaves 1973 as described in Krebs 1989) to count the number of stems per ha for black spruce and other mature trees as the meter square technique could not sample these large stems adequately.

Coarse woody debris was sampled along the vegetation transects. All logs crossing the transect were counted, and the first 5 logs were measured for length (in metres), diameter (in centimetres), and distance above ground (DAG; in centimetres). Diameter and DAG were measured with a tape, and length was estimated visually. Snags (dead standing trees) within ½ m on each side of the transect were counted, and the first five were measured for diameter at breast height (DBH). Roots and stumps within ½ m on each side of the transect were counted, and the first five were measured for diameter at breast height (DBH).

Vegetation Data Analysis

The percent cover data was arcsine transformed to achieve a normal distribution. Shannon-Wiener species diversity indices (*H'*) were calculated according to Krebs (1989). *H'* combines information on number of species and abundance. It increases with number of species, and for equal numbers of species, a high value indicates equal representation of all species, whereas a low value indicates dominance of a single species (Ludwig and Reynolds, 1988). A jacknife estimator for the Shannon-Wiener diversity index was used (Krebs 1989).

Shannon-Wiener Diversity Index

$$H' = \sum_{i=1}^{s} (p_i)(\log^2 p_i)$$

where $\boldsymbol{H'}$ = index of species diversity
$\boldsymbol{s}$ = number of species
$\boldsymbol{p_i}$ = proportion of total sample belonging to i^{th} species

Jacknife Estimator

Calculate pseudovalues of *H'* for each recombining of the data:

$$\phi_i = nH - (n-1)H_t$$

where ϕ_i = pseudovalue for jacknife estimate of diversity index *i*
$\boldsymbol{n}$ = original sample size
$\boldsymbol{H}$ = original diversity index
$\boldsymbol{H_t}$ = diversity index when original value i has been discarded from sample
$\boldsymbol{i}$ = sample number (1, 2, 3, ...*n*)

The mean and standard error for the diversity index are then estimated from the *n* pseudovalues.

Vegetation and coarse woody debris data were also analysed with multivariate techniques. Direct gradient analysis (Gauch 1982) is an examination of individual species abundance in relation to an environmental gradient and was used to search for patterns in relation to burn age. Ordination is the mathematical distillation of multidimensional data (in our case the species by samples data matrix) into few dimensions such that similar entities are close by and dissimilar entities are far apart (Gauch 1982). Two kinds of ordination were used to aid in describing the post-fire succession: detrended correspondence analysis (DECORANA) and principle components analysis (PCA). Two way indicator species analysis (TWINSPAN) and cluster analysis were used to classify the samples based on their species assemblages (Gauch 1982). We considered the latitude, longitude, elevation and age of the burn as variables.

Ordination and Classification of Percent Cover Data

Ordination is a mathematical technique for analysing multivariate data; in our case it reduces the species by samples data matrix (i.e. multi-dimensional data) into a lower number of dimensions to aid in understanding community structure. Classification is a related mathematical technique that groups the samples based on the similarity of their species abundance. There are many types of ordination and classification techniques, and there is little agreement in the literature as to which are the most effective for analysing community vegetation data. Gauch (1982) recommends using a few techniques on the same data set to enhance interpreting community data. We used two types of ordination: principal components analysis (PCA) and detrended correspondence analysis (DCA), and two types of classification: two-way indicator species analysis (TWINSPAN) and cluster analysis.

PCA is an eigenanalysis technique best suited for short environmental gradients, i.e. little sample variability (Gauch 1982). PCA provided a somewhat better picture of temporal succession than did DCA: there was a clear separation of the early, middle and late sites, and age emerged as a correlate of PCA axis 2 (Figure 8). The most important correlates however, were still latitude, longitude and elevation. In PCA there was a clear (albeit quite curved) successional path in ordination space from the early, to middle, to late sites.

Small Mammal Trapping

An index of small mammal abundance was obtained using snap-traps. Traplines were set adjacent to the vegetation transects. Three nights of snap-trapping were conducted with 300 traps set each night to make 900 trap nights (TN). A random starting point was chosen along the baseline and six parallel lines were established at 50 m intervals. Along each line there were 10 stations, 15 m apart. At each station one Museum Special and two Victor traps were set, using a peanut butter/oat mixture as bait. Wet bogs were avoided. The traps were checked each morning, dead animals were removed, and the traps reset. The index of abundance was captures per 100 trap-nights adjusted for closed traps (Nelson and Clark 1973).

Track Counts

Tracks were counted from snowmobiles along cutlines in the burns except when accessibility forced us to count tracks from a helicopter. For the aerial track counts, 2 km transects were arranged randomly within the burn, on the condition that each transect be at least 1 km from the edge of the burn as well as from the adjacent transects. Compass orientation of each transect was assigned at random. A minimum of 20 transects were plotted in each burn. The surveys were flown as low and as slow as possible (usually about 15 m above the ground and at a speed of 60 km/h). The same observer was used for all burns. Any track that intersected the helicopter skid (as seen by the observer) was counted. Species counted were marten, moose, fox, wolves, weasels, squirrels, hares, lynx, coyote, and grouse.

Track counts from snowmobiles were done in the same way, except for the arrangement of the transects. Transects were laid out consecutively along old cutlines and 20 transects were chosen at random for analysis after the survey was completed.

Golden's (1987) method of standardizing track counts was used with regard to days since last snowfall: Corrected Track Count = (Track Count * 1.5) / #Days since last snowfall. Track counts were standardized to 1 km. This standardization has been used elsewhere in the N.W.T. (Latour and MacLean 1990).

The relationship between helicopter and snowmobile track counts was tested in the extremely large 12 year old burn near Hay River. An observer drove along predetermined cut-lines with a snowmobile and counted tracks. An hour later, a second observer flew along the same cutlines and re-counted the tracks.

Moose Population Estimates

The census method used was strip transect, except for one 2 year old burn which was done as a block survey. The transects were flown with a Cessna 337 or 185, at 125 m agl and 180 km/h, with a strip width of 940 m. Coverage varied from 25% to 100 % depending on the size of the burn. Six burns had 100 % coverage and therefore no precision estimate was obtained. Where coverage was less than 100%, data were analysed according to Gasaway (1986) to obtain a population estimate, density and 90% confidence intervals.

RESULTS

Forest Age

Fire records from the GNWT fire centre provided us with precise ages for the 0, 2, 5, and 12 year old study sites (two study sites at each age) as well as for the single 20 and 22 year old sites (a second 20 year old burn was not available). The original intention was to sample two burns each at 80 and 150 years, but the lack of fire history data prior to 1960 meant that the older burns had to be aged by sampling trees from the study sites. There were four study sites aged, two at 106, and one each at 139 and 249 years (Appendix A). We believe these ages are about average for the stand of trees that was examined as they were derived from the average sized trees at each site (Appendix A).

We attempted to examine only burns within the Taiga Plains Ecozone in the southern NWT but did include two burns in the boundary area with the Taiga Cordillera Ecozone in the foothills of the Mackenzie Mountains.

Vegetation

i. Species Richness & Diversity

Species richness or the number of species found within each study site, rose rapidly during the first 22 years, then decreased slightly in the old growth sites. During the first 22 years, the curve can be described by a logistic function; no attempt was made to model the last 4 points due to small sample size (Figure 2).

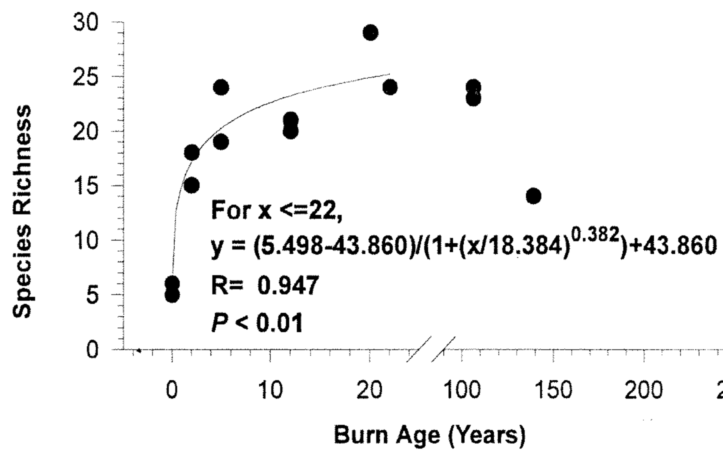


Figure 2 The relationship between burn age and species richness.

The Shannon Wiener diversity index is a measure of the degree of heterogeneity in the samples. The pattern of diversity was very similar to that of richness; a logistic rise until burn age 22 years, then a slight decrease in the old growth sites (Figure 3). Again, no attempt was made to model the last 4 points due to small sample size.

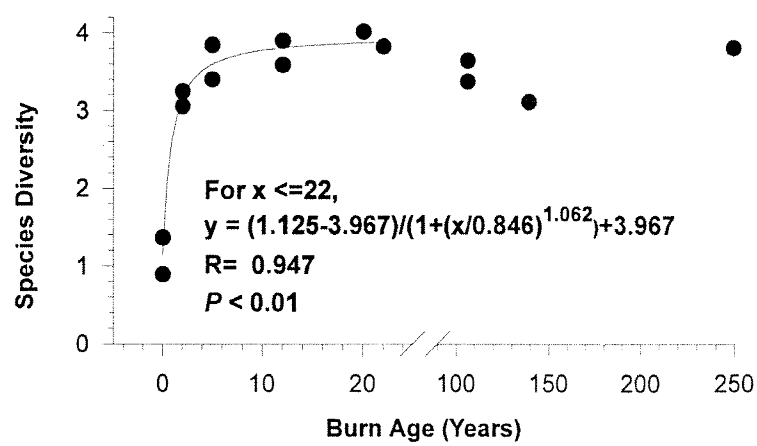


Figure 3 The relationship between burn age and Shannon-Wiener species diversity.

ii. Unvegetated Space

Unvegetated space declined rapidly with age, reaching its minimum (about 15%) after about 30 years (Figure 4).

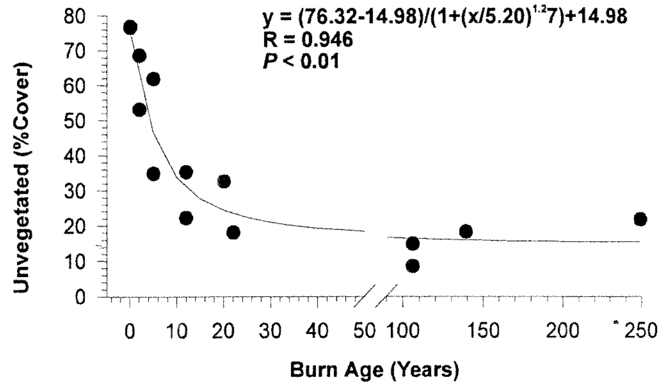


Figure 4 The relationship between burn age and percent cover unvegetated space.

iii. Vegetation as Percent Cover

As the years since the burns increased, some plant species increased in abundance, some decreased, and others reached a peak and declined.

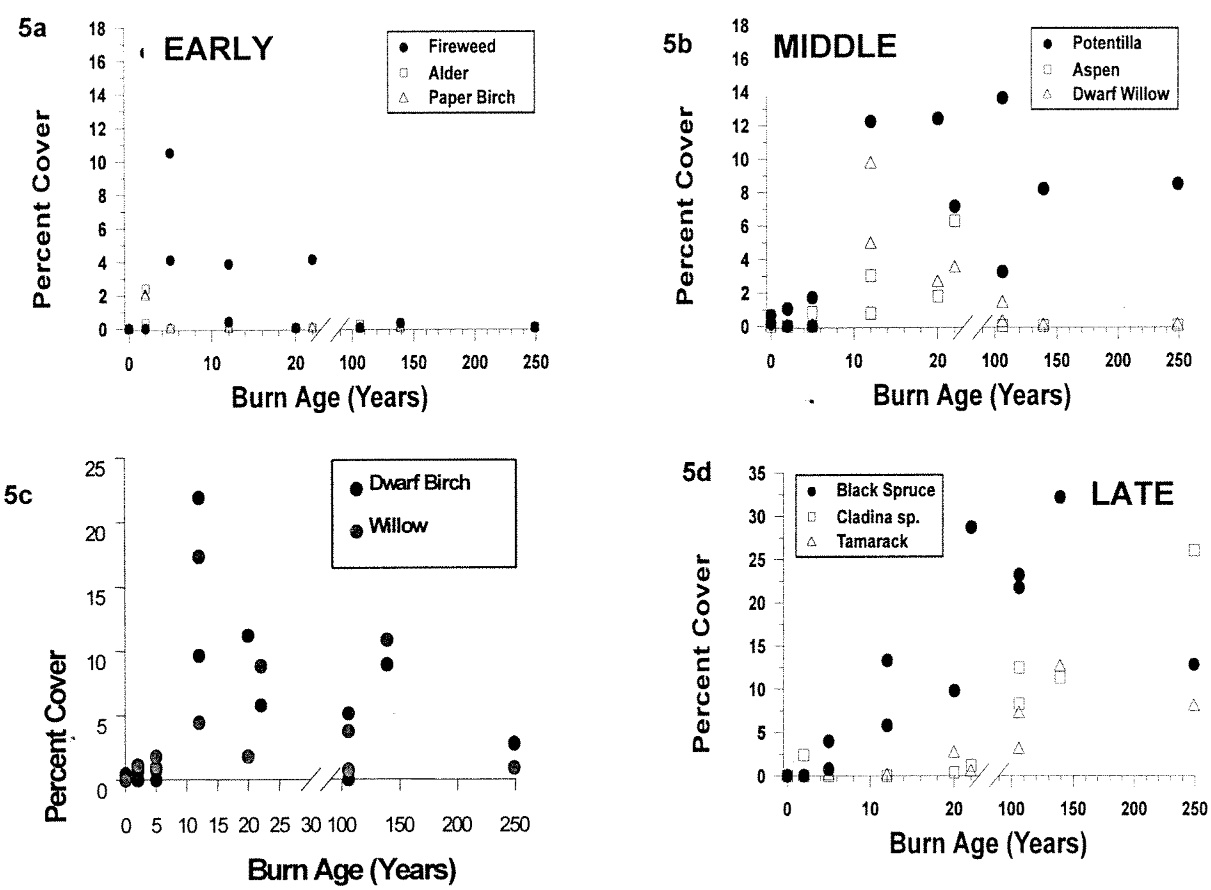


Figure 5 (a - d) Percent cover for plants prevalent in the early (a), middle (b & c) and late stages (d) of succession.

Fireweed *(Epilobium angustifolium)*, alder *(Alnus crispa)*, and paper birch *(Betula papyrifera)* achieved their greatest abundance in the early successional stage (0 - 5 years, Fig. 5a). Potentilla *(Potentilla fruticosa)*, dwarf willow, and aspen *(Populus tremuloides)* were most abundant in the middle of the succession (12 to 22 years, Fig. 5b) but were exceeded by the coverage of the dwarf birch and willow during the earliest portion of this part of succession (Fig. 5c). Black spruce *(Picea mariana)*, lichens and tamarack *(Larix laricina)* were most abundant in the late stage of the succession (over 100 years, Fig. 5d).

Many plants, like rose *(Rosa acicularis)*, sweet gale *(Myrica gale)*, and Labrador tea *(Ledum groenlandicum* Figure 6), did not seem to follow any clear successional trend; i.e. they were either generalists, or their abundance was related to some factor other than burn age.

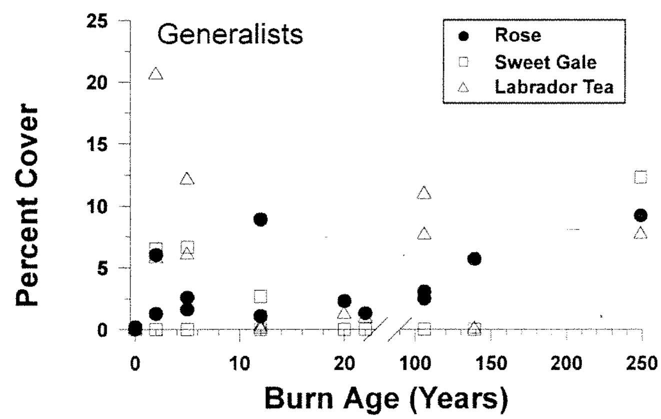
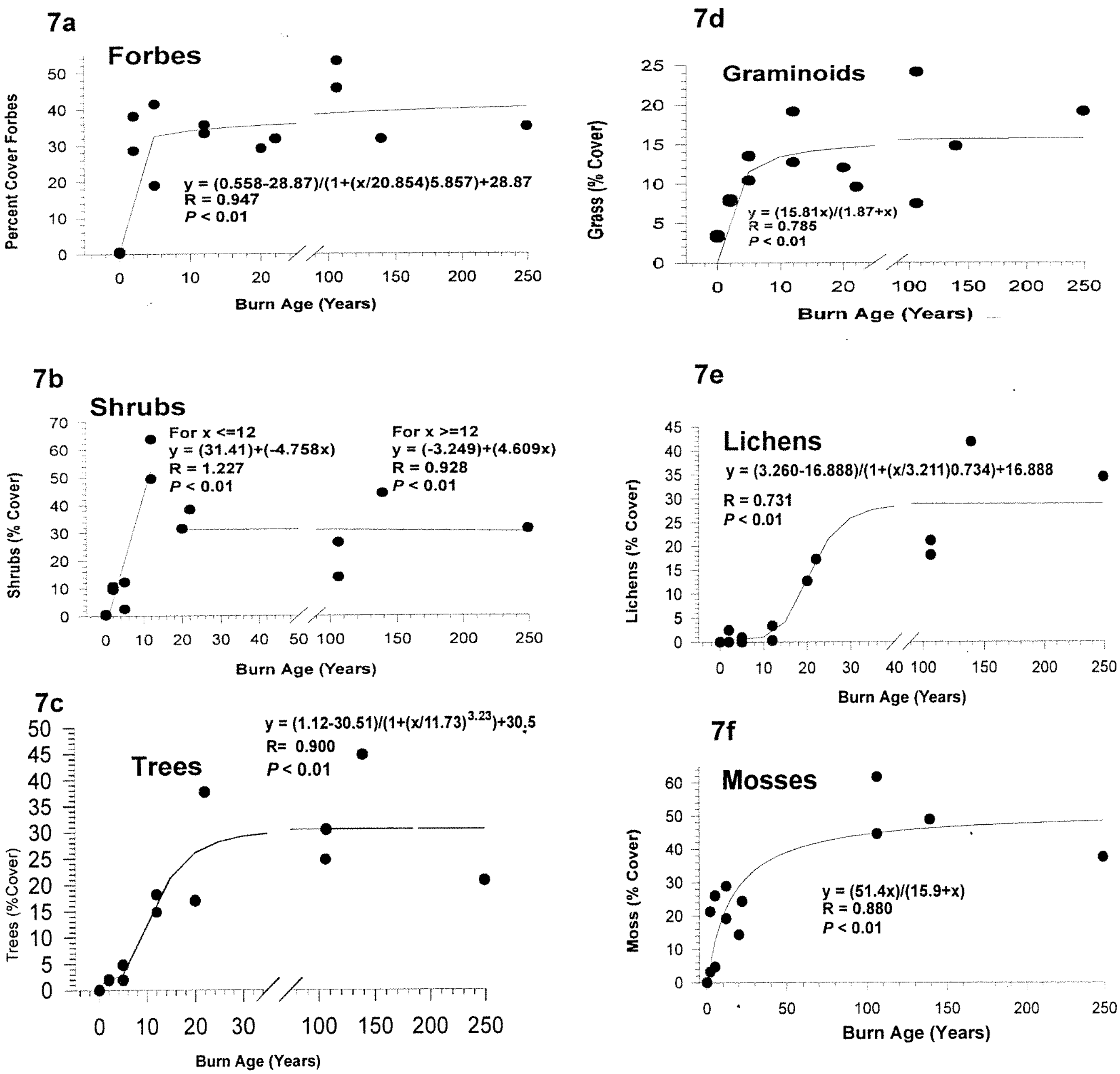


Figure 6 Percent cover for plants with no successional preference.

Finally, many plants were simply rare and found in only a few sample plots so no inferences could be made about their place in a temporal succession. Summaries of the percent cover data for all species are provided in Appendix B.

For a coarser analysis, the vegetation data was pooled into 6 groups: forbes, shrubs, trees, graminoids, mosses, and lichens (Fig. 7). Forbes percent cover increased rapidly over the first 2 years, then increased only slightly from age 5 to 249. Shrubs increased for the first 12 years, then decreased from age 20 to 249. Trees increased slowly until age 20 and reached a maximum coverage likely around 100 years before beginning a slow decline (Fig. 7c). Graminoids increased until age 12, then stayed constant. Lichens did not reach substantial coverage until somewhere between age 22 and 106 and then more than doubled to age 249 (Fig. 7e). Mosses increased rapidly until age 22, then increased more slowly until age 249 (Fig. 7f).

Figure 7 Percent cover relative to age of burn for forbes (7a), shrubs (7b), trees (7c), graminoids (7d), lichens (7e) and mosses (7f).



Ordination and Classification of Percent Cover Data

Both ordination techniques indicated that species richness and diversity were greater in the middle and old sites, compared to the early sites.

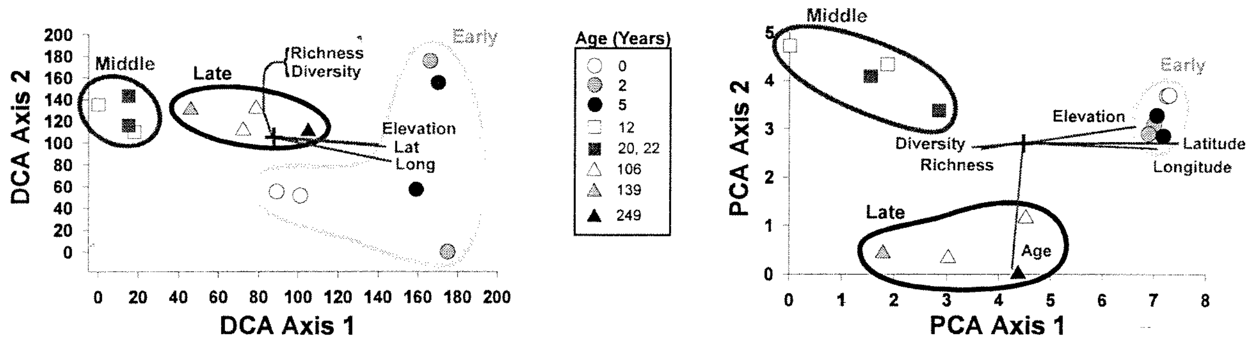
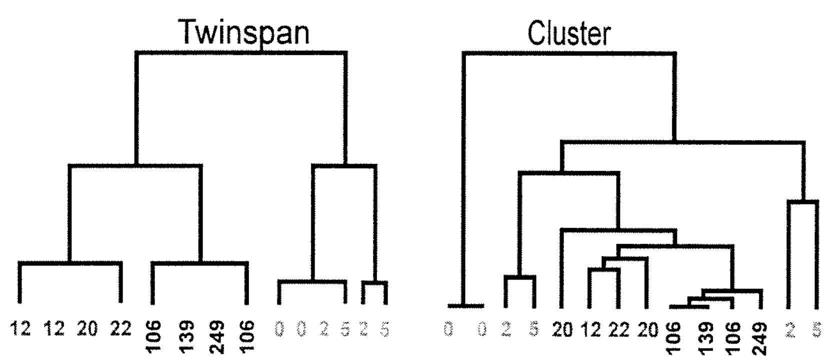


Figure 8 DCA and PCA ordinations of vegetation percent cover data. Vectors are proportional to the strength of correlation of each variable with the ordination axes.

The two classification techniques differ in that TWINSPAN is divisive (beginning with all samples in a single cluster, then dividing them into a hierarchy of smaller and smaller clusters), while cluster analysis is agglomerative (beginning with each sample in its own cluster then grouping them into a hierarchy of larger and larger clusters). The length of the vertical lines in the classification diagrams is proportional to the magnitude of the eigenvalues.

Figure 9 TWINSPAN and cluster analysis of percent cover vegetation data. Numbers refer to age since burning.



TWINSPAN classification separated the young sites from the middle and old, then separated the middle sites from the old sites (Figure 9). TWINSPAN also separated a pair of sites (2 and 5 years) from the other young sites. Cluster analysis first separated the young sites into 3 groups before separating them from the middle and older sites. The old sites ended up in one cluster, while one 20 year old site was separated from the old sites and the rest of the middle sites.

The ordinations and classifications indicate that there are some environmental gradients (latitude, longitude, and elevation) in our dataset that are probably more important than age. This is probably because the young sites (ages 0, 2 and 5 years) are geographically separated from the middle and older sites (Figure 1), so analysing them separately may give us more insight into the post burn successional pattern.

The Young Study Sites (0 to 5 years)

Both DCA and PCA ordinations placed the 0 age sites far from the 2 and 5 year old sites (Figure 10), but there was no clear temporal succession with the 2 and 5 year old sites. The sites in the mountains west of the Mackenzie River had more in common with each other than with the sites of equal age on the flatlands east of the Mackenzie River. An examination of the correlation vectors (Figure 10) shows that elevation, longitude and latitude were all more important ordination correlates than was burn age.

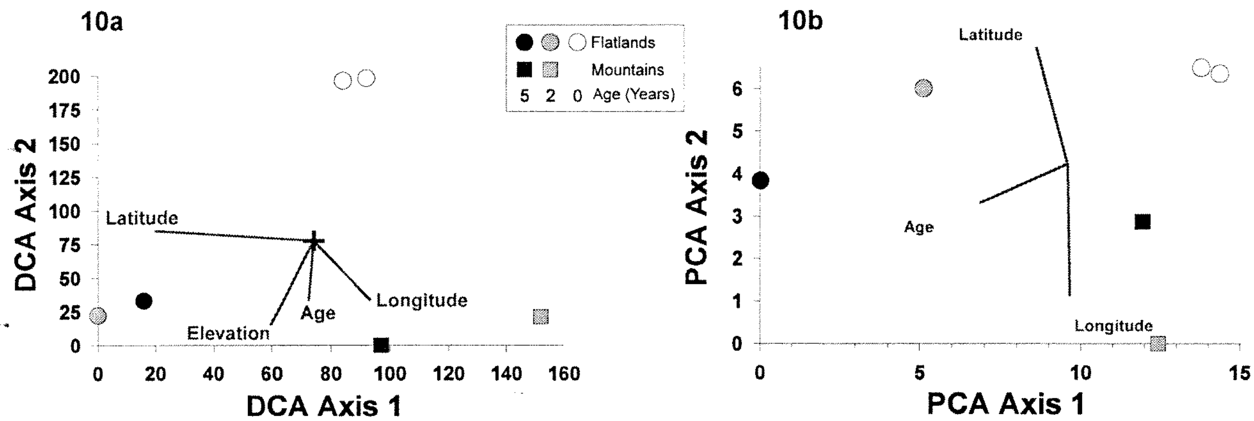


Figure 10 (a - b). DCA and PCA ordinations of vegetation percent cover data for the early successional stage. Vectors are porportional to the strength of correlation of each variable with the ordination axes.

Vectors representing correlations of the ordination axes with species richness, species diversity, and individual plants shows that the 0 age sites were nearly devoid of plants; all species, as well as richness and diversity were greater in the 2 to 5 year old sites (Figure 11). Within the 2 to 5 year old sites DCA indicated that the 'mountain' sites within the Taiga Cordillera Ecozone had relatively more dwarf birch, sweet gale, Potentilla, Vaccinium, soapberry *(Sherperdia canadensis)*, fireweed, and mosses, while the 'flatland' sites had more cloudberry *(Rubus chamaemorus)*, rose, and labrador tea. PCA indicated that the 'mountain' sites had relatively more black spruce, dwarf birch, sweet gale, horsetail, Potentilla, Vaccinium, fireweed, and mosses, while the 'flatland' sites within the Taiga Plains Ecozone had more cloudberry, rose, labrador tea and lichens.

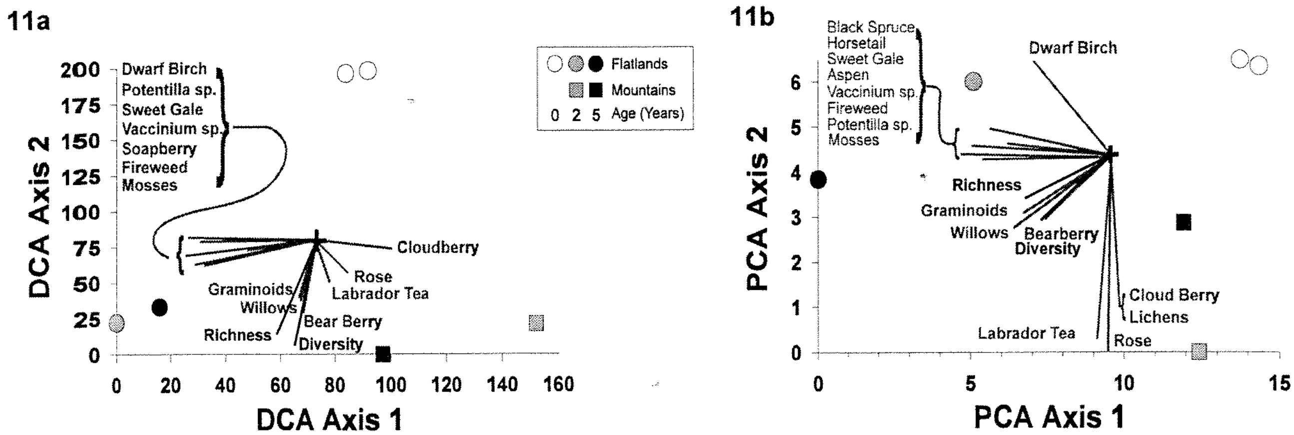


Figure 11 (a - b). DCA and PCA of vegetation percent cover data for the early successional stage. Vectors are proportional to the correlation of each variable with the ordination axes.

Middle and Old Age Sites

The DCA and PCA ordinations of the middle and old aged sites show that age is the most important environmental correlate of the ordination axes, but that once again latitude, longitude, and elevation are also important (Figure 12).

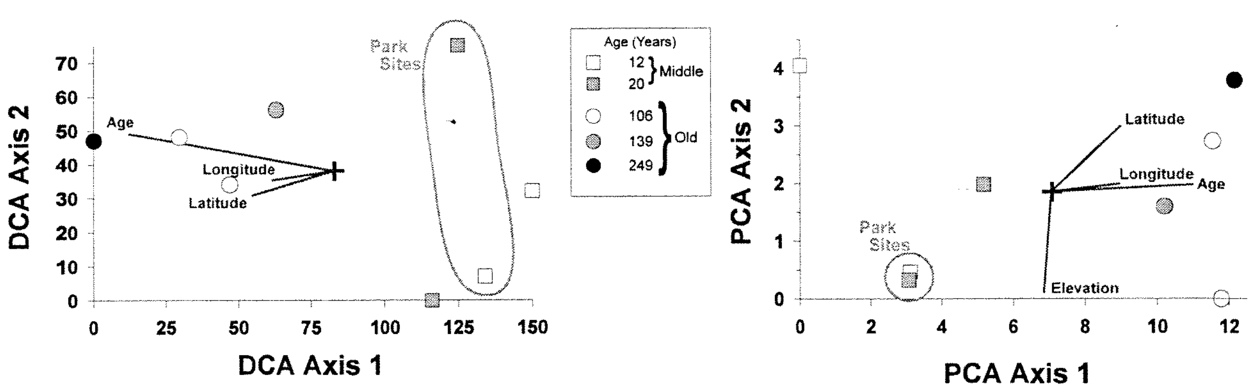


Figure 12 (a - b). DCA and PCA ordinations of vegetation percent cover data from the middle (age 12 - 22 years) and old aged (over 100 years) sites.

The strength of the age correlation is due mostly to the separation of the middle sites (12 to 22 year old) and the old sites (over 100 years old) rather than to a gradual succession within each age group. For example, in the middle sites, the PCA places the two sites from Wood Buffalo National Park almost coincidently in ordination space, even though they are different ages (12 and 22 years). The DCA places the 2 Park sites together on axis one, but separates them on axis 2.

Unlike the ordination of the young sites, species richness and diversity did not correlate with the ordination axes in either DCA or PCA (Figure 12). In other words, during the succession, some species became more abundant, while others became less abundant, as opposed to the succession in the young sites (Figures 12 and 13) where all plants increased. The old sites were associated with mosses, lichens, black spruce, labrador tea, creeping juniper, bearberry, tamarack and sweetgale. The middle sites were associated with many deciduous shrubs and trees: aspen, poplar, willows, dwarf birch, and Potentilla, as well as jackpine, fireweed, cloudberry, and strawberry.

To sum up the percent cover data, coverage of vegetation as a whole, as well as species richness and diversity, increased rapidly in the early years of the succession, reaching an asymptote by the middle years (12 to 22 years). Overall coverage of plants, as well as species richness and diversity, did not change much between the middle and late succession, but community composition did: deciduous shrubs and trees prevalent in the middle of the succession were replaced by black spruce, mosses, and lichens. Rather than representing a gradual, year to year succession, our data therefore presents a picture of 3 communities: an early succession community composed of pioneer species like fireweed, plus small amounts of the species that would become dominant later, a middle succession community dominated by deciduous shrubs and trees (or jackpine, depending on site conditions), and a late succession community dominated by black spruce, mosses, and lichens. Floristics of each site depended on geographical variables such as latitude, longitude and elevation as much or more than on precise age since burning.

Forest Structure

Vertical Structure of Trees: Dwarf Birch, Willow and Black Spruce

In the early successional stage (0 to 5 years) there are few, very short trees (Fig. 13). In the middle stage (12 to 22 years) the deciduous trees and shrubs dominate the taller strata, while short black spruce are becoming abundant. Finally in the late stage (100 years +), the deciduous shrubs and trees are becoming less abundant, while black spruce are represented in all height strata. In the oldest study site, the short spruce are again the most abundant height class.

The number of stems of black spruce increases dramatically after the first few years and continues to increase at least until 20-30 years after the burn. Later in the succession but before 100 years of age, the number of black spruce trees begins to decline and thin out.

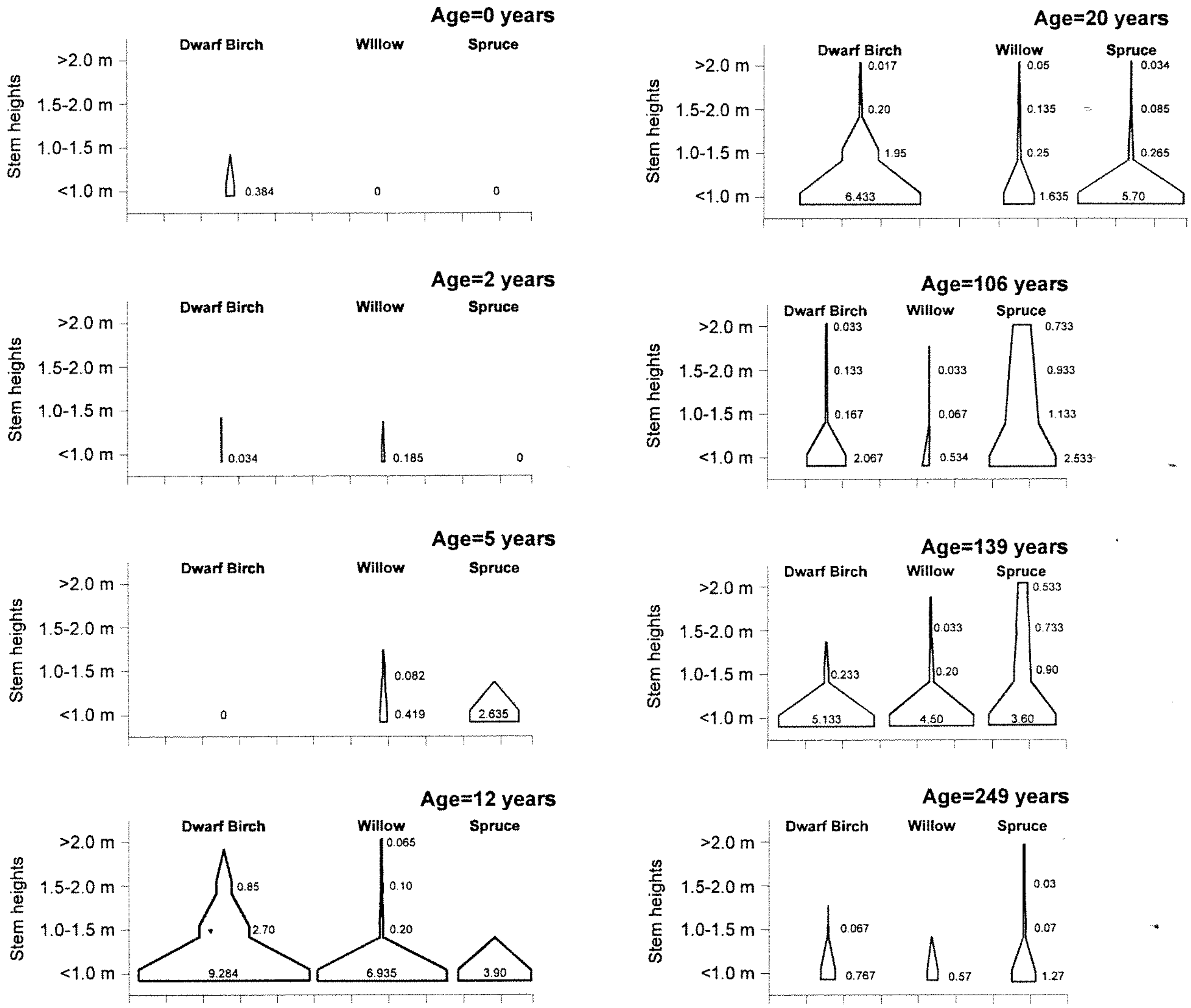


Figure 13 The relationship between burn age and vertical structure of dwarf birch, willow and spruce. Each small "spaceship" illustrates the mean number of stems of a particular species counted at each height above the ground in the m^2 study plots, e.g. in the 12 year old burns, the average number of dwarf birch stems found at ground level in the plots was 9.284, at 1.0m there were 2.70 stems, at 1.5m there were 0.85 stems and at 2.0m there were zero stems found.

Coarse Woody Debris

Logs

Both log number and volume started near zero at burn age zero and increased rapidly to age 22. Among the 4 older burns, log number and volume again started near zero at age 106 and increased through age 249 (Figure 14).

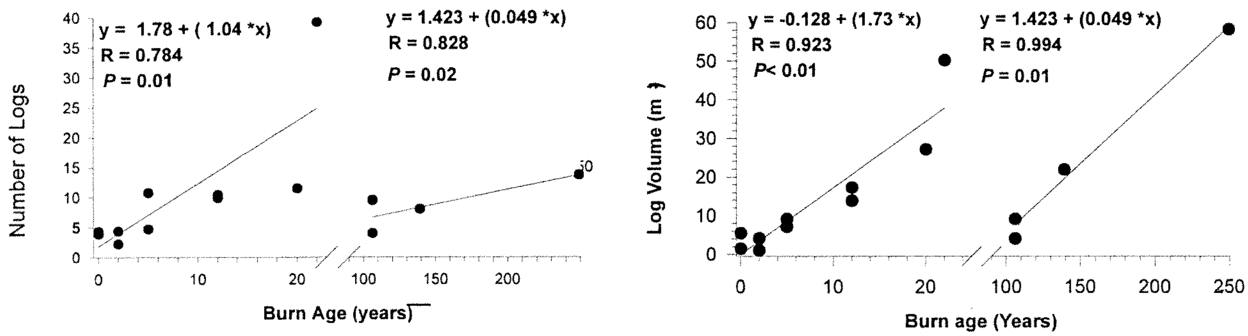


Figure 14 (a - b). The relationship between burn age and log number and between burn age and log volume.

Snags

Number of snags is difficult to interpret, as this variable is dependent on both tree density prior to the burn and fire severity (Fig. 15a). Snags divided by logs however (Fig.15b) shows that there are many snags and few logs immediately after a fire. As the stand ages the snags fall down and become logs, therefore the snag/log ratio falls through burn age 22. Among the older burn ages (over 100 years) all of the fire-killed snags should already have fallen down and decomposed, so the snags and logs are probably from trees that died after the fire.

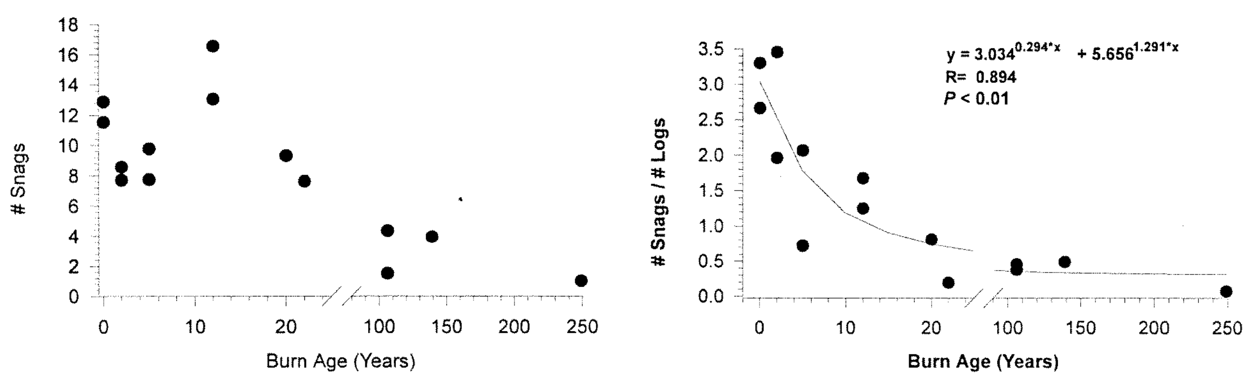


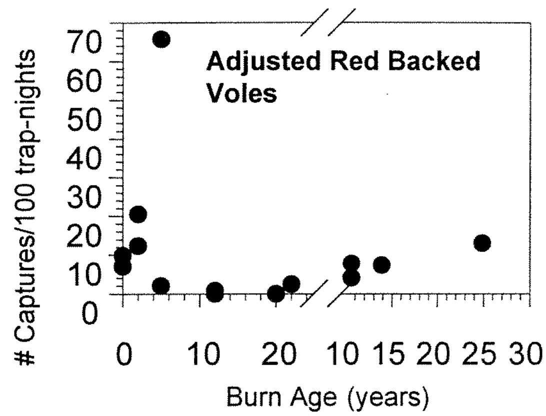
Figure 15 (a - b). The relationship between burn age and number of snags and between burn age and snags/logs.

Small Mammal Trapping

Red Backed Voles

Red backed voles showed no clear preference for any burn ages (Fig. 16a) although young and old burns seemed to hold higher densities than mid-age burns. Abundance did not show any relationships with any of our vegetation or coarse woody debris measures.

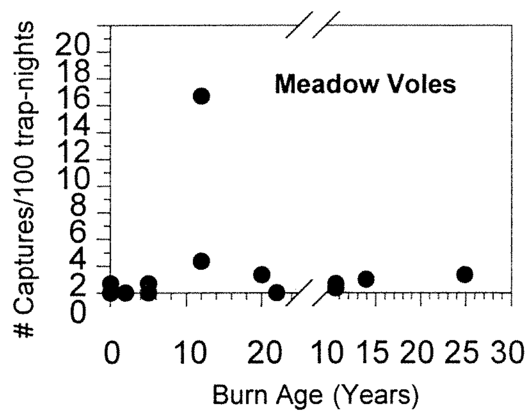
16a



Meadow Voles

The most striking feature of the meadow vole data is the 12 year old burns.

16b



Total Small Mammals

Total small mammals showed no relationship to either burn age or any of the vegetation or coarse woody debris characteristics. It should be noted however, that small mammal numbers in young burns were only slightly below the densities found in old growth areas. By the age of 12 years the burned areas seem to support densities of small mammals equal to old growth areas.

16c

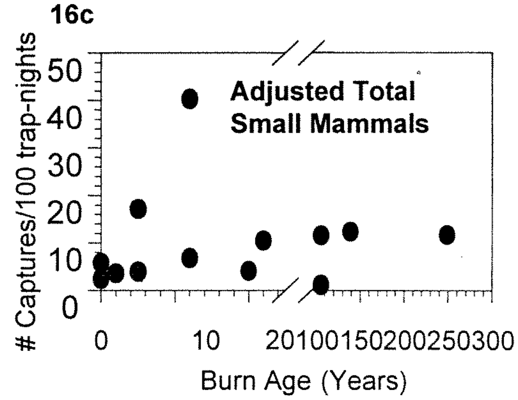


Figure 16 Capture success for red-backed voles (a), meadow voles (b) and total small mammals (c).

Furbearer Track Counts

Aerial vs. Ground-based Track Counts

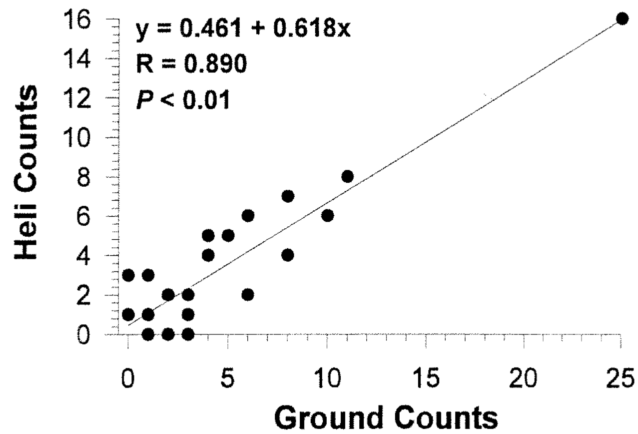


Figure 17 The relationship between ground and helicopter counts of marten tracks per transect.

There was a significant difference between aerial and ground track counts of the same transects (79 observations, 6 ties, Z = =3.872, $P < 0.01$, Wilcoxon matched pairs test). A linear regression provided a predictive equation to apply to the aerial track counts (Figure 17). Track counts in the remainder of the report are adjusted according to the formula in Figure 17, divided by the number of days since the last snowfall, and standardized to 1 km.

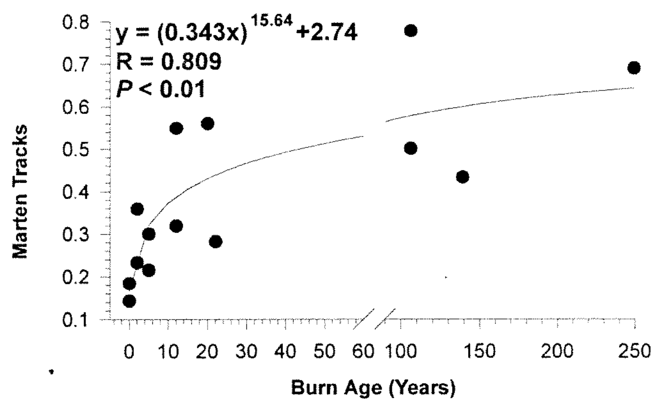


Figure 18 The relationship between the number of marten track per km and burn age.

Marten tracks rose exponentially during the early and middle stages of the succession (0 to 22 years), reaching a maximum somewhere between 22 and 100 years (Figure 18). The standard errors of the estimates were quite large however; it was possible to have about as many marten tracks in a 2 year old burn as in a 100 year plus burn.

Marten tracks did not vary with either number of snags or logs, but did show a significant relationship with snags/logs (Fig. 19) using a Spearman rank order correlation (Mendenhall 1975).

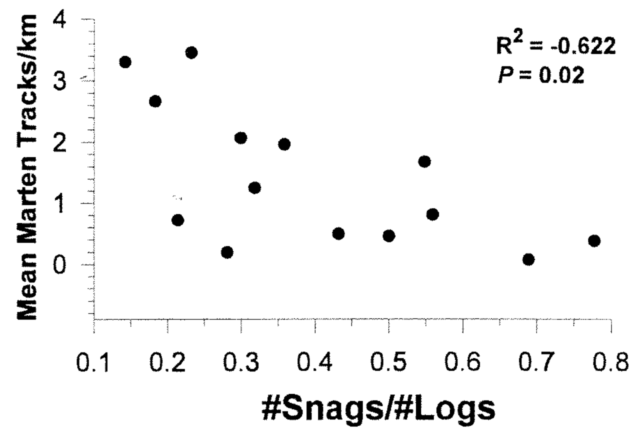


Figure 19 The relationship between snag to log ratio and marten track counts.

Marten tracks also showed a significant relationship with black spruce percent cover (Fig. 20) and also with percent cover of all trees (Fig. 21).

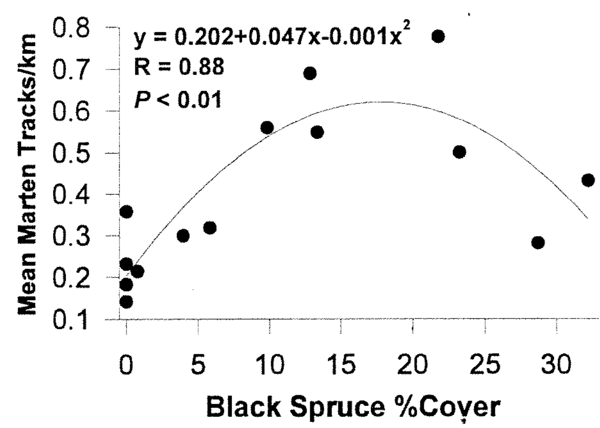


Figure 20 The relationship between black spruce % cover and marten track counts.

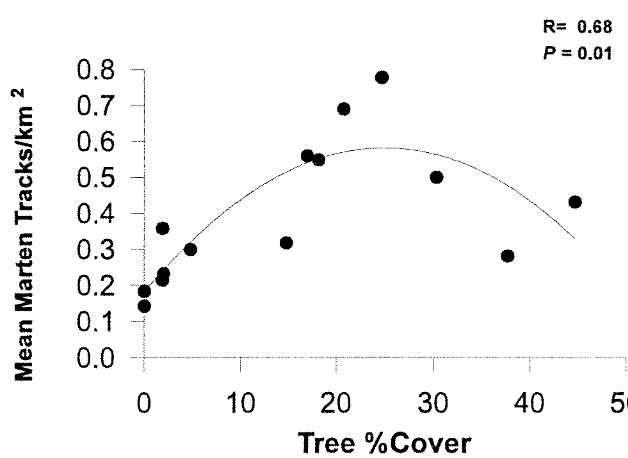


Figure 21 The relationship between total % tree cover and marten track counts.

Hare Tracks

Our track counts took place during the lowest part of the hare cycle (Adrian D'Hont, pers. comm.) but the data seem to suggest a relationship with burn age (Figure 22). Few hare tracks were found in three out of the four burns less than 12 years and then the numbers increased by an order of magnitude for the 12-22 year old burns. The numbers increased further for the older burns but showed a decrease in old growth.

This is not unexpected as there is little for hares to eat in fully mature black spruce forest. However, there has been a suggestion that hares may find refuge during the low part of the cycle in old growth spruce forest (Wolff 1980). It appears that a decade may be long enough for hares to return in reasonable numbers to a burn but it would be enlightening to examine hare densities in lower aged burns during the increasing or peak phase of a hare cycle.

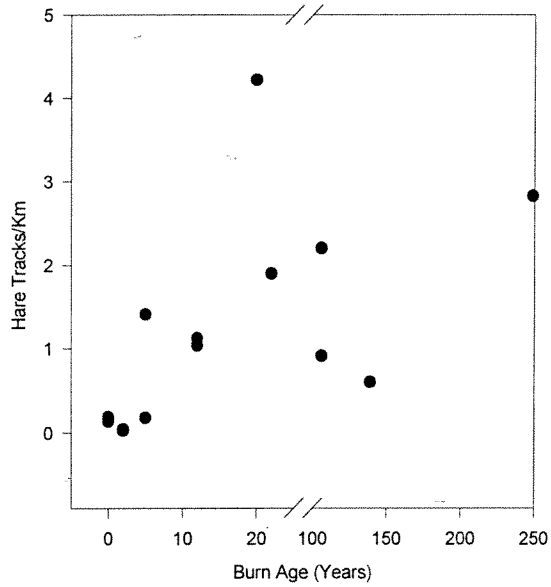


Figure 22 The Relationship between the number of hare track per km and burn age.

Lynx Tracks

Lynx tracks were found in extremely low numbers in all burns (Table 3-Appendix G). There seems to be no relationship between burn ages and lynx numbers but this may only be a result of low densities found during the low part of the cycle.

While we counted the tracks of other furbearers, the data is extremely variable and we are unable to discern any patterns.

Grouse

There were few grouse tracks found in burns less than 12 years old (Table 4 Appendix G). Numbers were much higher in the 12 and 20/22 year old burns. The highest density of grouse tracks were found in the oldest burn.

Moose Surveys

Moose density was near 0 moose/km^2 in the 0 aged burns, varied between 0.04 and 0.23 between burn age 2 and 22, and was 0.07 or lower in the 100 year plus burns (Fig. 22). Two things are worth noting here: variation in moose density within burn ages was as great or greater than variation between burn ages, and the highest densities recorded were in adjacent burns in the mountains (the two western-most burns, a 2 and a 5 year old).

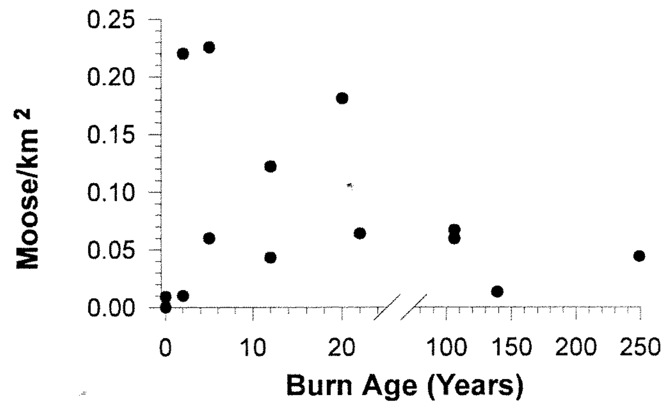


Figure 23 The relationship between burn age and moose density.

DISCUSSION

Limitations of Sampling Design

The original intention of sampling an unambiguous post-fire succession was compromised by the reality of fire occurrence patterns in the western NWT, and the lack of a complete fire history over the timespan of black spruce succession. Ideally, sites would have been chosen that were identical in every respect except for age since burning. Unfortunately, recent burns only occurred in the northwest section of the study area, while the older burns were grouped in the southeast. This introduced geographical and elevation gradients into our sampling design. The other problem in selecting a post-fire succession was an 84 year gap in our 'succession'. Fire records date back to only 1963, so accurate ages could only be obtained for the first 29 years of succession. The patchy nature of forest fires and the difficulty in detecting burn perimeters in older stands meant that years could be spent ageing tree cores and examining fire scarred trees or stumps in order to find an orderly succession of study sites older than 30 years. We therefore made the decision to accept four 100 year plus sites and the resultant gap in the data. Future opportunities may allow us to eventually fill in this data gap.

Vegetation

There are three major conclusions we can draw from the vegetation data. First, species richness, diversity and total percent cover reach their maxima early in the succession (about 15 years post burn). Second, three major plant communities were identified: early (0-5 years), middle (12-22 years), and late succession (100+ years) but there may have been more between 22 and 106 years. Third, variation within and to some degree between the three plant communities had as much to do with study site placement (longitude, latitude and elevation) as it did with stand age.

Species richness and species diversity reach their maxima early in the succession (Figures 2 and 3). The largest increase in species diversity and richness took place between 0 and 2 years post-burn. A high diversity index value indicates the presence of many species of roughly equal abundance, therefore the early years of succession were not dominated by one or a few species, rather, many species became established simultaneously. The highest species diversity index and species richness index occurred at 20 years in our data. In a lichen-spruce woodland with black spruce as the dominant tree in northern Quebec, Morneau and Payette (1989) found the same indices were highest in the 23rd year after a burn. The vegetation percent cover also reached its maximum of about 85% by about year 30 as illustrated by the plot of 'unvegetated space' in Figure 4.

Our species diversity should probably be called vascular species diversity, as we did not try to classify non vascular plants (other than 'mosses' and 'lichens'). Non-vascular plants are an important component of the mature boreal forest understorey (Johnston and Elliot, 1996) so our picture of species diversity may have changed had we included them.

Our early vegetation community (0-5 years) (Fig. 23) was typified by low shrub, tree, and lichen cover, but rapidly increasing forbe, grass and moss cover. There were no 'pioneer' species in this community that completely disappeared later, but fireweed, alder and paper birch were more prevalent early than in the middle or late communities. Although establishment of many species occurred during the early successional stage, several species were absent - poplar, tamarack, dwarf and ground willow - or appeared only in the 5 year burn(s) - black spruce, jack pine and aspen.

The middle vegetation community (12-22 years) was typified by the dominance of deciduous shrubs and trees such as dwarf birch, willow and aspen, as well as the herbaceous plant, cloudberry, and the coniferous jack pine. Fireweed was scarce, compared to the early community, otherwise most species that were present during the early successional stage increased in percent cover. Also, some plants appeared that would later become prevalent; e.g. black spruce, tamarack and lichens. Plants that were shared more or less equally between the middle and late vegetation community included: mosses, graminoids, and Potentilla. Total vegetation cover was approaching its maximum by this stage, whereas species richness and diversity had 'peaked'.

The dominance of shrubs during this middle stage has been found in other northern studies (Black and Bliss 1978; Viereck 1983) but no one else has reported dwarf birch as the dominant or co-dominant shrub (Fig. 5d and 13 and Appendix B - Table 6). Usually willows are the shrub considered to be dominant. We consider willows to be second and almost equal to dwarf birch in percent cover but they are a clear second when vertical structure is considered (Fig.13). Both shrubs regenerate by the rapid growth of shoots from underground parts. The determination of the dominant shrub will have relevance later as we discuss the density of moose found in these burns.

Lichens had reached a fairly substantial coverage somewhere between the time since the burn of 22 and 106 years but our data do not allow us to be any more certain (Fig. 7e). Thomas and Kilian (1998) indicated that lichens important to caribou such as *Cladina mitis* reached maximum biomass 60 years after a burn in the Taiga Shield Ecozone, east of our study area. Coverage by lichens in our oldest site of 249 years was more than twice the two 106 year old and the 139 year old burn. We would need sampling of more burns older than 200 years to know whether or not this is a standard pattern.

The late vegetation community (100+ years) was typified by the prevalence of black spruce, tamarack, and lichens and the continued abundance of mosses, graminoids, and Potentilla. Most of the deciduous shrubs and trees had disappeared by this stage. Total vegetation cover was maximal, while species richness and diversity had declined slightly since the middle successional stage.

The plant succession sequence just described is similar to that found by Viereck (1983) in Alaska and Morneau and Payette (1989) in northern Quebec. That is, almost all species found throughout the chronosequence are found on new burns within several years of the fire. The successional process is not new species coming in to dominate but species which are present increasing and/or decreasing in abundance.

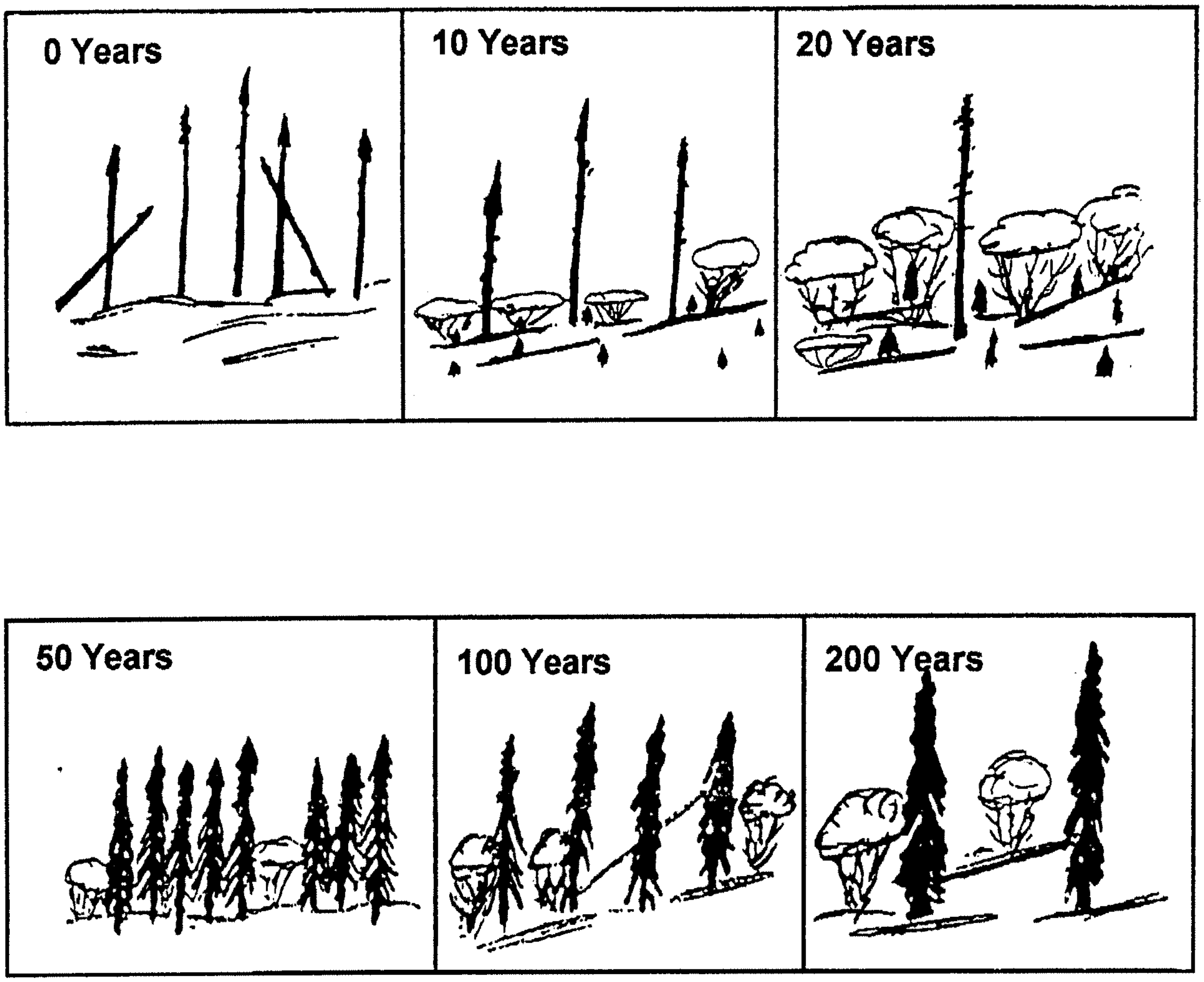


Figure 24 Stages in succession following fires in black spruce stands in the western Northwest Territories.

Although this ecosystem appears to regenerate back to a black spruce dominant system, it has gone through several stages where other species of vegetation such as dwarf birch, are dominant. Therefore, we can say that our black spruce forests will likely regenerate back to black spruce after a fire but not directly as a monoculture. From observations in the field however, it does appear that a predominantly jackpine forest will regenerate immediately back to jackpine after a fire with little other vegetation being part of the system, i.e. jackpine does not lose its dominant position - although this requires a field study to draw a firm conclusion.

Ordination demonstrated that the floristic components of each community were strongly influenced by geographical location of the study sites. Indeed, latitude, longitude and elevation emerged as the dominant correlates of the ordination axes in most of the ordinations. With our sampling of adjacent stands of similar age, it was impossible to partition the effect of geography. There was a maximum distance of approximately 650km latitude and 450km in longitude between burns and the sites varied from flat areas at elevations of 180m to foothill areas at elevations of 600m. We must therefore conclude that, as elsewhere, local conditions such as elevation, microclimate, soil characteristics, etc. play an important, but unmeasured part in the makeup of plant communities and probably also in the speed and nature of the post-fire succession, especially in the early years (Wein and MacLean 1983; Sirois and Payette 1989).

Forest Structure

We saw the same patterns for the vertical structure of the forests as we did for the percent cover: an early stage with few, small trees or shrubs, a middle stage with mostly deciduous shrubs and trees of all sizes, plus a few small conifers (Fig. 13). These data illustrate well the dominance of dwarf birch compared to willow in the shrub community. The late stage is dominated by the larger sizes of spruce and tamarack.

The 249 year-old site resembled sites from the young stage more so than the other late stage sites. This surprising result is an artifact of our sample plot size. Subjectively, the forest consisted of large but widely spaced black spruce, with an understorey of mosses, lichens and some black spruce seedlings and saplings. Our $1m^2$ sample plots were simply too small to capture this reality: none of the large trees happened to be in our sample plots. Our T-square data provided a good estimate of the density of trees in the older burns and they showed a declining density through thinning as expected (Fig.13).

The pattern of change seen in coarse woody debris was that of many snags and few logs in the early stage, followed by progressively fewer snags and more logs in the middle and late stages. We interpreted these data as the fire 'cleaning out' any downed material and killing the trees; thus many snags and few logs. In the middle stage the snags are starting to fall down; thus snags decrease and logs increase. In the late stage the fire killed trees should have long since fallen down and rotted, so the increase in logs may be from trees that died after the fire. This would follow from the previously observed decline in the number of standing trees (Fig.13) between 22 and 100 years post-burn.

Small Mammals

It is difficult to find a firm pattern in the small mammal data unless we tease out some details. We have adjusted our results with a factor to account for population cycles by adjusting the captures to the state of the Red Backed Vole cycle in the year 1992 for the area in question. We used data that we, and others, had collected as part of the NWT-wide small mammal survey (Shank 1993). The adjustment produced abundance indices that were reasonably close to other trapped populations at the peak.

The one data point which seems completely out of reasonable synchrony is the 12 year burn near Hay River (Fig.16b and 16c). This particular trapping session captured almost 15 meadow voles per 100 TN. This was likely the result of a wet meadow adjacent to the trapline which generally support high meadow vole populations (Banfield 1981). If we remove this outlier, the data suggest that for the first few years small mammal densities are low. They build gradually until, by the 10-15 year stage, they are about half of the densities found in old growth black spruce. The variability between localities was still too high to allow a firm conclusion of small mammal succession after fires. There is little if any data in the literature for the succession of northern boreal forest small mammals with which to compare our results.

We did, however, find small mammals in all burns, even the recent burns that were still smoking/burning. We do know there are such high densities of edible mushrooms found in some one year old burns that they are commercially harvested and this density of food may influence the density of voles in the area.

Because of the importance of small mammals to the ecosystem in general and to furbearers in particular, we believe there is a need to conduct further studies to tease out any relationships with fire. We believe a longer term, mark-recapture study may be necessary in both burned and old growth stands to track the populations of animals through one or two full cycles.

Furbearers

The small experiment to test the relationship between helicopter and snowmobile track counts following Golden (1987) was successful and allowed us to calculate a linear regression (with an R value of 0.89) and adjustment factor (Fig.17). There was a significant difference between aerial and ground counts.

Marten track density rose exponentially after a burn (Fig.18). The maximum was reached somewhere between 20 and 100 years, but it took only 5 years for density to reach the halfway point. Marten tracks were positively associated with black spruce percent cover up to approximately 25%; above this coverage the association appeared less strong (Fig.20). The stands that produced these favourable amounts of cover (10% to 25%) were of various ages - 12, 20, two at 106 and 249 years. These results differ somewhat from Thompson and Harestad's (1994) model that predicts increasing marten densities with canopy cover and a preference for cover of 50% to 70%. Considering total tree cover, the relationship stays the same (Fig. 21) but the preferred cover percentage increases to 20% to 30%. There were no black spruce stands evaluated that had more than a 50% canopy cover. While the preferred canopy covers do differ slightly, the ages of the forest most preferred include three out of the four oldest forests examined. Examining a mixed forest would perhaps reveal a higher percentage canopy cover preference.

Marten track density were negatively associated with snag:log ratio (Fig.19) likely because marten prefer the combination of many logs and few snags which would likely provide them with more subnivean access points. Those burns with the low snag:log ratio and high numbers of marten tracks were the same ones which had the favourable amount of black spruce cover mentioned above (except for the 12 year burn which had a higher ratio). This would suggest that marten would return much quicker and in greater numbers to burns which did not burn too hot and did not consume all of the logs on the ground and left some snags to fall down later.

Marten are associated with old growth forests to some degree throughout their range (Buskirk and Powell 1994; Thompson and Harestad 1994), but there is little agreement as to what aspect(s) of the habitat are most influential. Choices include subnivean access points for foraging (Sherburne and Bissonette, 1994), prey encounter rates (Thompson and Colgan 1994; Douglass et. al. 1983), denning sites in trees, snags and underground for thermal reasons (Taylor and Buskirk 1994), predator avoidance (Thompson 1994), and occurrence of meadows as a source of the prey item *Microtus* (Buskirk and MacDonald 1984). Many of these features are found in younger forests as well. We have documented that N.W.T. marten are associated with certain old growth forest habitat features, some of which appeared earlier in succession, but to reach any conclusions regarding the nature of their habitat use, a more intensive, behavioural study would have to be done.

Although the marten in our study area were more abundant in old growth forests, they did use burns, even very young ones, to a considerable degree. The use of young burns is in agreement with data from other high latitude study areas: Alaska (Johnson, et. al. 1995, Stephenson 1984), the N.W.T. (Latour et. al. 1994), and the Yukon (Slough 1989). There are several experienced NWT trappers who have reported consistently catching marten in good numbers in 7-15 year old burns. There is some evidence however that burns constitute habitat used only by juveniles (Latour et. al. 1994).

Alaskan trappers in Stephenson's study suggested that marten were using burns because of high small mammal densities. Our small mammal data also support that contention.

Grouse

Grouse tend to be species most often found in second stage and older growth forests, depending upon the species (Godfrey 1986). Our results support this tendency as few tracks were found in burns less than 12 years old and the highest densities were found in the oldest burns. It is uncertain whether the various species of grouse exhibit cycles in the NWT and whether the large numbers of predators may drive such cycles found at the peak and early decline portions of the hare cycle. Our period of data collection occurred during the low period of the hare cycle that could also suggest low numbers of grouse.

Moose

The two study sites with the highest moose densities (0.22 and 0.23 moose/km^2) were both in the foothills of the Mackenzie Mountains, separated by only 20 km. Densities were radically different from their equal-aged counterparts on the flatlands to the east (0.01 and 0.06 moose/km^2). Local hunters have indicated that moose will move into locally warmer areas once the temperature drops in mid-winter.

During one of the moose surveys, one of the mountain burns was above a thermocline and the air temperature was only -17C compared to the -36C at the same aged burn in the flatlands only a few miles away. These mountain sites were therefore probably outliers, i.e. their moose densities were strongly influenced by a factor or factors other than burn age, so we shall omit them from our interpretation of the data.

Moose typically prefer areas with large amounts of habitat in the deciduous shrub stage of post-burn succession, i.e. anywhere from 5 to 25 years post-burn (Loranger et. al. 1991; Oldemayer and Regelin 1987; Regelin et. al. 1987; Schwartz and Frantzmann 1989; Thomas 1990). Our moose populations adhered to this rule: densities were low but rising in the early successional stage, peaked during, or perhaps after the middle successional stage, and were much lower in the late stage. The two burns in Wood Buffalo National Park of 12 and 22 years both had appreciably lower densities of moose than equally aged areas in the west. In both cases, it seems the moose's preference for deciduous vegetation is confirmed as the Park burns had more than twice the black spruce cover and correspondingly less than one-half of the dwarf birch cover of the same aged western burns. Willow cover was split - much higher in the west for the 12 year old burn but lower in the west for the 22 year old burn.

The data gap between 20 and 100 years makes it impossible to tell exactly where the peak in moose density would occur. The rise in moose density was linear through burn age 22 but other authors suggest the peak occurs at about 30 years after the burn.

The moose densities found in this study confirm the overall low density of moose found in the Northwest Territories (Graf 1992). One surprising feature relative to moose was the discovery that the shrub stage resulting from fires tends to be dominated by dwarf birch rather than the willows, those species more often declared to be the favoured food of moose. The dwarf birch is seldom mentioned as a staple of moose populations and it may be this feature of the ecosystem that keeps the density of moose low in the NWT. It would be useful to conduct a study that examined the food preferences and habits of moose in different habitats in the southern NWT.

CONCLUSIONS

Relative to the general questions listed in the Introduction:

1. The pattern of post-fire vegetation succession was that almost all species are present within a few years of the fire followed by increasing/decreasing abundance which is reflected in plant cover and densities. Although black spruce forests will regenerate back to black spruce forests, it is after other plant species have gained and lost dominance, unlike a pine forest which is likely to regenerate immediately back to a pine dominated ecosystem with few other species having any effect.

2. Total small mammals appear to recover almost immediately but our data were not complete enough to be confident or to deal with species-specific abundance changes.

3. Snowshoe hares appear to increase substantially after approximately 10 years.

4. Marten appear to recover in reasonable numbers after about a decade. Lynx may take longer but we have insufficient data to draw any firm conclusions.

5. Moose populations reached similar densities to those found in old growth forests after about 5 years and then continued to increase to far above those densities at least for another 17 years.

6. Much coarse woody debris appears to be left after burns in black spruce forests which would provide good cover for furbearers and their prey for many years.

OTHER CONCLUSIONS:

The use of a helicopter to do winter track counts is an accurate and efficient method, if the habitat type allows it.

The low moose densities found in these burns in the southern NWT are similar to densities found throughout the NWT.

FUTURE DIRECTIONS:

a) Future work on post-fire succession should be done on a much smaller geographic scale, and efforts should be made to fill in the 23 to 100 year data gap.

b) The track count data were extremely variable, and it is recommended that any future work be done with much longer transects, perhaps 3-5 km.

c) Moose food habits relative to the frequency of use of dwarf birch vs willow should be studied both in and out of burns.

d) Moose habitat use could be better studied now with the advent of satellite imagery and GPS radiotelemetry.

e) A study of post-fire succession of small mammals, especially the red-backed voles, should be deemed a priority because of the importance of small mammals to marten. Students could do such studies. Small mammal will probably have to be studied over a number of years using mark-recapture techniques.

f) An abbreviated study covering vegetation, small mammals, hares and lynx should be done in pine dominated burns.

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PERSONAL COMMUNICATIONS

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APPENDICES

Appendix A: Size and Age of Study Sites

Table 1. Ages of trees sampled in the older burns. DBH = diameter at breast height.

Burn	Species	DBH Age	Stump Age	Fire Scar?
Hay River Old	Bs	119	137	No
	Bs	112	139	No
	Jp	97	104	No
	Jp	84	84	Yes - 70 years
	Ws	179	-	No
Pipeline	Bs	100	-	NoAppendix
	Bs	106	-	No
	Bs	66	-	No
Daniels	Bs	186	-	No
	Bs	93	-	No
	Bs	68	-	No
	Bs	106	-	No
Falaise Old	Bs	78	78	No
	Bs	102	103	No
	Bs	218	221	No
	Bs	245	249	No

Table 2. Ages of sampled trees in the younger (<25 years) burns. DBH = diameter at breast height.

Burn	Burn Age	Species	DBH Age	Stump Age	Fire Scar?
FS62	0 - 1993	Jp	172	174	Yes - 1836
		Tam	133	130	No
		Ws	128	148	No
		Bs	155	172	No
		Bs	141	177	No
		Bs	136	178	No
FS75	0 - 1993	Bs	164	176	Yes - 1877
		Jp	85	94	No
		Bs	65	82	No
		Bs	84	118	No
FS29	2 - 1990	Bs	106		No
		Bs	228		No
		Ws	131		No
		Bs	129		No
		Bs	241		No
		Bs	142		No
FS31	2 - 1990	Bs	141		No
		Bs	210		Yes - 1843
FS15	5 - 1989	Bs	116	128	No
		Bs	113	129	No
FS24	5 - 1987	Bs	80		No
		Bs	180		No
		Bs	241		No
		Bs	142		No

HY49	12 - 1981	Bs	180	Rot	-
		Bs	198	223	Yes -1881
		Bs	56	76	No
WB58	12 - 1981	Bs		82	No
		Bs		56	No
		Bs		89	No
		Bs		86	No
WB58,		Jp		151	Yes - 1881
		Bs		141	No
HY05	20 - 1973	Bs	172	168	Yes - 1850
		Bs	131	158	No
		Bs	127	150	No
		Tam - live	53	56	Yes - 1973
		Tam - live	139	139	Yes - 1915
WB78	22 - 1971	Bs		124	No
		Bs		128	No
		Bs - live		132	Yes - 1971

Table 3. The size of the study burns.

	Age	Area (ha)
FS62	0	89,904
FS75	0	17,563
FS29	2	28,847
FS31	2	13,909
FS15	5	12,428
FS24	5	16,519
HY49	12	478,589
WBNP58	12	208,343
HY05	20	106,661
WBNP78	22	26,173
PIPELINE	106	106,871
DANIELS	106	116,249
HY OLD	139	54,815
FALAISE OLD	249	108,656

Table 4. Research Hypotheses to be Investigated

1. After a large wildfire, most areas in the boreal forest of the NWT will regenerate basically in one-stage back to whatever forest existed on the site before the fire (Kelsall et al. 1977).

2. The deer mouse, *Peromyscus maniculatus*, recovers fastest after a fire.

3. Meadow voles, *Microtus* spp., will increase immediately after a fire for 1 – 3 years.

4. The red-backed vole, *Clethrionomys*, will start to increase one year after a fire and become abundant after 3 years.

5. Snowshoe hares will decrease for up to 10 – 20 years after a fire, depending upon the state of the cycle.

6. Grouse species will decrease and will probably take 10 – 20 years to come back in any numbers, with sharptails recovering first, followed by ruffed grouse and finally spruce grouse.

7. Marten will decrease for 1 – 2 years after a fire and then increase continually for the next five years.

8. Lynx will track hares and therefore decline after a fire.

9. Moose will begin to increase five years after the fire and will reach higher densities than pre-burn.

Appendix B: Vegetation

Species Richness and Diversity

Table 1: Species richness and Shannon-Wiener diversity index scores for the percent cover data.

	Age	Mean	Standard Error	Species Richness
FS62	0	1.3600	0.2834	6
FS75	0	0.8900	0.3288	5
FS29	2	3.2432	0.1213	18
FS31	2	3.0529	0.1150	15
FS15	5	3.3978	0.0776	19
FS24	5	3.8435	0.1074	24
HY49	12	3.5878	0.0569	21
WBNP58	12	3.8973	0.0729	20
HY05	20	4.0153	0.0620	29
WBNP78	22	3.8229	0.0832	24
PIPELINE	106	3.6418	0.0504	24
DANIELS	106	3.3698	0.0679	23
HY OLD	139	3.1071	0.1186	14
FALAISE OLD	249	3.8043	0.0383	23

Unvegetated Space

Table 2. Percent cover unvegetated space.

	Age	Mean	Standard Deviation
FS62	0	76.59030	4.21
FS75	0	76.8607	11.22
FS29	2	53.1205	13.371
FS31	2	68.545	8.384
FS15	5	61.81	23.172
FS24	5	34.841	11.961
HY49	12	35.25	10.421
WBNP58	12	22.192	10.965
HY05	20	32.549	12.821
WBNP78	22	18.097	9.489
PIPELINE	106	14.790	9.326
DANIELS	106	8.480	7.860
HY OLD	139	18.215	8.662
FALAISE OLD	249	21.817	12.215

Equisetum sp.

Table 3. Percent cover horsetail *(Equisetum sp.)*.

	Age	Mean	Standard Deviation
FS62	0	0.000	0.000
FS75	0	0.000	0.000
FS29	2	9.459	9.254
FS31	2	3.934	5.386
FS15	5	0.462	1.787
FS24	5	2.178	5.390
HY49	12	7.115	7.513
WBNP58	12	13.004	6.993
HY05	20	5.550	3.717
WBNP78	22	9.707	5.888
PIPELINE	106	10.045	12.661
DANIELS	106	14.425	10.304
HY OLD	139	13.516	7.146
FALAISE OLD	249	4.848	7.103

Graminoids

Table 4. Percent cover graminoids.

	Age	Mean	Standard Deviation
FS62	0	3.571	3.270
FS75	0	3.188	3.331
FS29	2	7.730	10.818
FS31	2	8.100	8.813
FS15	5	10.437	11.196
FS24	5	13.543	8.537
HY49	12	19.153	6.663
WBNP58	12	12.738	4.556
HY05	20	12.007	6.640
WBNP78	22	9.569	2.916
PIPELINE	106	24.102	11.086
DANIELS	106	7.445	5.421
HY OLD	139	14.765	4.623
FALAISE OLD	249	19.127	9.607

Bearberry

Table 5. Percent cover bearberry *(Arctostaphylos uva-ursi)*.

	Age	Mean	Standard Deviation
FS62	0	0.000	0.000
FS75	0	0.000	0.000
FS29	2	2.733	3.300
FS31	2	2.333	1.826
FS15	5	3.964	3.663
FS24	5	3.967	5.887
HY49	12	1.933	10.031
WBNP58	12	3.000	10.989
HY05	20	9.233	7.295
WBNP78	22	3.333	5.182
PIPELINE	106	19.737	15.342
DANIELS	106	13.493	11.204
HY OLD	139	8.000	8.449
FALAISE OLD	249	10.367	10.601

Dwarf Birch

Table 6. Percent cover for dwarf birch *(Betula glandulosa)*.

		% Cover		# Stems	
Burn	Age	Mean	S.D.	Mean	S.D.
FS62	0	0.462	1.787	0.567	2.254
FS75	0	0.383	1.456	0.200	0.761
FS29	2	0.702	2.744	0.067	0.365
FS31	2	0.000	0.000	0.000	0.000
FS15	5	0.000	0.000	0.000	0.000
FS24	5	0.760	4.160	0.000	0.000
HY49	12	21.896	15.859	8.933	10.167
WBNP58	12	9.634	12.062	9.100	16.736
HY05	20	11.141	14.508	7.033	15.626
WBNP78	22	5.749	11.036	3.267	9.773
PIPELINE	106	5.106	7.843	2.067	4.623
DANIELS	106	0.000	0.000	0.000	0.000
HY OLD	139	8.897	10.415	4.600	7.859
FALAISE OLD	249	2.760	8.491	0.600	2.061

Willows

Table 7. Willow *(Salix spp.)* percent cover and number of stems.

		% Cover		# Stems	
Burn	Age	Mean	S.D.	Mean	S.D.
FS62	0	0.000	0.000	0.000	0.000
FS75	0	0.000	0.000	0.000	0.000
FS29	2	0.951	4.255	0.367	1.450
FS31	2	1.117	4.466	0.000	0.000
FS15	5	0.935	3.073	0.100	0.403
FS24	5	1.805	5.658	0.000	0.000
HY49	12	17.31	14.38	6.600	10.34
WBNP58	12	4.424	7.634	4.900	14.08
HY05	20	1.767	6.748	0.300	1.643
WBNP78	22	8.792	9.524	2.167	3.018
PIPELINE	106	3.721	9.578	0.833	2.102
DANIELS	106	0.702	2.743	0.100	0.403
HY OLD	139	10.800	12.01	3.567	5.841
FALAISE OLD	249	0.886	4.85	0.567	2.459

Fireweed

Table 8. Percent cover fireweed *(Epilobium angustifolium)*.

	Age	Mean	Standard Deviation
FS62	0	0.000	0.000
FS75	0	0.000	0.000
FS29	2	16.497	11.700
FS31	2	0.000	0.000
FS15	5	4.085	5.817
FS24	5	10.502	7.200
HY49	12	3.842	4.360
WBNP58	12	0.385	2.110
HY05	20	0.000	0.000
WBNP78	22	4.089	5.690
PIPELINE	106	0.000	0.000
DANIELS	106	0.000	0.000
HY OLD	139	0.271	1.480
FALAISE OLD	249	0.000	0.000

Crowberry

Crowberry *(Empetrum nigrum)* was found in only 3 burns (FALAISE OLD GROWTH, DANIELS and WBNP78), and at low abundance (less than 4%).

Potentilla

Table 9. Percent cover potentilla or cinquefoil *(Potentilla fruticosa)*.

	Age	Mean	Standard Deviation
FS62	0	0.654	2.030
FS75	0	0.191	1.050
FS29	2	1.034	3.220
FS31	2	0.000	0.000
FS15	5	0.000	0.000
FS24	5	1.702	5.370
HY49	12	18.598	11.000
WBNP58	12	12.229	11.200
HY05	20	12.401	8.150
WBNP78	22	7.144	9.390
PIPELINE	106	13.611	12.146
DANIELS	106	3.223	5.326
HY OLD	139	8.167	8.230
FALAISE OLD	249	8.474	10.700

Rose

Table 10. Percent cover rose *(Rosa acicularis)*.

	Age	Mean	Standard Deviation
FS62	0	0.191	1.048
FS75	0	0.000	0.000
FS29	2	1.259	3.310
FS31	2	6.035	6.090
FS15	5	1.614	5.033
FS24	5	2.586	6.460
HY49	12	8.906	7.830
WBNP58	12	1.084	2.810
HY05	20	2.304	3.890
WBNP78	22	1.307	2.710
PIPELINE	106	3.059	3.457
DANIELS	106	2.496	3.753
HY OLD	139	5.696	6.620
FALAISE OLD	249	9.198	7.530

Juniper

Ground Juniper *(Juniperus communis)* was found only the old growth burns, and at very low abundance (less than 1%). Creeping juniper *(Juniperus horizontalis)* was found only the old growth burns, and at low abundance (less than 5%).

Sweet Gale

Sweet Gale *(Myrica gale)* showed no clear successional trend; it could show up in any burn over 0 years of age, but at low abundance.

Lichens

Table 11. Percent cover lichens.

	Age	Mean	Standard Deviation
FS62	0	0.000	0.000
FS75	0	0.000	0.000
FS29	2	0.000	0.000
FS31	2	2.423	7.191
FS15	5	0.000	0.000
FS24	5	0.000	0.000
HY49.	12	0.000	0.000
WBNP58	12	0.000	0.000
HY05	20	0.385	2.106
WBNP78	22	1.196	2.970
PIPELINE	106	12.552	15.632
DANIELS	106	8.306	10.174
HY OLD	139	11.322	15.575
FALAISE OLD	249	26.033	19.870

Fungus

Fungus only occurred in burn older than 12 years, and then at low abundance (< 3%).

Labrador Tea

Table 12. Labrador tea *(Ledum groenlandicaum)*.

	Age	Mean	Standard Deviation
FS62	0	0.000	0.000
FS75	0	0.000	0.000
FS29	2	5.741	8.510
FS31	2	20.573	5.730
FS15	5	6.027	5.960
FS24	5	12.092	11.700
HY49	12	0.000	0.000
WBNP58	12	0.191	1.050
HY05	20	1.218	5.120
WBNP78	22	0.893	2.890
PIPELINE	106	7.627	10.871
DANIELS	106	10.914	11.505
HY OLD	139	0.000	0.000
FALAISE OLD	249	7.691	15.800

Vaccinium

Table 13. Percent cover for vaccinium *(Vaccinium sp.)*.

	Age	Mean	Standard Deviation
FS62	0	0.000	0.000
FS75	0	0.000	0.000
FS29	2	2.68	5.21
FS31	2	0.27	1.48
FS15	5	0.27	1.46
FS24	5	10.55	11.22
HY49	12	0.000	0.000
WBNP58	12	0.000	0.000
HY05	20	0.000	0.000
WBNP78	22	0.000	0.000
PIPELINE	106	0.000	0.000
DANIELS	106	0.000	0.000
HY OLD	139	0.000	0.000
FALAISE OLD	249	0.000	0.000

Black Spruce

Table 14. Black spruce *(Picea mariana)*, percent cover, number of stems and stem height.

		% Cover		# Stems		Stem Height	
Burn	Age	Mean	S.D.	Mean	S.D.	Mean	S.D.
FS62	0	0.000	0.000	0.000	0.000	0.000	0.000
FS75	0	0.000	0.000	0.000	0.000	0.000	0.000
FS29	2	0.000	0.000	0.000	0.000	0.000	0.000
FS31	2	0.000	0.000	0.000	0.000	0.000	0.000
FS15	5	0.767	2.500	0.400	1.673	7.407	2.635
FS24	5	3.960	5.230	1.270	2.200	8.729	3.329
HY49	12	5.810	6.930	1.930	3.040	16.771	8.143
WBNP58	12	13.30	11.000	5.867	5.911	13.929	6.265
HY05	20	9.800	6.160	2.733	2.612	16.967	8.705
WBNP78	22	28.700	15.000	8.733	5.924	39.967	18.070
PIPELINE	106	21.707	23.870	1.633	1.991	153.123	156.197
DANIELS	106	23.184	19.109	3.433	4.216	190.552	161.900
HY OLD	139	32.155	18.800	3.600	4.260	231.632	331.144
FALAISE OLD	249	12.800	15.300	1.267	1.856	42.062	45.626

Tamarack

Table 15. Percent cover tamarack *(Larix laricina)*.

	Age	Mean	Standard
FS62	0	0.000	0.000
FS75	0	0.000	0.000
FS29	2	0.000	0.000
FS31	2	0.000	0.000
FS15	5	0.000	0.000
FS24	5	0.000	0.000
HY49	12	0.000	0.000
WBNP58	12	0.000	0.000
HY05	20	2.563	5.840
WBNP78	22	0.385	2.110
PIPELINE	106	2.964	7.896
DANIELS	106	7.114	9.323
HY OLD	139	12.499	14.800
	139		
FALAISE OLD	249	7.917	9.760

Aspen

Table 16. Percent cover for aspen *(Populus tremuloides)*.

	Age	Mean	Standard Deviation
FS62	0	0.000	0.000
FS75	0	0.000	0.000
FS29	2	0.000	0.000
FS31	2	0.000	0.000
FS15	5	0.000	0.000
FS24	5	0.815	3.110
HY49	12	3.014	6.700
WBNP58	12	0.782	3.120
HY05	20	1.771	3.400
WBNP78	22	6.273	9.330
PIPELINE	106	0.000	0.000
DANIELS	106	0.000	0.000
HY OLD	139	0.000	0.000
FALAISE OLD	249	0.000	0.000

Poplar

Table 17. Percent cover for poplar *(Populus balsamifera)*.

	Age	Mean	Standard Deviation
FS62	0	0.000	0.000
FS75	0	0.000	0.000
FS29	2	0.000	0.000
FS31	2	0.000	0.000
FS15	5	0.000	0.000
FS24	5	0.000	0.000
HY49	12	1.077	3.730
WBNP58	12	0.603	2.310
HY05	20	0.191	1.050
WBNP78	22	1.836	5.440
PIPELINE	106	0.000	0.000
DANIELS	106	0.000	0.000
HY OLD	139	0.000	0.000
FALAISE OLD	249	0.000	0.000

Alder & Paper Birch

Alder *(Alnus crispa)* and paper birch *(Betula papyrifera)* only occurred in the 2 year old burns, and not very abundant in those (i.e. less than 2%).

Dwarf Willow

Table 18. Percent cover for dwarf willow.

	Age	Mean	Standard Deviation
FS62	0	0.000	0.000
FS75	0	0.000	0.000
FS29	2	0.000	0.000
FS31	2	0.000	0.000
FS15	5	0.000	0.000
FS24	5	0.000	0.000
HY49	12	4.884	11.700
WBNP58	12	9.691	15.500
HY05	20	2.568	6.750
WBNP78	22	3.427	8.000
PIPELINE	106	0.191	1.048
DANIELS	106	1.316	4.238
HY OLD	139	0.000	0.000
FALAISE OLD	249	0.000	0.000

Ground Willow

Table 19. Percent cover ground willow.

	Age	Mean	Standard Deviation
FS62	0	0.000	0.000
FS75	0	0.000	0.000
FS29	2	0.000	0.000
FS31	2	0.000	0.000
FS15	5	0.000	0.000
FS24	5	0.000	0.000
HY49	12	5.360	10.600
WBNP58	12	24.132	14.900
HY05	20	10.616	7.440
WBNP78	22	14.825	10.000
PIPELINE	106	6.953	8.047
DANIELS	106	8.195	10.506
HY OLD	139	10.524	11.000
FALAISE OLD	249	0.000	0.000

Cloudberry

Table 20. Percent cover cloudberry *(Rubus chamaemorus)*.

	Age	Mean	Standard Deviation
FS62	0	0	0
FS75	0	0	0
FS29	2	0	0
FS31	2	0.94	2.87
FS15	5	0	0
FS24	5	0	0
HY49	12	2.26	5.79
WBNP58	12	0	0
HY05	20	0	0
WBNP78	22	2.50	3.42
PIPELINE	106	0.40	1.52
DANIELS	106	0.20	1.10
HY OLD	139	1.29	3.47
FALAISE OLD	249	0	0

Jack Pine

Table 21. Percent cover jack pine *(Pinus banksiana)*.

	Age	Mean	Standard Deviation
FS62	0	0	0
FS75	0	0	0
FS29	2	0	0
FS31	2	0	0
FS15	5	0	0
FS24	5	1.13	2.66
HY49	12	4.85	6.19
WBNP58	12	3.43	8.52
HY05	20	2.63	5.83
WBNP78	22	0.43	2.36
PIPELINE	106	0	0
DANIELS	106	0	0
HY OLD	139	0	0
FALAISE OLD	249	0	0

Appendix C: Vertical Structure

Table 1. Vertical structure of trees (all species).

		<1m		>1m<1.5m		>1.5m<2m		>2m	
Burn	Age	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
FS62	0	0.567	2.254	0.000	0.000	0.000	0.000	0.000	0.000
FS75	0	0.200	0.761	0.000	0.000	0.000	0.000	0.000	0.000
FS29	2	1.600	2.554	0.000	0.000	0.000	0.000	0.000	0.000
FS31	2	1.633	3.792	0.000	0.000	0.000	0.000	0.000	0.000
FS15	5	0.733	1.964	0.033	0.183	0.000	0.000	0.000	0.000
FS24	5	5.333	7.048	0.133	0.730	0.000	0.000	0.000	0.000
HY49	12	22.733	13.734	5.600	6.284	1.967	3.135	0.200	0.664
WBNP58	12	21.600	23.145	0.733	2.033	0.033	0.183	0.000	0.000
HY05	20	14.233	17.200	3.567	14.400	0.367	1.542	0.033	0.183
WBNP78	22	17.667	13.270	1.933	2.924	0.867	2.240	0.367	1.326
PIPELINE	106	5.133	5.841	1.100	1.689	0.833	1.510	0.567	1.331
DANIELS	106	4.600	4.789	1.633	1.921	1.333	1.768	1.067	1.507
HY OLD	139	15.967	13.451	1.500	1.834	0.867	1.306	0.633	0.964
FALAISE OLD	249	4.167	5.995	0.133	0.434	0.033	0.183	0.000	0.000

Table 2. Vertical structure of dwarf birch *(Betula glandulosa)*.

		<1m		>1m<1.5m		>1.5m<2m		>2m	
Burn	Age	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
FS62	0	0.567	2.254	0.000	0.000	0.000	0.000	0.000	0.000
FS75	0	0.200	0.761	0.000	0.000	0.000	0.000	0.000	0.000
FS29	2	0.067	0.365	0.000	0.000	0.000	0.000	0.000	0.000
FS31	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FS15	5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FS24	5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HY49	12	8.767	8.709	4.867	6.078	1.700	3.153	0.000	0.000
WBNP58	12	9.800	17.195	0.533	2.03	0.000	0.000	0.000	0.000
HY05	20	8.633	15.677	3.567	14.4	0.367	1.542	0.033	0.183
WBNP78	22	4.233	10.572	0.333	1.213	0.033	0.183	0.000	0.000
PIPELINE	106	2.067	4.806	0.167	0.747	0.133	0.730	0.033	0.183
DANIELS	106	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HY OLD	139	5.133	8.148	0.233	0.679	0.000	0.000	0.000	0.000
FALAISE OLD	249	0.767	2.431	0.067	0.365	0.000	0.000	0.000	0.000

Table 3. Vertical structure of willows *(Salix sp)*.

		<1m		>1m<1.5m		>1.5m<2m		>2m	
Burn	Age	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
FS62	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FS75	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FS29	2	0.370	1.450	0.000	0.000	0.000	0.000	0.000	0.000
FS31	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FS15	5	0.1673	0.531	0.033	0.183	0.000	0.000	0.000	0.000
FS24	5	0.670	2.070	0.130	0.730	0.000	0.000	0.000	0.000
HY49	12	8.600	11.300	0.400	1.070	0.200	0.760	0.130	0.571
WBNP58	12	5.270	14.900	0.000	0.000	0.000	0.000	0.000	0.000
HY05	20	0.300	1.640	0.000	0.000	0.000	0.000	0.000	0.000
WBNP78	22	2.970	3.450	0.500	1.550	0.270	1.290	0.100	0.548
PIPELINE	106	0.967	2.785	0.067	0.365	0.033	0.183	0.000	0.000
DANIELS	106	0.100	0.403	0.000	0.0000 0	0.000	0.0000 0.	0.000	0.000
HY OLD	139	4.500	6.986	0.200	0.660	0.033	0.183	0.000	0.000
FALAISE OLD	249	0.570	2.460	0.000	0.000	0.000	0.000	0.000	0.000

Table 4. Vertical structure of black spruce *(Picea mariana).*

		<1m		>1m<1.5m		>1.5m<2m		>2m	
Burn	Age	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
FS62	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FS75	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FS29	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FS31	2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
FS15	5	4.000	1.673	0.000	0.0000	0.000	0.000	0.000	0.000
FS24	5	1.270	2.200	0.000	0.000	0.000	0.000	0.000	0.000
HY49	12	1.930	3.040	0.000	0.000	0.000	0.000	0.000	0.000
WBNP58	12	5.870	5.910	0.000	0.000	0.000	0.000	0.000	0.000
HY05	20	2.670	2.630	0.000	0.000	0.000	0.000	0.000	0.000
WBNP78	22	8.730	5.920	0.530	1.070	0.170	0.461	0.067	0.365
PIPELINE	106	1.633	1.991	0.833	1.621	0.666	1.398	0.533	1.332
DANIELS	106	3.433	4.216	1.433	1.924	1.200	1.769	0.933	1.484
HY OLD	139	3.600	4.264	0.900	1.450	0.733	1.230	0.533	0.900
FALAISE OLD	249	1.270	1.860	0.070	0.250	0.030	0.183	0.000	0.000

Appendix D: Coarse Woody Debris

Table 1. Number of logs per 25m transect.

	Age	Mean	Standard Deviation
FS62	0	3.900	2.354
FS75	0	4.333	3.651
FS29	2	4.367	3.459
FS31	2	2.233	1.654
FS15	5	10.733	5.271
FS24	5	4.733	3.107
HY49	12	10.433	9.058
WBNP58	12	9.867	5.431
HY05	20	11.467	5.532
WBNP78	22	39.200	15.795
PIPELINE	106	3.967	4.687
DANIELS	106	9.467	7.771
HY OLD	139	8.000	6.046
FALAISE OLD	249	13.700	5.621

Table 2. Log diameters (in centimetres).

	Age	Mean	Standard Deviation
FS62	0	4.870	2.099
FS75	0	6.215	2.445
FS29	2	6.884	2.829
FS31	2	7.174	3.037
FS15	5	5.437	1.330
FS24	5	5.863	1.808
HY49	12	5.345	2.271
WBNP58	12	4.231	1.759
HY05	20	5.553	1.454
WBNP78	22	4.744	1.188
PIPELINE	106	5.328	2.241
DANIELS	106	4.566	1.791
HY OLD	139	5.423	2.267
FALAISE OLD	249	7.486	2.155

Table 3. Log length (in metres).

	Age	Mean	Standard Deviation
FS62	0	4.000	1.561
FS75	0	4.796	1.760
FS29	2	3.893	1.065
FS31	2	3.308	1.716
FS15	5	4.871	1.775
FS24	5	3.451	0.944
HY49	12	4.616	2.029
WBNP58	12	4.245	2.169
HY05	20	5.548	1.221
WBNP78	22	4.587	1.259
PIPELINE	106	5.013	2.007
DANIELS	106	4.676	1.879
HY OLD	139	4.461	2.172
FALAISE OLD	249	7.333	1.620

Table 4. Distance above ground (DAG) in centimetres.

	Age	Mean	Standard Deviation
FS62	0	10.84	8.18
FS75	0	10.14	9.22
FS29	2	10.78	9.35
FS31	2	18.12	21.06
FS15	5	8.40	6.94
FS24	5	10.95	6.95
HY49	12	14.92	9.57
WBNP58	12	14.07	10.06
HY05	20	15.94	9.42
WBNP78	22	10.15	7.08
PIPELINE	106	12.16	15.59
DANIELS	106	9.82	8.44
HY OLD	139	11.86	8.29
FALAISE OLD	249	7.00	4.40

Table 5. Mean number of snags/transect.

	Age	Mean	Standard Deviation	#Snags/#logs
FS62	0	12.87	4.22	3.30
FS75	0	11.53	5.46	2.66
FS29	2	8.57	6.19	1.96
FS31	2	7.70	2.94	3.45
FS15	5	9.77	3.49	0.91
FS24	5	7.73	3.40	1.63
HY49	12	13.03	9.46	1.25
WBNP58	12	16.53	15.74	1.68
HY05	20	9.30	4.31	0.81
WBNP78	22	7.60	4.95	0.19
PIPELINE	106	1.50	1.55	0.38
DANIELS	106	4.33	5.47	0.46
HY OLD	139	3.93	3.35	0.49
FALAISE OLD	249	1.00	1.05	0.07

Table 6. Mean number of stumps.

	Age	Mean	Standard Deviation
FS62	0	2.83	2.98
FS75	0	1.70	1.34
FS29	2	0.00	0.00
FS31	2	0.00	0.00
FS15	5	1.10	1.06
FS24	5	0.00	0.00
HY49	12	2.10	2.14
WBNP58	12	2.03	2.03
HY05	20	0.93	1.14
WBNP78	22	2.23	2.27
PIPELINE	106	0.20	0.61
DANIELS	106	0.13	0.35
HY OLD	139	1.33	1.54
FALAISE OLD	249	0.00	0.00

Table 7. Mean number of roots per transect.

	Age	Mean	Standard Deviation
FS62	0	0.10	0.40
FS75	0	0.43	0.77
FS29	2	0.00	0.00
FS31	2	0.00	0.00
FS15	5	0.20	0.48
FS24	5	0.00	0.00
HY49	12	1.17	1.68
WBNP58	12	1.73	1.68
HY05	20	1.03	1.27
WBNP78	22	2.37	2.79
PIPELINE	106	0.00	0.00
DANIELS	106	0.03	0.18
HY OLD	139	0.53	1.38
FALAISE OLD	249	0.00	0.00

Appendix E

Table 1. Mean basal area per hectare (calculated for each site using T-square data) for the old growth study sites.

	AGE	MEAN
PIPELINE	106	235.66
DANIELS	106	241.44
HY OLD	139	169.28
FALAISE OLD	249	97.05

Appendix F: Small Mammal Snap-Trapping

Table 1. Small mammal trapping success.
Catch per 100 trapnights = #captures/(trap nights minus closed traps). Total Mammals and Red-backed Voles have been adjusted to peak of the cycle in order to compare different years of trapping based on long term trapping in control plots. #- represents only catch of Zapus.

Burn	Age	Adj. Total Mammals	Unadj. Total Mammals	Adj. RBV	Unadj. RBV	Meadow Voles	YCV	Deer Mice	Shrews
FS62	0	2.9	1.429	7.047	1.429	0.000	0.000	0.000	0.000
FS75	0	6.3	3.000	9.864	2.000	0.667	0.000	0.333	0.000
FS29	2	4.1	1.667	20.554	1.667	0.000	0.000	0.000	0.000
FS31	2	4.1	1.667	12.330	1.000	0.000	0.667	0.000	0.000
FS15	5	4.4	2.667	2.055	1.667	0.667	0.000	0.333	0.000
FS24	5	17.7	7.333	65.756	5.333	0.000	0.000	0.000	0.000
HY49	12	40.8	15.000	0.000	0.000	14.667	0.000	0.000	0.333
WBNP58	12	7.3	2.667	0.819	0.333	2.333	0.000	0.000	0.000
HY05	20	4.6	1.667	0.000	0.000	1.333	0.000	0.333	0.000
WBNP78	22	11.0	4.000	2.460	1.000	0.000	0.000	0.000	3.000
PIPELINE	106	1.7	1.000	4.110	0.333	0.333	0.000	0.333	0.000
DANIELS	106	12.1	7.667	7.809	6.333	0.667	0.667	0.000	0.000
HY OLD	139	12.9	6.000	7.379	3.000	1.000	0.000	0.000	1.667
FAL. OLD	249	12.2	4.000	13.041	2.333	1.333	0.000	0.000	0.333

Appendix G: Track Counts

Marten

Table 1. Marten tracks per km, corrected for sightability (Fig. 20) and days after last snowfall.

	Age	Mean	Standard Deviation	Median
FS62	0	0.142	0.185	0.014
FS75	0	0.183	0.230	0.174
FS29	2	0.358	0.286	0.334
FS31	2	0.232	0.268	0.125
FS15	5	0.214	0.304	0.000
FS24	5	0.299	0.224	0.267
HY49	12	0.318	0.708	0.000
WBNP58	12	0.548	0.448	0.494
HY05	20	0.559	0.832	0.250
WBNP78	22	0.281	0.239	0.254
PIPELINE	106	0.777	0.548	0.750
DANIELS	106	0.500	0.686	0.125
HY OLD	139	0.432	0.503	0.333
FALAISE OLD	249	0.689	0.587	0.500

Appendix G: Track Counts

Hares

Table 2. Hare tracks per km, corrected for sightability and days after last snowfall.

	Age	Mean	Standard Deviation
FS62	0	0.190	0.343
FS75	0	0.137	0.330
FS29	2	0.030	0.049
FS31	2	0.039	0.096
FS15	5	3.950	6.629
FS24	5	0.178	0.515
HY49	12	1.038	1.346
WBNP58	12	1.125	2.108
HY05	20	4.221	5.846
WBNP78	22	1.900	2.428
PIPELINE	106	4.857	9.900
DANIELS	106	7.633	18.570
HY OLD	139	0.603	1.091
FALAISE OLD	249	2.828	3.454

Appendix G: Track Counts

Lynx

Table 3. Lynx tracks per km, corrected for sightability and days after last snowfall.

	Age	Mean	Standard Deviation
FS62	0	0.01	0.00
FS75	0	0.01	0.00
FS29	2	0.02	0.04
FS31	2	0.04	0.10
FS15	5	0.05	0.38
FS24	5	0.03	0.06
HY49	12	0.05	0.10
WBNP58	12	0.03	0.05
HY05	20	0.04	0.10
WBNP78	22	0.02	0.03
PIPELINE	106	0.05	0.38
DANIELS	106	0.08	0.40
HY OLD	139	0.00	0.00
FALAISE OLD	249	0.02	0.06

Appendix G: Track Counts

Grouse

Table 4. Grouse tracks per km, corrected for sightability and days after last snowfall.

	Age	Mean	Standard Deviation
FS62	0	0.046	0.122
FS75	0	0.070	0.252
FS29	2	0.022	0.036
FS31	2	0.040	0.096
FS15	5	0.195	0.370
FS24	5	0.351	0.251
HY49	12	1.061	2.566
WBNP58	12	1.103	1.356
HY05	20	1.206	1.947
WBNP78	22	1.050	0.991
PIPELINE	106	0.458	0.622
DANIELS	106	0.725	0.859
HY OLD	139	0.961	1.755
FALAISE OLD	249	1.750	2.157

Appendix H: Moose Population Censuses

Table 1. Moose survey data. Density units are moose/km^2.

	Age	Aircraft	Method	% Coverage	Area	Density	CV
FS62	0	Helicopter	Transect	100	327.75	0.0092	n/a
FS75	0	Helicopter	Transect	100	170.5	0.00	n/a
FS29	2	Helicopter	Block	36	256.6	0.01	0.60
FS31	2	Helicopter	Transect	100	139.5	0.22	n/a
FS15	5	Helicopter	Transect	100	133	0.2256	n/a
FS24	5	Helicopter	Transect	100	140	0.06	n/a
HY49	12	Fixed Wing	Transect	30	1200	0.122	0.17
WBNP58	12	Helicopter	Transect	25	2100	0.043	0.28
HY05	20	Fixed Wing	Transect	33	714	0.181	0.30
WBNP78	22	Helicopter	Transect	100	266	0.064	n/a
PIPELINE	106	Fixed Wing	Transect	30	1012	0.0596	0.22
DANIELS	106	Fixed Wing	Transect	28	1164	0.067	0.24
HY OLD	139 Fixed Wing	Transect	33	465	0.013	0.48	
FALAISE OLD	249 Fixed Wing	Transect	33	823	0.044	0.43	