Effects of Natural and Clearcut Disturbances on Small Mammal and Bird Diversity in Conifer Dominated Boreal Forest
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Effects of Fire and Harvest Disturbance on Small Mammal and Bird Abundance in Three Age Classes of Conifer Dominated Boreal Mixedwood Forest

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March 31, 1998

-1998 Project Update-

Summary

The purpose of this study is to address the issue of how large scale harvesting might change biodiversity in the boreal forest. To accomplish this, we began by asking a presently pertinent question 'if and how does timber harvesting differ from fire disturbance?'. We thought this question could best be addressed by comparing vegetation, small mammal and bird diversity in four clearcuts to that in four burn sites in each of three age classes: 3, 16 and 27 year old sites. This design allows for direct comparisons between harvest and burn sites within a given age class, as well as an opportunity to observe if any initial differences disappear over time as regrowth, decay and recolonization take place.

By addressing this issue at the stand scale, we will gain information on how clearcut harvesting can, if necessary, be modified at the site level to more closely mimic fire disturbance. This will provide forest companies with information needed to maintain biodiversity at the harvest site.

Rationale

Disturbance is a natural part of the boreal forest and plays an important role in determining ecosystem structure, composition and function (DesGranges and Rondeau 1992). Variation in disturbance size, intensity and frequency creates a mosaic of habitats which supports a variety of wildlife (Telfer 1992). Before fire suppression, the boreal forest was dominated by a fire-disturbance regime to which each species is adapted (Wein 1991; Telfer 1992). Presently, large sectors of Alberta's boreal forest are subjected to large scale timber harvesting. Fire suppression and clearcut harvesting practices are changing the type of disturbance dominating the landscape. The effect on wildlife and vegetation diversity is not known.
To reduce potential changes in biodiversity arising from timber harvesting, it has been proposed that forest companies use harvest techniques that mimic natural disturbance processes (Titterington et al. 1979; DesGranges and Rondeau 1992; Hunter 1993, Thompson 1992). Both fires and harvesting alter stand structure and composition (DesGranges & Rondeau 1992), but it is not known whether structural and compositional differences exist between these two disturbance regimes and, if extant, how they may affect wildlife.

In past studies, effects of clearcutting have been compared to undisturbed forests. Not surprisingly, vast differences in vegetation and wildlife diversity were found between clearcut disturbed and undisturbed forests. Studies investigating the effects of clearcut harvesting on wildlife communities found that after harvesting, the number and species richness of birds increases over time and often will increase to levels higher than in mature forests (Kavanagh et al. 1985; DesGranges & Rondeau 1992). In a study on small mammals, Kirkland (1977) found that in coniferous forests, clearcut harvesting initially resulted in an increase in abundance, diversity, and density of small mammals, followed by a decrease with succession. Although Ramirez and Hornocker (1981) stated that timber harvesting may simulate fires by providing a variety of habitats for small mammals as succession occurs, their failure to actually compare harvest and burn sites renders this conclusion speculative.

Fox (1983) reviewed a number of papers on post-fire succession of wildlife communities for North American boreal forests. Under this disturbance regime, he also found an increasing trend in bird species diversity and richness with succession to a mature forest stage. Numbers of birds increased to the shrub stage to levels higher than mature forests, but were lower in the sapling stages. After fire disturbance, small mammal abundance was greatest in the early stages of succession relative to mature forest, but was lower in the shrub and sapling stages.

Thus, based on previous, although separate, investigations, there appear to be few differences in the patterns of abundance and diversity of birds and small mammals on harvest versus fire disturbed sites. To confirm this, biodiversity studies must incorporate comparisons of vegetation and wildlife abundance in burned and logged sites to determine if the use of harvest techniques to mimic natural disturbance processes is a sound approach to sustaining biodiversity. Indeed, Thompson (1992) states that "the most important research priority in forest/wildlife is...is the biodiversity associated with post-logging forest the same as would be expected under a natural disturbance regime?" and advocates further investigation into succession after fires. The purpose of this study is to determine any differences in wildlife and vegetation diversity between
harvest and fire disturbed sites in spruce dominated mixedwood forest in order to make recommendations to forest companies to maintain vegetation and wildlife diversity.

**Objectives**

1) Identify any vegetation variables that distinguish clearcut and fire disturbed sites in three age classes of white spruce dominated boreal forest.

2) Compare relative abundance, species richness and species composition of birds and small mammals in three age classes of clearcut and fire disturbed sites of white spruce dominated boreal forest.

**Experimental Design and Methods**

1) **Study Area and Layout**

   This study is being conducted in harvest and fire disturbed sites in three age classes of white spruce dominated boreal forest. The study area (47 km²) is located in the region northwest of the town of Manning (58°, 117°), 92 km north of Peace River, Alberta, Canada.

   Three age classes of burns and cutblocks were selected; 3 years, 16 years, and 27 years. The design consists of a total of 24 sites with four burn and four cutblock sites within each age class. Three age classes were chosen in order to determine if convergence in vegetation and wildlife occurs between fire and clearcut disturbed sites over time, but each age class has its own reason for being selected. The three year age class was chosen to determine what occurs immediately after disturbance. The 16 year age class was selected because at approximately this age, coniferous trees have reached a height of 3.0 m when logging companies can harvest adjacent leaves in a two pass system (Alberta Environmental Protection 1994). The 27 year age class was chosen for two reasons. We believe convergence between fire and harvest disturbed sites may have occurred by this age and it is the earliest date at which clearcut harvesting replaced selective logging in this area (Pers. Comm.).

   Harvest strategies in this region target old stands, use a 110 year rotation age and use clearcutting as the primary method of harvesting. Harvesting typically follows a two pass cutting regime resulting in an orthogonal patchwork of cut and uncut blocks (Alberta
Environmental Protection 1994). The mean cutblock size harvested by Manning Diversified Forest Products (MDFP) in 1994/95 was 9.3 ha and in 1995/96 will be 17.4 ha. Cutblocks are generally harvested in the winter and scarified and replanted in the summer months. For our sampling purposes, harvest sites between 14.7 and 31.2 ha situated on the edge of a cut/leave pattern were chosen. This layout represents realistic past and future harvesting practices, yet reduces the influence of nearby cutblocks. In order to be considered part of a cut/leave pattern, a cutblock had to be located within 1000 m of another cutblock on one side, but have sufficient forested landscape between to allow for further harvesting. The remaining three sides of the cutblock had to be adjacent to a minimum of 1000 m of undisturbed landscape. To ensure independence, sample sites had to be a minimum of 1000 m apart.

Even before effective fire suppression was implemented in northern Alberta in the early 1980's, small fires largely dominated the fire disturbance regime in Alberta (Murphy 1985). In the Peace River Forest District, which encompasses the study area, 87 % of all fires between 1960 and 1980 were less than 40.0 ha in size (determined from fire records obtained from the Provincial Forest Fire Centre). Small fire disturbances best represent the predominant fire regime in our study area. Due to difficulties in accurately locating and accessing small fire disturbances, 15 ha sites will be selected in fingers of larger burns for each age class. Fingers were defined as having three edges adjacent to 1000 m of undisturbed landscape. Burn sites located in fingers of larger fires most closely represent a small fire disturbance.

Although fires cross all vegetation boundaries (Sousa 1984), only fingers that were previously merchantable timber (large diameter white spruce dominated, aspen/white spruce mix or white spruce/pine mix) were selected for study. Using sites with similar pre-disturbance vegetation will allow for meaningful comparisons between fire and harvest disturbed sites, particularly for comparison of vegetation variables. As for cutblock sites, burn sites had to be a minimum of 1000m apart to ensure independence.

In summary, there were 4 stands/treatment, where a treatment equals each disturbance type and it’s age (i.e. 1993 Burn or 1969 Cut). Within each stand, a 250m transect was set up at a position of no less than 100m within the perimeter of the disturbance. All subsequent sampling sites were positioned relative to these transects as referred to in the following report.
2) Small Mammal Census

Live trapping sessions were conducted in spring over a five week period in 1997. A total of sixteen Longworth traps were located at 40m intervals along, and 20m on either side of the 250m transects. Each stand was pre-baited for three consecutive nights, followed by three consecutive trap nights. The species, sex, and reproductive condition were recorded for all captured animals.

To determine abundance of red squirrels (*Tamiasciurus hudsonicus*), a modified bird sampling technique from Ralph *et al.* (1992) was used. As with birds, red squirrels are territorial. Territories are defended by vocalizations (Lair 1990). During point count sampling for birds, red squirrel vocalizations were recorded using the same method (see 3) Avian Census).

3) Avian Census

Two point count stations were located within each harvest and burn site. Point count stations were located at the end of the 250m transects. Sample stations were located 250m apart to ensure site independence. Each treatment stand was visited on 4 separate occasions between May 25 and June 3, 1997 between 4:00 and 10:00 a.m. Bird calls were recorded for a period of five minutes at each point count station. Species seen and heard within and outside a 50m radius were recorded separately. Data collection followed Ralph *et al.* (1992).

4) Vegetation

Numerous vegetation variables were measured including snags, coarse down woody material, live trees, shrubs, herbs, and duff layer.

Snags and live trees were sampled using a nearest neighbor technique. Sampling points were located at regular intervals. From this sampling point, the distance to the nearest tree and snag was recorded within each of four quadrats. These quadrats extended out from the sampling point with their borders located north, south, east and west from the sampling point. The number of sampling points were dependent on the treatment type. For 1993 Harvest sites, distance between sampling points were located every 120m to accommodate the obviously low density of snags and live trees. For 1993 Burns, distance between sampling points was 40m. For the remaining treatments, sampling points were separated by 80m.
Shrubs, seedlings, saplings, and herbs were sampled using a nested sample plot comprised of three nested plots; .5mx.5m plot nested within a 3mx3m, nested within a 5mx5m plot. Each plot was located every 40m along the sampling transect, and at 20m on either side of the sampling transect. A total of 12 nested sampling plots were sampled within each treatment stand. In addition, an 8m transect extended along one edge of the quadrat for sampling down woody material and duff layer depth.

Grasses and Herbs
Percent cover and species richness of herbs was determined within each .5mx.5m sample plot. Within each plot, the species of all herbs were identified and the % cover of rocks, wood, soil, grasses, moss, and herbs was estimated.

Shrubs, Saplings, and Seedlings
Twelve 3mx3m sample plots within each stand were used to determine species richness of shrubs, and species richness and relative abundance of saplings and seedlings. The number of saplings, seedlings, and shrubs was recorded along with species type.

Trees and Snags
All trees and snags <10cm DBH were counted and species recorded in a sample plot of 5mx 5m.

Duff Layer
At each sample site along an 8m transect, duff layer depth was measured at 1m intervals by inserting a metal ruler into the duff.

Coarse Down Woody Material
The diameter and length were recorded for down woody material (CDWM) greater than 10cm in diameter that crossed the 8m transect.
Preliminary Results and Discussion

I) Relative Abundance of Small Mammals:

A total of 215 small mammals were live-captured in 1,152 trap nights spread evenly across 24 stands (48 trap nights/stand). There were 74 captures in 1993 harvest sites, 34 captures in 1993 burn sites, 29 captures in 1980 harvest sites, 26 captures in 1980 burn sites, 21 captures in 1969 harvest sites, and 31 captures in 1969 burn sites (Figure 1). No significant differences were found in small mammal abundance among treatments (Kruskal Wallis; $H=5.47, \chi^2_{0.05,5} =11.07, p=0.032$). However, there was a trend for higher abundance of small mammals in 1993 harvest sites compared to the other treatment groups. Trapping intensity will be increased in the following year to ensure that the lack of significance is not due to insignificant trapping intensity. However, it is clear that any initial difference in small mammal abundance between disturbance types disappears by 1980 treatments.

![Figure 1](image.png)

Figure 1. Average abundance of small mammals in burn versus harvest sites in three age classes.

II) Relative Abundance of Birds:

Fifty two (52) different bird species were detected with a number of unidentifiable bird calls. There was a significant differences among treatment types (Kruskal Wallis test; $H=12.41, \chi^2_{0.05,5} =11.07, p=0.027$) with 1980 Cuts having a greater abundance of birds relative to the other treatment types.
The greater abundance of birds in the 1980 Cuts is likely due to a greater density of shrubs compared to the other treatment types. Greater shrub density might provide a habitat niche that supports a greater abundance of birds. In the 1980 Burns, the stage of succession has past the shrub stage, or perhaps has skipped this stage entirely, and progressed to a high density sapling stage.

III) Snag Characteristics:

A total of 1,114 snags were sampled across the six treatments. Snag densities were significantly higher in the 93 Burns as compared to the other treatments (Kruskal Wallis test; H=14.09, $\chi^2_{0.05,5} =11.07$, p=0.011; figure 3) with seven times more snags in 93 Burns that the other treatments. Although snag densities were consistently higher in burn treatments relative to harvest treatments within the same age class, these differences decreased with time as snags decay, fall, and contribute to down woody material.
Figure 3. Density of snags in burn versus harvest treatments in each of three age classes.

Cavity Characteristics:

Of the 1,114 snags sampled, 48 contained a cavity. The highest density of snags with cavities occurred in the 93 burn sites (3.03 snags/ha; figure 4). Although it was rare for a snag in any of the burn sites to have a cavity (Figure 5), the relatively high density of snags in the 93 Burn sites led to a greater density of cavities as compared to the other treatments. The potential for timber harvest companies to maintain the same density of cavities in harvest sites relative to burns sites exists. However, this would mean paying careful attention to the snags and trees left at the harvest site. A very high percentage of snags and live trees with existing cavities, or at least a high potential for cavities, would have to be conserved at the harvest site.
Figure 5. Density of snags with a cavity in burn and harvest sites in each of three age classes.

Figure 6. Average percent of snags with cavities in burn and harvest sites in each of three age classes.

IV) Coarse Down Woody Material:

For each of the four stands within each treatment, twelve 8m transects were used to sample coarse down woody material (CDWM). A total of 96m were sampled for CDWM in each treatment. CDWM sampled included logs and stumps that had a diameter ≥10cm at the point which it crossed the 8m transect. Estimates of CDWM volume per unit area were calculated using the following formula (Van Wagner 1968):

\[ v = \frac{\pi^2}{8l} \sum_{i=1}^{n} (n_i d_i^2) \]
There was a significant difference in the volume of CDWM (Kruskal Wallis test; $H=32.09$, $\chi^2_{0.05,5} = 11.07$, $p<0.001$) with a lower volume of CDWM occurring in the 93 Burn treatment relative to the other treatments (Figure 7.). In both the burn and harvest treatments, the volume of CDWM increased with time since disturbance. This trend was expected due to the increased input of large diameter snags as death and decay occurred with stand age. However, it is interesting to note that the input of CDWM increased more dramatically in burns with age relative to harvest sites. This is likely a result of the low density of snags present at the harvest site as compared to burn sites at the time of disturbance (see Figure 3. for relative snag densities). The end result was an insignificant difference between burn and harvest sites in the volume of CDWM as time from disturbance increases.

![Figure 7. Volume of coarse down woody material (diameter ≥10cm) in burn versus harvest sites in each of three age classes.](image)

**Summary**

All results and discussion in this report are preliminary. Where only partial data have been collected, analysis was meaningless, and therefore omitted. An additional year of research will complete the data needed for the final report. At this time, more indepth statistical analysis examining the relationship between wildlife abundance and vegetation analysis will be performed.
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