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The impact of site preparation on terrestrial lichen: nine-year re-measurement

Abstract

Five site preparation methods in a chunk-management harvest block were monitored from 1996 to 1998 and the resulting cost and productivity, site disturbance, and terrestrial lichen distribution are described in Phillips (2001). After nine years, there were few measurable differences in the impact of site preparation on lichen growth. Vegetative propagation, "seeding" with fragments of shrub lichen (*Cladina* spp.), increased the amount of lichen in all areas/treatments except on the wettest sites.

Keywords:

Lichen, Site preparation, Site disturbance, Vegetative propagation, Disc trenching, Mounding, Scarification, Woodland caribou.

Introduction

In Alberta, woodland caribou are blue-listed by the Fish and Wildlife Division of Alberta Sustainable Resource Development and are designated as threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) because of a reduction in populations (Dzus 2001). Their population dynamics are influenced by a suite of factors and inter-relationships. Food source such as terrestrial lichen (e.g., *Cladina* spp., *Peltigera aphthosa, Cetraria islandica* and *Stereocaulon paschale*) is a consideration, especially in winter habitat (Sulyma 2008, Johnson et al.1995). This report discusses the impact of site preparation and vegetative propagation on terrestrial lichen communities in the first decade after harvesting. The original study design and site-preparation monitoring are described in Phillips (2001). The Connacher Creek chunk-management harvest block, near the confluence of the Berland and Little Smoky Rivers in northwestern Alberta, provided the opportunity to compare different site preparation techniques. The Connacher Creek trial was a 361 ha block, composed of 324 ha in clearcut and 37 ha in in-block reserves. The timeline for the research and other activities at Connacher Creek included harvest planning in 1992–95, harvesting in 1995–96, site preparation in fall 1996, planting in 1997, literature review in 1997–98, lichen measurement and vegetative "seeding" in 1998, and lichen re-measurement in 2007. Overall, the lichen monitoring and propagation were minor components of a larger trial (chunk-management harvest and regeneration) and were driven by local forest company interest and opportunity.

The literature indicated that lichen vegetative propagation may be possible and, in fact, pieces of lichen (thallus fragments) carried by wind, birds, hares, and rodents may be the normal method of lichen re-establishment when a major disturbance, such as fire, removes most of the lichen from a site (Roturier et al. 2007). The literature also indicated that site disturbance usually negatively impacts lichen growth. However, in the study area, more lichen was observed on old heavily disturbed seismic lines than in the undisturbed stand. Lichen is a poor competitor with mosses, and the pre-harvest stand conditions favoured moss growth. Lichen is frequently displaced by feather moss in mid- to late succession, depending on canopy closure (Sulyma and Coxson 2001), and is usually most prevalent on nutrient-deficient sites. This is probably why the lichen was abundant only on old seismic lines and not under the forest canopy throughout the area near and within the treatment block. Pre-harvest lichen assessment showed relatively low volumes of lichen on this site.

Since that time, other studies have been initiated to investigate the ability of "seeding" to offset the effects of site preparation disturbance on lichen forage in caribou/reindeer areas (Roturier et al. 2007).

Objectives

The objectives of this phase of the project were as follows:

- Determine if the site preparation method impacted lichen growth.
- Determine if vegetative propagation was successful.
- Assess the potential value of future monitoring.

Methods

In 1998, lichen was measured along some of the existing lichen lines established by a consultant and along new lines within each of the site preparation treatments, including a straight plant/no-site-preparation area. Some of the lines within each treatment were "seeded" with lichen fragments to enhance the lichen through vegetative propagation. Lichen was collected from a donor area with hand shears (Figure 1), further sheared into approximately 1 cm^3 fragments, and distributed by hand along the designated measurement lines (Figure 2) at a rate of 145–165 g wet weight (equivalent to 45 g dry weight or 1500–1700 cm^3) per 30 m line. No adhesive or other binder was used and it was not known if the lichen would remain in the locations it was placed. This small amount of lichen would cover only one-fifth of a single 1 x 1 m plot to 100% coverage. The remainder of the lines were not treated.

The original measurements for both disturbance and lichen coverage were made in 1 m quadrats centred on lines radiating from grid point centres spread throughout the treatment areas. The re-measurement re-established the same lines and attempted to measure the same quadrats. The percentage of lichen coverage was estimated by adding up the area occupied by each clump of lichen within each quadrat (Figure 3). Shrub lichen, predominantly reindeer lichen (*Cladina rangiferina*) (Figure 4) and star lichen (*Cladina stellaris*) (Figure 5), and leaf lichen, primarily freckle pelt (*Peltigera aphthosa*) (Figure 6), were measured separately (Johnson et al. 1995). All grid point centres were re-staked and the GPS coordinates recorded to allow future re-measurements at the same locations.

The data were summarized and the mean area covered by shrub lichen was compared using Fisher-Snedecor F-tests and Student's t-tests of paired data sets without data transformation. The data were paired to determine whether the changes in coverage were significantly different between 1998 and 2007, canopy and clearcut, seeded and not seeded, and treatments. Regression analysis was used to compare changes in lichen coverage and site-preparation disturbance levels.

Figure 1. (*left*) Lichen collection.

Figure 2. (*right*) Lichen distribution.

Figure 3. (*left*) Lichen re-measurement.

Figure 4. (*right*) Reindeer lichen.

Figure 5. (*left*) Star lichen.

Figure 6. (*right*) Leaf lichen.

Results and discussion

Table 1 compares the shrub lichen coverage in each of the treatment areas. The lichen lines were used as a non-harvest control and were not seeded. The lichen lines and the no-site-preparation areas were different. The lichen lines within the harvested area were treated as no-machine zones during harvest, generally had some understory retention, and were generally not skidded across. The no-site-preparation treatment was part of the conventional harvested area but was excluded from site preparation. The chain-drag treatment's seeded area was completely destroyed by oil and gas activities and most of the seeded plots in the row-mound treatment were also destroyed. The leaf lichen data are not presented in this report.

Canopy effects

There was a significant difference in shrub lichen coverage between the canopy and the clearcut (no machine zone) lichen lines in 1998. However, shrub lichen coverage had not increased in the last nine years under either the canopy or in the clearcut. The leaf lichen coverage did not increase under the canopy section of the lichen line; however, there was more leaf lichen under the canopy than on the clearcut portion of the lichen line in both 1998 and 2007. Much of the clearcut leaf lichen was shrivelled and appeared to be dead when the first measurements were made in 1998, two years after harvest.

Table 1. Coverage of shrub lichen (reindeer and star)[(1)]

Treatment	1998 mineral soil exposure (% of total area)	1998 all disturbance (% of total area)	1998 lichen coverage (mean % of total area)	2007 lichen coverage (mean % of total area)		Number of quadrats	
				Not seeded	Seeded	Not seeded	Seeded
No harvest (lichen line): under canopy	0.0	0.0	0.08^{a}	$<0.01^{m}$	n/a	202	n/a
No harvest (lichen line): in clearcut	0.0	~25[(2)]	0.33^{c}	0.48^{c}	n/a	352	n/a
No site preparation; plant	0.9	16.1	0.18^{cd}	0.41^{n}	0.87^{o}	624	174
Chain drag; natural regeneration	6.1	53.5	0.01^{b}	0.07^{p}	n/a	577	n/a[(3)]
Disc trench; plant	17.2	45.7	0.13^{ac}	0.17^{c}	1.70^{q}	519	120
Excavator mound; plant	13.1	26.2	0.07^{adf}	0.30^{r}	3.00^{s}	378	92
Row mound; plant	21.4	32.1	0.01^{bef}	0.04^{f}	0.63^{t}	417	24[(4)]

(1) Different letters indicate a significant difference at the 95% confidence level. Lichen coverage for 1998 is compared between treatments, and each treatment is compared between 1998, 2007 seeded, and 2007 not seeded.
(2) Some disturbance was observed from tops or branches disturbing the moss layer or possibly from limited skidding across the lines. Detailed measurements were not conducted.
(3) All seeded plots were destroyed.
(4) Note limited seeding data—remaining plots were destroyed.

Vegetative propagation effects

Vegetative propagation resulted in significant increases in lichen coverage in all site preparation treatments. At the time of seeding, it was not known if the wind would remove the lichen chunks (thallus fragments) from the plots; however, most of the seeded lichen seemed to have remained where it was placed. In fact, some of the plots, whose reference stakes were destroyed by oil and gas activities, were re-located by following the concentrated strip of lichen in the seeded plots (Figure 7). The no-site-preparation and row-mounded areas were seeded primarily with star lichen, which dramatically illustrated the effect of vegetative propagation since there was no other star lichen in the plots prior to seeding in 1998.

Disturbance effects

Overall, the effect of disturbance on shrub lichen growth is not completely clear, at least partly because the original lichen distribution was spotty which resulted in no lichen coverage on many undisturbed plots. The literature (Roturier et al. 1997) indicated that mineral and organic soil layer disturbance usually reduces lichen coverage. In this study, there is a poor relationship between surface disturbance in 1998 and lichen coverage in 2007 when all plots are compared; however, most of the lichen coverage was on undisturbed plots. About 60% of the variation of the net lichen growth from 1998 to 2007 can be explained by the total amount of soil surface disturbance. The relationship to

Figure 7. Seeded lichen line.

mineral soil exposure was weaker and only explained 34% of the net lichen change. Only 6% of the increase in the means of the seeded plots can be explained by the post-site-preparation soil surface condition from 1998, indicating that seeding can negate the effect of soil disturbance from site preparation.

Site preparation effects

There was a small but significant shrub lichen abundance increase in the chain-drag, excavator-mound, and no-site-preparation areas. There was no significant change in the disc-trench, row-mound, and no-harvest areas. In addition to the regular site preparation areas determined by cost, machine availability, and prescription requirements, all site preparation methods except for the excavator mounding were also applied side-by-side in a small, flat plateau area for research and demonstration reasons. This area had visibly more shrub lichen before the site preparation treatments than surrounding areas and had consistent vegetation throughout the small area. The means of these non-seeded plots in this area were compared to determine if the variables from the different site preparation location were screening the differences between site preparation techniques. There was no significant lichen growth in the disc-trench, row-mound, and no-site-preparation areas. There was a small but significant growth in the chain-drag area—the treatment with the lowest mineral soil exposure.

In general, the site preparation methods were not applied randomly. For example, the chain drag was only used where there was an adequate cone/seed source. Also, because the excavator was the most expensive site preparation method, it was only used in the areas that were not suitable for the other techniques, especially the areas with moisture seepage. These moist areas had the highest vascular plant growth response and are therefore the least suitable for lichen growth.

Conclusions

Disturbance from site preparation can impact the amount of lichen growth; however, there was not a significant enough difference between the site preparation techniques in this study to choose a technique solely on lichen impact. Vegetative propagation can significantly increase the coverage of lichen and can offset the impacts from site preparation. Growth and re-colonization by lichen, once moss competition is reduced, is slow—beyond the nine-year time frame of this study—and it is unknown how long the reduction in moss competition will continue. At least one more measurement in 5–10 years of the lichen on this site is justified to confirm if the initial trends continue.

Implementation

This study did not explore lichen collection or distribution methods during vegetative propagation or "seeding". If target lichen coverage was prescriptive and seeding was desired, a donor area would need to exist and collection and distribution methods would need to be explored.

- Before collecting or seeding lichen, the species should be checked to ensure the target caribou forage species are prominent.
- Collection for the research trial was by hand with topiary shears but the relatively flat donor area could have had larger-scale collection with powered equipment such as a lawn mower with a collection bag.
- Distribution of lichen chunks during seeding was again by hand for the research trial but could be applied aerially for large-scale application, during tree planting, or with agricultural seeding equipment for smaller-scale areas.
- Some monitoring would be needed to determine the distribution rates to achieve the desired coverage and long-term outcome.
- Areas selected for lichen enhancement must be ecologically suitable for the specific lichen species, have low competition from vascular plants and mosses, and have the necessary wet/dry cycles.

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