

Use of Replacement Vegetation for Control of Competing Vegetation in Spruce Plantations in the BWBS

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Introduction

The most consistent control of competing vegetation in northeastern B.C. has been achieved through use of the herbicide glyphosate. As an alternative to the use of this herbicide, an experiment using seeded agronomic forage species to displace competing vegetation in *Picea glauca* (white spruce) plantations in northeastern British Columbia was initiated in 1992. The objectives of this study are as follows: 1) to determine the effectiveness of vegetation control using replacement with agronomic species; and 2) to assess survival and initial growth of white spruce seedlings on sites that have been mechanically site prepared and seeded with agronomic species.

Site Descriptions and Methods

Two sites were established during the 1992 growing season. The Muskwa site is located on a terrace of the Muskwa River five km south of Fort Nelson. This site is in the BWBSmw2/05 (white spruce-currant-horsetail) site series and has silty loam-sandy loam alluvial soils. Common plant species in 1992 included *Populus balsamifera* ssp. *balsamifera* (balsam poplar), *Rosa acicularis* (prickly rose), and *Calamagrostis canadensis* (bluejoint). The Johnson Creek site is located 14 km southwest of Hudson's Hope. This site is in the BWBSmw1/01 (white spruce/aspens-stepmoss) site series and has loamy soils developed on morainal deposits. Common plant species in 1992

were *Rubus idaeus* (red raspberry), *Rubus parviflorus* (thimbleberry), *Calamagrostis canadensis* (bluejoint), *Mertensia paniculata* (tall bluebells), and *Epilobium angustifolium* (fireweed). Both of these locations were mechanically site prepared. The Muskwa site was sheared and piled in January 1992. The Johnson Creek site was sheared and piled in March 1991, then treated with a Madge rotary plough in August 1991. The two sites were planted with white spruce stock in 1992, Muskwa in June and Johnson Creek in July.

A randomized block design was used at each site, with species seeded as the main plot factor. Species seeded were *Festuca rubra* cv. 'Boreal' (red fescue), *Festuca saximontana* cv. 'Nakiska' (sheep fescue), *Lotus corniculatus* cv. 'Leo' (birds-foot trefoil), *Medicago sativa* cv. 'Rangelander' (alfalfa), *Trifolium hybridum* cv. 'Dawn' (alsike clover), and *Trifolium repens* cv. 'Grasslands Huia' (white clover). Within each 0.02 ha plot, ten randomly selected seedlings were used as centres for subplots (1 m diameter). Seedling damage, mortality, height, current height increment, basal diameter, and crown radius were recorded. Vegetation species, absolute cover, and height were recorded. Analysis of variance was used to test for differences between treatments (alpha of 0.01). Results presented here are from data collected in August 1993.

Results and Discussion

In 1993, cover and heights of the agronomic species were generally higher at the Muskwa site (Table 1.) The better establishment and initial growth of most agronomic species at the Muskwa site is likely due to: 1) better moisture and nutrient availability; and 2) better seedbed.

The intense churning and mixing of the Madge rotary plough creates many air spaces, making the seedbed more prone to desiccation. The growth potential and winter survival of the legumes at Muskwa may have been reduced by an extreme frost in August 1992, the establishment year.

At both sites, a significant treatment effect existed for both heights and covers of a number of species that regenerate from seed and rhizomes, including bluejoint and fireweed. However, most of these were herbaceous rather than woody species. Exceptions were red raspberry at Muskwa and thimbleberry at Johnson Creek. The most impressive exclusion of native vegetation was in the alfalfa, alsike clover, and birds-foot trefoil treatments at Muskwa and the alsike treatment at Johnson Creek.

At the Muskwa site, the lush growth of alsike clover, birds-foot trefoil, and alfalfa caused extensive vegetation press damage to the white spruce seedlings. At Johnson Creek, only the alsike clover caused noticeable vegetation press damage.

Table 1. Mean cover and height of agronomic species

	Muskwa		Johnson Creek	
	Cover (%)	Height (cm)	Cover (%)	Height (cm)
Alsike clover	26.9b	62.0ab	35.2a	56.8a
Alfalfa	47.0a	63.7ab	2.5b	45.0ab
Birds-foot trefoil	8.7c	53.9ab	11.6b	41.8ab
Red fescue	11.0bc	49.9cd	3.6b	41.7ab
White clover	9.7c	34.4cd	5.3b	28.6b
Sheep fescue	4.0c	26.9d	1.7b	23.7bc
Control	0.0c	0.0e	0.0b	0.0c

Identical letters in the same column indicate no significant difference (alpha = 0.01) as determined by Scheffe's test.

Conclusions

These initial results suggest that, on highly productive sites, vigorous growth of alfalfa, birds-foot trefoil, and alsike clover may damage seedlings and possibly reduce survival compared to the fescues and white clover. On average upland sites, the growth of alsike clover may also result in seedling damage from vegetation press. However, spruce seedlings may recover from the damage and experience less vegetative competition once they are above the canopy created by the agronomics.

After two seasons of growth, agronomic species indicated an ability to reduce the cover and height of some species of native vegetation.

COAST R_x: A Conceptual Model of a Decision Support System for Regenerating Oregon's Coast Range

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Management activities during early stages of succession are critical to the long-term trajectories of Pacific Northwest forests. Competitive effects from vegetation, animal damage, and climatic events pose the most frequent limitations to productivity of regenerating trees. While much is known about these factors and processes, information on them have never been integrated or synthesized into an accessible and useful form. Coast R_x is a decision support system designed to: 1) integrate and compile information on the physical and biological factors and processes important to the regeneration process; 2) use this information to model regeneration; and 3) prescribe management options for improving regeneration success. Coast R_x focuses on modeling the first five years of forest development, and interfaces with young stand models for projecting tree growth and yield later in forest development.

The principal state variables modeled include diameter and height of tree species, and cover and height of shrubs, herbs, and forbs. Supporting state variables also modelled include aerial resources and conditions such as radiation and humidity and soil resources. Competition between trees and their associate vegetation is the predominant process simulated. Hazards such as the potential for animal, wind, frost, and drought damage are incorporated into predictions of regeneration success.

A series of menus is designed to prompt clients for site-specific information, management objectives and constraints, and desired future conditions. Site Set-up allows the client to input climate, plant association, and soil information, as well as perceived hazards, constraints, and objectives. These settings form the foundation for the simulation as well as specifying the desired future condition. Harvest Set-up customizes the initial harvesting scenario. Post Harvest Set-up customizes the initial choice of post-harvest management activities. Vegetation Scenario Evaluation then proceeds by simulating growth of trees and other plants in the system, as modified by site features and initial management events. Output from this module is passed to a young stand model for further stand projections. The output from this model—predicted future conditions—is compared to desired future conditions. If criteria specified by the client are met, then the initial set of management activities is verified as acceptable. If criteria are not met, a new set of management activities are selected, the vegetation scenario is simulated again and evaluated as before. This process continues until a set of management activities is formulated that result in a match of predicted future conditions with desired future conditions.

Forest Herbicide Use and Small Mammals

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Three relatively long-term studies on the influence of forest herbicide use on small mammals have been conducted in British Columbia: 1) the small mammal community in a coastal western hemlock forest in south coastal B.C.; 2) small mammal community and vegetation changes; and 3) snowshoe hare populations and vegetation changes in Sub-Boreal Spruce (SBS) forest near Prince George.

In terms of the response to habitat change in the south coast study, there was little difference in abundance of deer mice (*Peromyscus maniculatus*), Oregon voles (*Microtus oregoni*), and shrews (*Sorex* spp.) between control and treatment study areas. Townsend chipmunk (*Eutamias townsendii*) populations appeared to decline temporarily on the treatment area relative to the control. These populations should be able to persist in areas of coastal coniferous forest that are treated with herbicide for conifer release.

In terms of potential direct effects of forest application of glyphosate herbicide on deer mice and Oregon voles, the demographic parameters of reproduction, growth, and survival were examined. Manifestation of physiological changes in individual animals that might have resulted from exposure to or ingestion of glyphosate was not apparent in these demographic attributes at the population level.

In Sub-Boreal Spruce forest, control and treatment sampling areas were located in herb and shrub successional stages in each of the SBSvk and SBSwk subzones. Vegetation and small mammal populations were monitored during 1987 (pre-treatment year),

1988–1989 (post-treatment years), and in 1991–1992 (fourth and fifth post-treatment years). Shrub layers were significantly reduced on all study areas after treatment. Herbaceous vegetation layers recovered to control levels of biomass by two to three years post-treatment. Small mammal (deer mice and red-backed voles, *Clethrionomys gapperi*) populations in herb stages followed the recovery of vegetation. However, there were no consistent differences in small mammal populations between control and treatment shrub stages. Herbicide treatment of areas dominated by herbaceous plant species should be staggered in time and space to allow recovery (two to three years) of vegetation and small mammals.

Changes in vegetation and snowshoe hare (*Lepus americanus*) populations were assessed in areas of “conifer release” and “backlog conversion” herbicide treatments. This study tested the hypothesis that herbicide-induced habitat alteration would reduce hare populations in these early- to mid-successional (<25 years post-harvest) stages of sub-boreal spruce forest. Intensive population sampling and monitoring of vegetation were conducted in replicate control and treatment blocks from 1988 to 1991. Index line surveys of hares were also conducted in 10 paired control-treatment blocks. Herb layers recovered to control levels by two to three years post-treatment. Shrub and tree layers were little affected in the “conifer release” treatment where coniferous species dominated these layers. In the “backlog conversion” treatment, the dominant deciduous trees and shrubs were relatively slow to recover. This habitat alteration

appeared not to affect abundance of snowshoe hares, at least in terms of optimum habitat during summer-fall periods. Hares seem able to persist in abundance in early to mid-successional (25 years) habitats that undergo herbicide-induced alteration. Nevertheless, a staggered approach to treatment of blocks should be followed in a given area whenever possible, since we have little information on response of hare predators to this habitat alteration.

Potential direct effects of glyphosate on reproduction, growth, and survival in snowshoe hare populations were examined. There were no consistent differences in proportion of breeding hares or number of successful pregnancies between control and treatment populations. Recruitment and survival parameters showed no consistent trends in terms of differences between populations. Lack of significant differences in mean body weights and growth rates suggested that glyphosate had little or no direct effect on metabolic or general physiological processes in the development of young hares. Similar profiles of body weight distribution between control and treatment populations indicated that comparable levels of biomass of hares were available as prey for predators. Glyphosate probably does not adversely affect demographic parameters of snowshoe hare populations.

Acknowledgements

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Effects of Prescribed Fire, Mechanical Site Preparation, and Herbicide Treatments on Vegetation and Tree Seedling Establishment on a Backlog NSR Site in Central Interior British Columbia

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A trial of treatment regimes consisting of six site preparation treatment combinations (including herbicide, prescribed fire, and mechanical methods), planted with two tree species (lodgepole pine and interior spruce), and a three-year post-planting glyphosate treatment/no treatment level was carried out on a disturbed (backlog NSR) site in the central interior of British Columbia (SBSwk/01). The principal plant species on the site prior to treatment were black twinberry (*Lonicera involucrata*), fireweed (*Epilobium angustifolium*), and thimbleberry (*Rubus parviflorus*).

The initial results indicate that:

1. The nutrient status of the mineral soil was not strongly affected by any of the treatments. However, there were moderate losses of total P, S, and probably N from the forest floor in all of the treatments.
2. Soil temperatures during the first two years following site treatment were greater in the spray and burn than in the windrow treatments at some times of the year, and were generally greater in the disc-trenched plots.
3. Fireweed accounted for most of the vegetation canopy volume in the first five years. Fireweed, twinberry, and total vegetation volume were significantly different between the primary site preparation treatments in the series windrow > burn > spray and burn (Figure 1).
4. Fireweed, twinberry, and total vegetation volume were not affected by disc-trenching.
5. Thimbleberry was not affected by site preparation treatments. Raspberry was greater in the spray and burn than the windrow and the burn treatments, and was increased by disc-trenching.

6. All of the vascular plant species present before treatment still occur in each treatment regime.
7. After five years interior spruce height and diameter and lodgepole pine height were greater in the spray and burn treatment than in the windrow and the burn treatments. Disc-trenching increased pine and spruce diameter. Lodgepole pine height and diameter and interior spruce diameter were increased by the brushing treatment (Figure 2).
8. Seedling survival was uniformly high among treatments (>95%).

The implications of these results to silviculture prescription development will depend on tree seedling growth performance targets, and on broader ecosystem management objectives.

Volume (m³/m²)

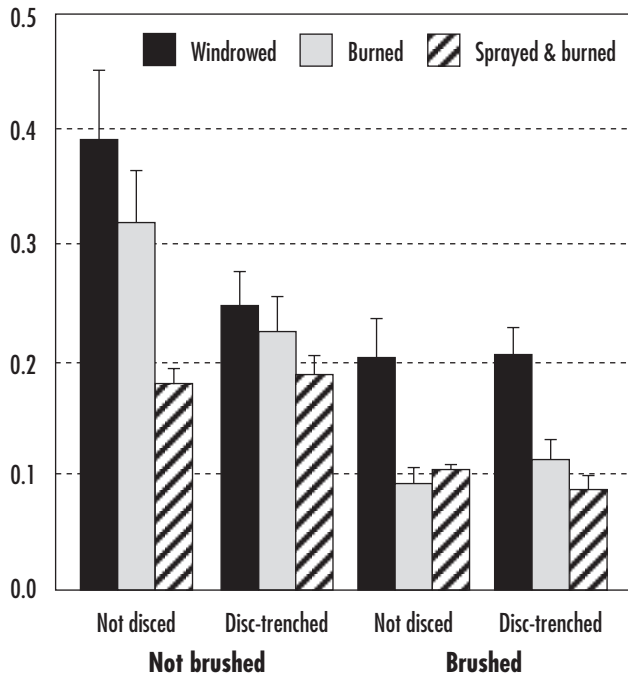


Figure 1. Total vegetation volume five years following site preparation and two years following brushing.

Volume index (cm³)

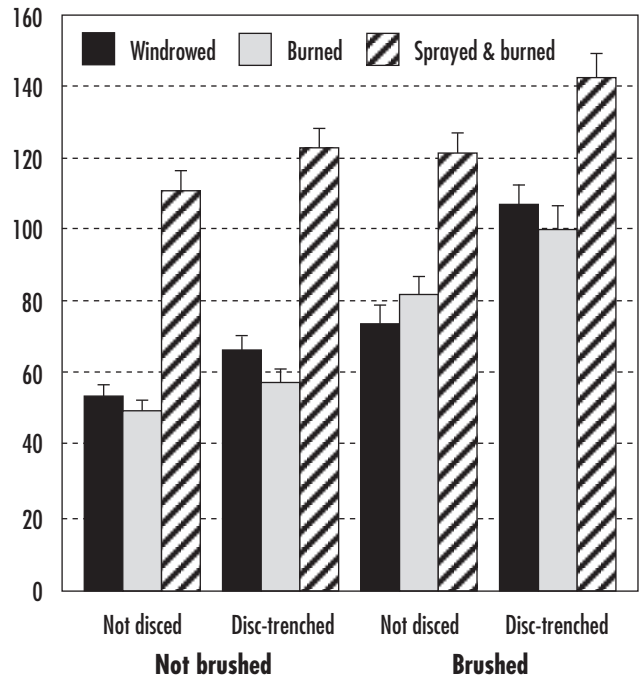


Figure 2. Interior spruce stem volume index five years following planting.

SCORCH: A Fire-induced Tree-mortality Prediction Model for Canadian Forests

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In some ecosystems, prescribed fire may be used to emulate the natural role of a surface fire and reduce the proportion of certain tree species or sizes in a stand.

Trees are weakened or killed by fire through heat damage to the cambium or crown scorch. Mortality is generally greater for smaller, thin-barked trees with a lower crown base height, and can be represented as a probability function.

Fire and resource managers need to be able to predict the effects of particular burning conditions on stand structure and composition in order to develop prescribed fire prescriptions.

We have developed an interactive computer program that links tree mortality equations used in the First Order Fire Effects Model (FOFEM) (USDA Forest Service) with Canadian Fire Behaviour Prediction System equations, and burning conditions given in terms of Canadian Fire Weather Index System values.

The program incorporates fire behaviour predictions for three forest types and probable effects on eight western conifer species.

Mortality/resprouting equations need to be developed for other Canadian tree species (particularly trembling aspen) to make the model more widely applicable. Also, a mechanism for incorporating the spatial variability in fire intensity and crown scorch within fires is needed.

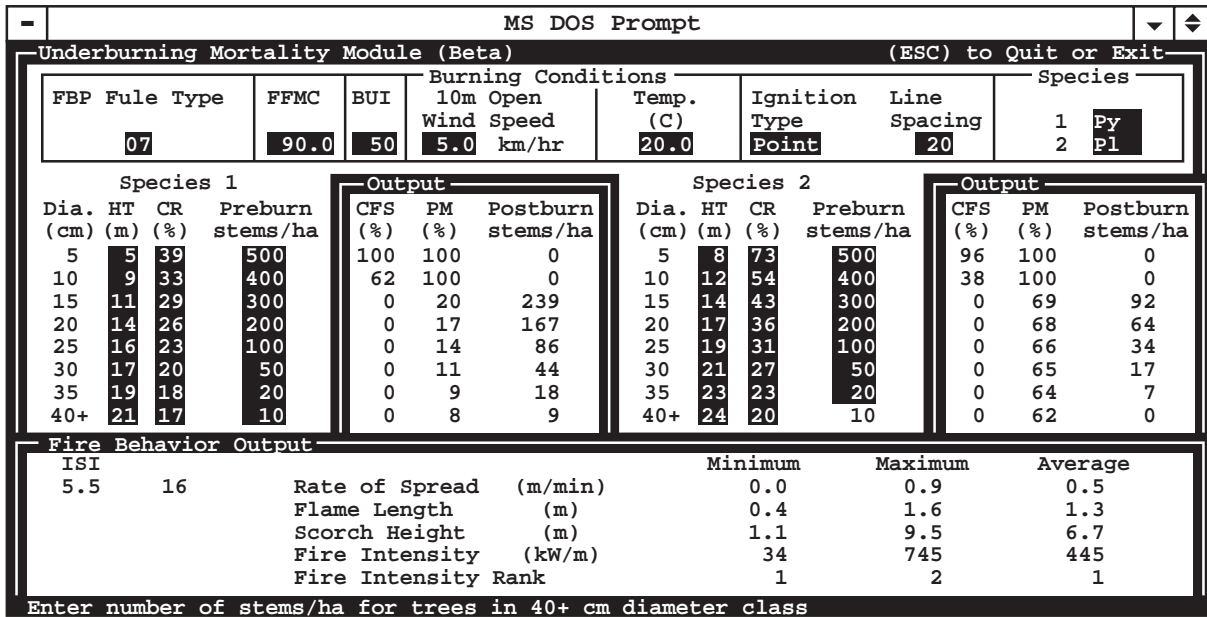


Figure 1. Prototype model screen showing potential fire behaviour and tree mortality (Pm) for particular burning conditions.

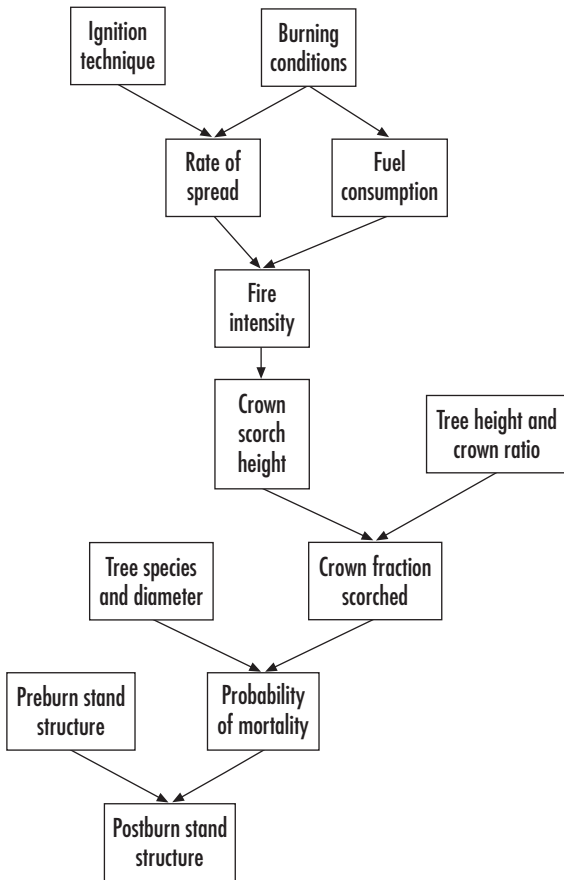


Figure 2. Simplified tree-mortality model structure.

Grass and Legume Seeding for Vegetation Control in the Nelson Forest Region – Species Screening Trial on a Low Impact Burn

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Objectives

1. To assess the growth of selected grass and clover species on a low impact burn.
2. To assess the effect of the seeded species on the growth and survival of planted Engelmann spruce.
3. To assess the effect of the seeded species on the invasion of native vegetation.

Methods

Three blocks were established in early June 1990 on a spring burn in the ICHwk1 at Big Eddy Creek north of Revelstoke, B.C. Each block was divided into five 10-metre wide strips running north-south and five 10-metre wide strips running east-west. This produced twenty-five 10-metre square plots in each block. Three species of grass, orchardgrass (*Dactylis glomerata* L.), creeping red fescue (*Festuca rubra* L.), and perennial ryegrass (*Lolium perenne* L.) plus white

dutch clover (*Trifolium repens* L.), were seeded individually in strips running N-S. The same species were also seeded in the strips running E-W. The fifth strip in each direction was an unseeded control. All seed was applied at a rate that was planned to deliver 25 seeds per 100 cm². The rates used were:

Orchardgrass	17 kg/ha
Perennial ryegrass	50 kg/ha
Creeping red fescue	19 kg/ha
White dutch clover	14 kg/ha

Thus each plot received two applications of seed (one from the N-S strips and one from the E-W strips). The result was all seeding combinations of all species, plus double rates of each species, and single rates of each species where a sowing in one direction crossed a control in the other direction. Species were assigned randomly to each strip. All seed was applied using hand cyclone seeders.

The blocks were planted operationally with 1+0 415B styroblock Engelmann spruce (*Picea engelmannii* Parry) seedlings immediately after seeding.

Measures

Ten randomly selected seedlings in each plot were assessed. One-metre square vegetation plots were centred on four assessed seedlings in each plot. Seedlings and vegetation were assessed annually in 1990, 1991, and 1992. The next assessment is in 1994.

Six weeks after seeding, all germinants were counted in four 100 cm² sub-plots in each plot.

Results

Germination

Spring 1990 was moist and cool, providing excellent conditions for germination. At the germination count, germinants were relatively sparse, but the importance of seedbed was clearly demonstrated with more than double the density of germinants on disturbed and mineral soil seedbeds. Germinants on the blackened forest floor were concentrated in those locations where something had produced a depression, making a slightly moister micro-environment. Seed had also been redistributed over the surface after seeding, as germinants were found in the crevices of the planted seedlings.

Vegetation Control

After three growing seasons, control of the reinvading native species was excellent. There were dramatic visual differences between the seeded and unseeded plots. Native species returning to the unseeded plots were typical of the mixed shrub complex. These species were poorly represented in the seeded plots.

After three years, plots seeded at the single rate were generally indistinguishable from those seeded at the double rate, although they seemed to take longer to reach that level of cover. The plots seeded to grasses generally showed higher levels of control of native species than did those plots seeded to clover. The level of control of native species was proportional to the cover achieved by the seeded species. No vegetation control measures have been considered necessary for the control plots.

Seedling Response

The planted seedlings grew well, and are now almost free growing. There was moderate mortality in the first two years due to root rot (*Rhizina undulata* Fr.) that was directly related to the broadcast burn. There was consistently less rhizina-caused mortality in the plots that received the double seeding of clover. No mortality could be related to vegetation competition in either the seeded or unseeded treatments. Growth of both height and diameter is greatest on the seedlings in the control plots. The reductions in growth due to seeding are proportional to the cover achieved by the seeded species.

Interim Conclusions

A well-distributed, appropriate seedbed and a good environment for germination are essential for successful seeding.

Perennial ryegrass and orchardgrass were the most rapid colonizers, followed by creeping red fescue and clover. After two to three years, ryegrass tended to decline, and clover declined where it was sown in a mixture with grass. Both orchardgrass and fescue continued to increase.

After seeding, the total cover is usually greater than without seeding, but the cover due to native species is less than without seeding. The reduction in cover of native species varies with species.

Seeding caused a decline in spruce seedling growth that was proportional to the cover of the seeded species.

Mulch Mats May Help Regenerate Harvested White Spruce Forest

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Introduction

Interest in Alaska's boreal forest resources is increasing, with much attention being given to the white spruce forest type. This trend, and the ongoing bark beetle infestation on Alaska's Kenai Peninsula, has led to increased levels of harvesting in the white spruce forest in recent years. Yet regenerating harvested white spruce stands has proven to be a challenge on many Alaskan sites. A large percentage of the land logged to date has not been adequately restocked with young trees.

The most common cause of regeneration failure is the grass *Calamagrostis canadensis*. After logging, this grass colonizes harvested areas aggressively, often growing to 1.5 m in height, and producing a thick, nearly impenetrable mat of roots and rhizomes. The slow-growing tree seedlings (either planted or naturally occurring) can't survive in this severe competitive environment.

Several methods for converting grass-dominated sites to stands of young trees have been tried, including various herbicides and mechanical site preparation

methods. While each method has its benefits, none has been found to be both appropriate and effective on a wide range of sites. Recently, however, fabric and plastic mulch mats have appeared on the market. Mulch mats are designed to control the growth of competing vegetation in the area immediately surrounding planted seedlings. They are available in a variety of materials and sizes, and have an "X" cut in the centre to allow them to be installed over newly planted seedlings. They are then fastened to the ground with wire landscape staples or wooden stakes.

Methods

This study investigates the potential of three types of commercially available mulch mats to regenerate grass-dominated sites on Alaska's Kenai Peninsula. The five sites used in this study were selection-harvested three to four years before the start of this study, and since harvesting all had become dominated by *Calamagrostis*.

Trial plantations were installed during the summer of 1991. Plantations consisted of a grid of planting spots at 2.4 m (8') spacing. At each planting spot, a pulaski was used to scarify a 30 × 30 cm (1 × 1') area to a depth of 10 to 15 cm (3 to 4 inches). Two seedling stock types, 1-0 and 2-0, were used. Seedlings were planted at each point on the grid, and mulch mats were installed over half of them. Three types of mats were used in this study (Table 1).

Results

Some limitations of the mulch mats were immediately apparent. In widespread use, mats made from synthetic materials (and wire landscape staples) could lead to a substantial forest pollution problem. One reviewer of our research plan suggested that synthetic mats were “just

Table 1. Characteristics of the three types of mulch mats used in this study (costs are expressed in 1991 US dollars)

Black woven plastic			
Material:	High UV-stabilized woven polypropylene		
Advertised benefits:	Water permeable, long-lasting		
Available sizes:	60 × 60 cm (2 × 2')	120 × 120 cm (4 × 4')	180 × 180 (6 × 6')
Cost per 1000:	\$ 420.00	\$1270.00	\$2400.00
Cost of landscape staples needed per 1000 mats:	\$189.00	\$265.00	\$265.00
Sold by:	International Reforestation Suppliers, Eugene, Oregon USA		
ARBORTEC® “Brush Blankets”			
Material:	IRT-76 plastic		
Advertised benefits:	Suppresses weed growth like black plastic, but allows for soil warming like clear plastic. Microperforations allow water and air passage.		
Available sizes:	1 m × 1m	60 × 60 cm (2 × 2')	
Cost per 1000:	\$328.00	\$204.00	
Cost of landscape staples needed per 1000 mats:	\$212.00	\$212.00	
Sold by:	Arbortec Indust., Penticton, B.C., Canada		
Burlap			
Material:	Woven jute burlap		
Advertised benefits:	Water permeable, biodegradable		
Available sizes:	40 × 46 cm	60 × 60 cm (2 × 2')	
Cost per 1000:	\$380.00	\$420.00	
Cost of landscape staples needed per 1000 mats:	\$189.00	\$189.00	
Sold by:	Rusher’s Services, Wasilla, Alaska USA		

another form of chemical weed control.” There were also operational limitations. The “brush blanket” material (IRT-76) is thin and fragile. Care had to be taken to avoid tearing it during installation. All three types of mulch mats were time-consuming to install, with larger-sized mats being especially cumbersome. Extra efforts were needed to secure large mats against the wind. Under operational conditions, installation costs could be quite significant. Finally, grass shoots were observed growing up through the burlap mats the first growing season after installation.

By the end of the 1993 growing season, the effect of the mulch mats on the growth of the seedlings was not clear. Growth varied inconsistently with mat type, size, and site. Seedling survival ranged between 75 and 100% for all treatments and sites. We will monitor these plantations over the next ten years, to see if differences in growth or survival become apparent. If differences arise, we will determine the cost of producing an established seedling in a backlogged area with and without the use of a mulch mat.

Mixed Plantations of Spruce and Alder: A Proposal to Increase the Diversity and Productivity of Alaska's Managed Forests

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Naturally occurring nitrogen fixers have significant ecological and silvicultural value. Many forest managers are beginning to look beyond single-species plantations to regenerate harvested sites. In Alaska's boreal forest region, mixed plantations of white spruce (*Picea glauca* [Moench.] Voss) and green alder (*Alnus crispa* [Ait.] Pursh.), a native, nitrogen-fixing shrub, may have potential. Because green alder is short in stature at maturity, I hypothesize that the long-term benefits from its inclusion in plantations may exceed the detrimental effects of early competition with crop tree seedlings.

Two long-term studies of spruce:alder interactions in the boreal forest of Alaska are currently underway. Together they examine competitive and facilitative interactions between the two species, including trends in spruce growth and architecture, changes in the chemistry and physical characteristics of the soil, and the effects of alder on other vegetation that typically colonizes harvested sites.

The first study is intended to function in the manner of a controlled laboratory experiment. It uses a special plantation layout, the so-called "Nel-Rep" plot: a combination of the standard circular Nelder plot design and the classical two-species replacement series. Nel-Rep plots are useful for interaction studies because a variety of densities and species ratios can

be tested in a small space. In this study, plant densities range over three orders of magnitude, from roughly 30 trees per m² to 1 tree per 10 m². Five species ratios are being considered: 100% spruce:0% alder, 75% spruce:25% alder, 50:50, 25:75, and 0:100. This experiment was installed in 1990 and is intended to run for 10 to 15 years. It is located at the University of Alaska Fairbanks Experimental Farm, on a flat agricultural field with homogeneous soils. All weeds are controlled. Data being collected include relative growth rates of both species, spruce architectural indices, alder reproductive output, and soil chemical and physical changes over time.

The second study is the operational counterpart of the first. It considers spruce:alder interactions in three managed boreal forest sites in Alaska. Its objectives are to determine the effects of alder on the regenerating stand of crop trees, and to test the feasibility of mixed species plantations as a management tool. The scope of interest includes the alders that occur naturally on a site both before and after it is harvested, as well as alders introduced to the site in plantations. I am particularly interested in the hypotheses that the rapid development of a shady alder canopy may limit the spread of the grass *Calamagrostis canadensis*, and that such a canopy may represent a less competitive environment for white spruce seedlings than dense swards of *Calamagrostis*.

Before harvesting, stem maps were made of each site, including the locations of individual alder ramets. Biomass models were developed, and detailed maps of the pre-harvest distribution of understory alder biomass were generated. Units were divided into 30 18 × 18m plots, and a randomized complete block design was determined, using pre-harvest alder biomass as the blocking factor. When evaluating future plantation performance, this blocking design will allow for the removal (from the experimental error) of time-zero variation in soil nitrogen availability.

Results

As expected, soils collected beneath naturally occurring understory alders had significantly more available nitrogen and lower pH than soils collected beneath other types of vegetation on all three sites. Yet the extent to which this amelioration affected the growth of seedlings in a greenhouse bioassay depended on the background fertility at each particular site. On the site with relatively high background nitrogen levels, alder soils produced no more seedling biomass than other-vegetation soils. On the two sites with comparatively low background fertility, alder soils represented nitrogen hotspots that increased seedling biomass production.

By spring 1993 all three sites had been clearcut, and containerized white spruce seedlings were planted at 2.4 m (8') spacing throughout each. Alder seedlings were added to the different plots at two different ratios (1 spruce:2 alders and 1 spruce:4 alders) and two different distances from the spruce (0.3 m and 0.6 m). I will compare seedling growth, soil chemistry, other vegetation, and sub-canopy light environment among the different plantations as they develop. These data will allow for an assessment of the overall costs and benefits of mixed plantations of spruce and alder.