A LONG-TERM STUDY ON THE COMPATIBILITY OF GRASS SEEDING AND CONIFEROUS REGENERATION ON CLEARCUTS IN THE SOUTH-CENTRAL INTERIOR OF BRITISH COLUMBIA 13-YEAR RESULTS

by
T. Baloc, S. Wikeem, A. McLean
and R. Strang

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A LONG-TERM STUDY ON THE COMPATIBILITY OF GRASS SEEDING AND
CONIFEROUS REGENERATION ON CLEARCUTS
IN THE SOUTH-CENTRAL INTERIOR OF BRITISH COLUMBIA:
13-YEAR RESULTS

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ABSTRACT

Five clearcut areas in the south central interior of British Columbia were selected for study of the long-term effects of grass seeding on conifer regeneration, growth, and survival. Although conifer density and growth were generally found to be less in seeded than in unseeded areas, site variability, seed source, post-logging treatments, and interspecific and intraspecific competition were other factors involved in tree-grass compatibility. The effect of cattle grazing on conifer regeneration was not a major part of this study since there was only one site where a comparison of grazed and ungrazed areas could be made. Nevertheless, at this one study site, grazing of seeded grasses by cattle did not appear to affect conifer growth and survival adversely.
ACKNOWLEDGEMENTS

Appreciation is expressed to Judy Steves for her help with the field work and Ed Elmes, Research Branch, B.C. Ministry of Forests for assistance in locating sites. Review of the manuscript by M.B. Clark is also gratefully acknowledged.

Financial assistance for this round of re-measurement was provided by the Forest Research Council of British Columbia.
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INTRODUCTION

The seeding of clearcut forest blocks with appropriate mixtures of domestic grasses and legumes, now widely practised, has increased the forage value and carrying capacity of the forested range. Its full effect on conifer regeneration has not yet been elucidated and so the practise is still controversial (Pearson 1950; Roy 1953; Tackle and Roy 1953; Rummell and Holscher 1955; Denham 1959; Schubert et al. 1970; Embry 1971; Fober and Giertych 1971; Clark and McLean 1974, 1978). Five clearcut blocks in south-central British Columbia (Fig. 1) were selected as long-term study sites (Appendix 1) to help resolve the issue of grass seeding effects on conifer regeneration. In 1971-72, they were sown with the B.C. Forestland Mix (Appendix 2), except for a portion in each which was left unseeded as a control.

Two earlier accounts have been published (Clark and McLean 1974, 1978) and a detailed report on one area (Community Lake) is in preparation. This report presents results of remeasurement 13 years after initial treatment. Because the paired plots were established in operational areas without replication, the results cannot be subjected to detailed statistical analysis.

The Eden fire site was omitted from this study because exclosures in the heavy and light grass areas had been removed, and because part of the area was juvenile spaced in 1982.
FIGURE 1. Location of five clearcut sites in the Kamloops Forest Region.
METHODS

In 1984 two sample plots were established in typical areas at each of the five sites. At three sites, Dardanelles, Equises-McGregor, and Glimpse Lake, two sample plots, each 5 x 20 m, were established in operationally seeded areas and two in unseeded portions. At the other two sites, Badger Lake and Martin Mountain, the comparison was between densely and lightly seeded areas. Species list (Appendices 3a and 3b), abundance rating (Appendix 4), deciduous and coniferous tree stocking and conifer height and diameter were recorded in each plot. Also, within exclosures (Badger and Glimpse Lake sites), four 1-m² subplots were clipped to estimate herbage production.

The boundary between seedling and sapling was arbitrarily set at 2.54 cm (1 in.) diameter at breast height (dbh).

The sites are sufficiently dissimilar that comparison between sites is not useful. Three sites—Badger Lake, Equises-McGregor, and Martin Mountain—are in the Englemann Spruce-Subalpine Fir zone (ESSF), and two sites—Dardanelles and Glimpse Lake—are in the Interior Douglas-fir zone (IDF).

Nomenclature follows Hitchcock and Cronquist (1973) (Appendix 5).
RESULTS AND DISCUSSION

Badger Lake (ESSF) (51° 02' N, 120° 07' W, 1280 m elev.)

Windrowing and burning removed dense stands of willow prior to grass seeding. Since ecasis was uneven, two exclosures were constructed: one in dense grass, the other in a lightly grassed area (Plate 1). Because deciduous trees and shrubs had been cut recently outside the exclosures, comparisons between the dense and sparse grass fenced and unfenced areas could not be made.

Thirteen years after seeding, spruce and alder were dominant with a vigorous ground layer of native forbs and herbs inside the exclosure (Plate 2). Seeded species were rare. Herbage biomass from clipped subplots are tabulated below:

<table>
<thead>
<tr>
<th>Herbage biomass (kg/ha o.d. wt.)¹ in fenced seeded areas at Badger Lake²</th>
<th>Sparse grass</th>
<th>Dense grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seeded spp.</td>
<td>73</td>
<td>16</td>
</tr>
<tr>
<td>Native grass</td>
<td>1</td>
<td>80</td>
</tr>
<tr>
<td>Forbs</td>
<td>1789</td>
<td>535</td>
</tr>
<tr>
<td>Shrubs</td>
<td>268</td>
<td>318</td>
</tr>
<tr>
<td><strong>Total production</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1984</td>
<td>2131</td>
<td>949</td>
</tr>
<tr>
<td>1974³</td>
<td>1744</td>
<td>4065</td>
</tr>
</tbody>
</table>

1 o.d.wt. = oven-dry weight.
2 Current year's growth; mean of four 1-m² subplots clipped July 1984.
3 Data from Clark (1975a).

Forbs contributed 84% and 56% of yields in sparse and dense grass plots, respectively. Seeded grasses were more productive in the sparse than in the dense grass area but the converse was true for native grasses. Total production in the sparse grass area was more than twice that of the dense grass area in 1984, although it had been less than half the yield from the dense grass area 10 years earlier.
Natural regeneration of Engelmann spruce seedlings was so abundant in both exclosures (Table 1) that growth was suppressed so that few saplings developed. Deciduous species were also abundant, especially alder in the sparsely grassed area, but whether or not a good grass cover inhibited alder establishment could not be determined.

Spruce seedlings in the sparse grass ($\bar{x} 1.6$ m, SE 0.09) were taller than those in the dense grass ($\bar{x} 1.3$ m, SE 0.05).

Since seeded grasses were not notably more abundant in one area than in the other 12 years after seeding, differences in tree heights and densities between the two areas may be a result of factors other than grass density. The fact that there were fewer spruce seedlings in the sparse grass area, which had a higher forage production (especially of forbs), suggests that interspecific competition affected conifer establishment and regeneration. On the other hand, in the dense grass area where forage yields were less and conifer density was higher, the trees were shorter in height. Thus, excessive intraspecific competition appears to have a negative impact on conifer growth.

_Equiset-McGregor (ESSF) (50° 21'N, 119° 38'W, 1400 m elev.)_

There were five cutblocks at this site (Table 2).

The original stand consisted of lodgepole pine, Engelmann spruce, subalpine fir, and Douglas-fir. Initial establishment of seeded grass was reportedly variable among the blocks.

The species diversity and composition did not differ substantially between the seeded and unseeded areas (Appendices 3_a and 3_b and 4) in 1984. Alder and lodgepole pine were site dominants, with small shrubs such as raspberry, blueberry, and spiraea being frequent understory species, along with arnica, fireweed, and hawkweed. Orchardgrass and timothy were common on the seeded areas.

Tree density counts for seeded block 3 were not included in the data summary because lodgepole pine saplings there had been thinned. The density of coniferous species in the two unseeded areas has been tabulated separately because of different post-logging treatments (Table 3).
TABLE 1. Density (no./ha) of coniferous and deciduous species at Badger Lake in sparse grass and densegrass exclosures

<table>
<thead>
<tr>
<th>Species</th>
<th>Sparse grass</th>
<th>Dense grass</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Saplings</td>
<td>Seedlings</td>
</tr>
<tr>
<td>Engelmann spruce</td>
<td>750</td>
<td>18250</td>
</tr>
<tr>
<td>Lodgepole pine</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Douglas-fir</td>
<td>-</td>
<td>150</td>
</tr>
</tbody>
</table>

**Coniferous**

**Deciduous**

<table>
<thead>
<tr>
<th>Species</th>
<th>Sparse grass</th>
<th>Dense grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitka alder</td>
<td>2000</td>
<td>13250</td>
</tr>
<tr>
<td>Trembling aspen</td>
<td>-</td>
<td>1100</td>
</tr>
<tr>
<td>Black cottonwood</td>
<td>100</td>
<td>2850</td>
</tr>
<tr>
<td>Willows</td>
<td>300</td>
<td>1250</td>
</tr>
</tbody>
</table>
TABLE 2. Characteristics and treatment of Equises-McGregor site

<table>
<thead>
<tr>
<th>Cutblock Elevation (m)</th>
<th>Slope Aspect</th>
<th>Size (ha)</th>
<th>Condition</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1435</td>
<td>30% SE</td>
<td>20</td>
<td>seeded(^b)</td>
</tr>
<tr>
<td>2</td>
<td>1435</td>
<td>30% SE</td>
<td>10</td>
<td>control</td>
</tr>
<tr>
<td>3</td>
<td>1400</td>
<td>0</td>
<td>16</td>
<td>seeded(^b)</td>
</tr>
<tr>
<td>5</td>
<td>1370</td>
<td>10-15% E</td>
<td>8</td>
<td>control</td>
</tr>
<tr>
<td>6</td>
<td>1415</td>
<td>20% E</td>
<td>16</td>
<td>seeded(^b)</td>
</tr>
</tbody>
</table>

\(^a\) Abandoned because of disturbance by road building.
\(^b\) BC Forest Service Forestland Mix - 2.25 kg/ha (4 lb/ac).
TABLE 3. Density (no./ha) of coniferous and deciduous species in seeded and unseeded areas at Equises-McGregor

<table>
<thead>
<tr>
<th>Species</th>
<th>Seeded Burned</th>
<th>Unseeded Bunched-burned</th>
<th>Unseeded Scarified</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Saplings</td>
<td>Seedlings</td>
<td>Saplings Seedlings</td>
</tr>
<tr>
<td>Coniferous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engelmann spruce</td>
<td>-</td>
<td>75</td>
<td>-</td>
</tr>
<tr>
<td>Lodgepole pine</td>
<td>2467</td>
<td>1433</td>
<td>1150</td>
</tr>
<tr>
<td>Douglas-fir</td>
<td>-</td>
<td>75</td>
<td>-</td>
</tr>
<tr>
<td>Deciduous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitka alder</td>
<td>2000</td>
<td>-</td>
<td>900</td>
</tr>
<tr>
<td>Trembling aspen</td>
<td>100</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>Black cottonwood</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Willows</td>
<td>500</td>
<td>-</td>
<td>2600</td>
</tr>
</tbody>
</table>
There were more conifer saplings and seedlings in the bunched-burned block (5) than in the scarified post-logging treatment block (2). The method of site preparation thus may have influenced tree establishment. There were more lodgepole pine seedlings in the control areas than in the seeded clearcuts and, similarly, deciduous saplings and seedlings were more numerous in the controls.

Mean height and dbh of lodgepole pine were similar between seeded and unseeded blocks as the following tabulation shows:

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ht (m)</th>
<th>dbh (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td>SE</td>
</tr>
<tr>
<td>Seeded</td>
<td>3.5</td>
<td>0.09</td>
</tr>
<tr>
<td>Unseeded</td>
<td>3.4</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Martin Mountain (ESSF) (50° 36’N, 119° 47’W, 1280 m elev.)

The original stand of spruce, sub-alpine fir, Douglas-fir and lodgepole pine was logged in 1970-71 and broadcast burned in fall 1971. Of the 50-ha area, 40 ha were grass seeded from the air; windy conditions during seeding resulted in the intended control strip being lightly seeded. The whole area was planted with bare-root Engelmann spruce in fall 1972.

By 1984 an open spruce-aspen stand had a vigorous shrub and forb understorey (Appendix 3a) and grasses were well established. More trees were recorded in the densely seeded area than in the lightly seeded area, except for Douglas-fir which was more common in the latter (Table 4). Although heights of Englemann spruce, the most abundant species, were similar in the densely and lightly seeded blocks, diameters were somewhat greater in the former.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ht (m)</th>
<th>dbh (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>x</td>
<td>SE</td>
</tr>
<tr>
<td>Densely seeded</td>
<td>2.7</td>
<td>0.06</td>
</tr>
<tr>
<td>Lightly seeded</td>
<td>2.5</td>
<td>0.07</td>
</tr>
</tbody>
</table>

Site variability may have contributed to these apparent anomalies.

Some 40% of the trees sampled had suffered leader damage, probably by spruce weevil (Plates 3a and 3b).
TABLE 4. Density (no./ha) of coniferous and deciduous species in densely and lightly seeded areas at Martin Mountain

<table>
<thead>
<tr>
<th>Species</th>
<th>Densely seeded</th>
<th>Lightly seeded</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Saplings</td>
<td>Seedlings</td>
</tr>
<tr>
<td>Subalpine fir</td>
<td>-</td>
<td>200</td>
</tr>
<tr>
<td>Engelmann spruce</td>
<td>400</td>
<td>1700</td>
</tr>
<tr>
<td>Lodgepole pine</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Douglas-fir</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td><strong>Deciduous</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitka alder</td>
<td>-</td>
<td>200</td>
</tr>
<tr>
<td>Trembling aspen</td>
<td>-</td>
<td>2550</td>
</tr>
<tr>
<td>Black cottonwood</td>
<td>-</td>
<td>200</td>
</tr>
<tr>
<td>Willows</td>
<td>-</td>
<td>1450</td>
</tr>
</tbody>
</table>
Dardanelles (IDF) (50° 22'N, 120° 10'W, 1220 m elev.)

This lodgepole pine/Douglas-fir site had been logged, windrowed, and burned in 1970. In fall 1971, 12 ha were sown with the Forestland Mix at 2.25 kg/ha, and 5 ha were left unseeded. Grass seed was well established and regeneration was adequate.

In 1984 lodgepole pine was dominant and shrubs were sparse, although ground vegetation was common (Appendix 3b). Grass-seeded and unseeded plots were distinctly different. The seeded area had been heavily grazed and some rubbing damage by cattle was noted (Plate 4), although more extensive damage had been caused by carelessly-driven snowmobiles (Plate 6). The unseeded control block had many more and bigger trees than the seeded block (Table 5), which suggests that grass competition may have restricted tree regeneration and growth (Plate 5).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ht (m) ( \bar{x} )</th>
<th>SE</th>
<th>dbh (cm) ( \bar{x} )</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seeded</td>
<td>2.9</td>
<td>0.1</td>
<td>3.7</td>
<td>0.1</td>
</tr>
<tr>
<td>Unseeded</td>
<td>4.0</td>
<td>0.1</td>
<td>4.9</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Glimpse Lake (IDF) (50° 16'N, 120° 16'W, 1370 m elev.)

The study area comprises two cutblocks, one 36 ha and the other 34 ha, both of which were logged (spruce, Douglas-fir and lodgepole pine) in 1970-71 and drag-scarified in summer 1971. The larger block was seeded with the Forestland Mix at 2.25 kg/ha, while the smaller block was left as a control (Plate 7). Both blocks have regenerated naturally to lodgepole pine, with pinegrass, showy aster, fireweed and lupine in the field layer (Appendix 3b).

Two exclosures were constructed in each block for productivity studies but, in the seeded area, only one has remained intact. Within each of the three remaining exclosures four 1-m² subplots were clipped to estimate current year's growth (Table 6).

Although total herbage production was similar for seeded and unseeded fenced areas, the composition of this production showed marked differences. Forbs made up 69% of total production in the seeded plots but only 54% in the unseeded plots. Conversely, shrubs contributed only 1% to production in the seeded plots and 14% in the unseeded plots. The 1984 and 1974 yields were very similar in the unseeded exclosures, while in the seeded exclosure the 1984 yield was only 43% of that recorded in 1974.
TABLE 5. Density (no./ha) of coniferous and deciduous species in seeded and unseeded areas at Dardanelles

<table>
<thead>
<tr>
<th>Species</th>
<th>Seeded Saplings</th>
<th>Seeded Seedlings</th>
<th>Unseeded Saplings</th>
<th>Unseeded Seedlings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coniferous</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engelmann spruce</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>800</td>
</tr>
<tr>
<td>Lodgepole pine</td>
<td>1100</td>
<td>850</td>
<td>3,500</td>
<td>10000</td>
</tr>
<tr>
<td>Deciduous</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitka alder</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>Trembling aspen</td>
<td>-</td>
<td>200</td>
<td>100</td>
<td>2850</td>
</tr>
<tr>
<td>Black cottonwood</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>Willows</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1350</td>
</tr>
<tr>
<td>Seed Type</td>
<td>Seeded</td>
<td>Unseeded (mean of 2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>--------</td>
<td>---------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seeded species</td>
<td>1</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Native grass</td>
<td>384</td>
<td>389</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forbs</td>
<td>877</td>
<td>650</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shrubs</td>
<td>15</td>
<td>171</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total production 1984</td>
<td>1277</td>
<td>1210</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total production 1974(^b)</td>
<td>3005</td>
<td>1332</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Current year’s growth; mean of four 1-m\(^2\) subplots clipped July 1984.
\(^b\) Data from Clark (1975a).
By 1984, there were few seeded grasses to distinguish between unseeded and seeded plots (Appendix 3b). There were, however, 2 to 8 times more pine seedlings in the fenced unseeded plots (Plate 8) than in the fenced seeded plots but, within seeded plots, there was little difference in conifer stocking between fenced and unfenced plots. Lacking numbers of initial germinants, the authors cannot say if this is a treatment effect or is due to other causes such as irregular seed dispersal. Few seedlings, if any, have developed into the sapling stage in any of the treatments (Table 7).

Height and diameter of pines were similar for grazed and ungrazed seeded plots, with both being marginally smaller than the unseeded plots.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ht (m)</th>
<th></th>
<th>dbh (cm)</th>
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<tbody>
<tr>
<td></td>
<td>$\bar{x}$</td>
<td>SE</td>
<td>$\bar{x}$</td>
<td>SE</td>
</tr>
<tr>
<td>Control - ungrazed</td>
<td>3.0</td>
<td>0.05</td>
<td>3.4</td>
<td>0.10</td>
</tr>
<tr>
<td>Seeded - ungrazed</td>
<td>2.7</td>
<td>0.05</td>
<td>3.1</td>
<td>0.10</td>
</tr>
<tr>
<td>Seeded - grazed</td>
<td>2.7</td>
<td>0.05</td>
<td>3.0</td>
<td>0.09</td>
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</table>
TABLE 7. Density (no./ha) of conifer and deciduous species in seeded and unseeded areas at Glimpse Lake

<table>
<thead>
<tr>
<th>Species</th>
<th>Seeded</th>
<th>Unseeded</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Saplings</td>
<td>Seedlings</td>
</tr>
<tr>
<td></td>
<td>Unfenced</td>
<td>Fenced</td>
</tr>
</tbody>
</table>

**Conifer**

- **Subalpine fir**: 100 - - - - -
- **Engelmann spruce**: 50 - 300 150 - 50
- **Lodgepole pine**: 900 600 2800 2750 1400 7625
- **Douglas-fir**: 50 - 150 - - 75

**Deciduous**

- **Sitka alder**: - 50 1500 1350 - 225
- **Trembling aspen**: - - 100 100 - 150
- **Willows**: - 50 1650 1700 - 575
CONCLUSIONS

Because, as was noted in the introduction, the plot arrangement does not permit rigorous statistical analyses, interpretation of the results must be largely qualitative and inferential.

Comparison of vegetation in seeded and in unseeded or lightly seeded plots indicates that grass seeding had not inhibited establishment of native vegetation.

Herbage biomass decreased in the seeded areas after 10 years, which is consistent with other findings (McLean 1969). Although herbage production was inversely related to crown canopy density, soil moisture and nutrients may also have played an important role (Dodd et al. 1972). If root development of conifer seedlings had become extensive enough for the trees to compete with understorey plants for soil moisture then herbage and forage production productivity would decline (Clark, 1975).

In this assessment of the effects of seeded grasses on conifer density other potentially significant factors were also found, although it was not easy to attribute cause and effect relationships to interactions between grasses and coniferous trees. Site conditions, seed distribution and post-logging treatment also bear on the interaction.

Conifer saplings were taller in the control areas at some sites but not at others, which suggests that seeded grass may inhibit conifer growth and development to some degree.

This competition between grass and conifers probably occurs as a result of competition for soil moisture (Clark 1975). Differences in dbh were inconsistent and small between conifer saplings in seeded and control areas. Of the four sites where dbh was measured, two showed no differences, one had larger pine in the control plots, and spruce were larger in the densely seeded areas of the fourth site. Intraspecific competition between conifer reproduction, especially in overstocked areas, may have been significant in limiting tree growth at Badger Lake. Similar conclusions were drawn by Sowder (1957) and Fober and Giertych (1971). In addition, deciduous species may have had an adverse effect on conifer development.
There was no difference in conifer sapling density and height measurements between grazed and ungrazed seeded areas at the one site where such a comparison was possible. With only one pair of plots available in this study, a firm assessment of the impact of cattle grazing on tree development could not be made, though it did not seem harmful.

The effect of grass seeding on conifer regeneration is a complex problem affected by several interacting factors, which cannot be isolated one from another in this set of field trials. Although more precise and rigorous statistical treatments are needed for exact interpretation, these existing long-term study sites continue to provide valuable insights.
LITERATURE CITED


PLATE 1. Difference in deciduous tree growth inside and outside light grass exclosure at Badger Lake, resulting from manual removal of brush.

PLATE 2. Luxuriant growth of forbs in the understorey of the Badger Lake exclosure.
PLATE 3a and b. Insect-damaged leader and irregular top growth of Engelmann spruce at Martin Mountain.
PLATE 4. Heavily grazed, seeded area at Dardanelles, 3 years after logging and 2 years following seeding.

PLATE 5. Grazed, seeded area at Dardanelles, 13 years after seeding.
PLATE 6. Recreational Vehicle damage to lodgepole pine in the seeded area at Dardanelles.

PLATE 8. Seeded area at Glimpse Lake in 1984 with lodgepole pine dominant and no seeded grasses.
APPENDIX 1. Equivalent clearcut descriptions used in 1978 and 1984 reports

<table>
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<tr>
<th>Research Note 83</th>
<th>1984 study site</th>
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<td>Area</td>
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<td>2</td>
<td>Martin Mountain</td>
</tr>
<tr>
<td>3</td>
<td>Dardanelles</td>
</tr>
<tr>
<td>4</td>
<td>Equises-McGregore</td>
</tr>
<tr>
<td>5</td>
<td>Glimpse Lake</td>
</tr>
<tr>
<td>6</td>
<td>Foolhen(^a)</td>
</tr>
<tr>
<td>7</td>
<td>Badger Lake</td>
</tr>
<tr>
<td>8</td>
<td>Eden Fire(^a)</td>
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</table>

\(^a\)Deleted from 1984 study.
APPENDIX 2. B.C. Forest Service Forestland Mix percent composition by weight

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<th>Composition (%)</th>
<th>Common</th>
<th>Scientific</th>
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<td>Phleum pratense</td>
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<tr>
<td>25</td>
<td>Orchard grass</td>
<td>Dactylis glomerata</td>
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<tr>
<td>20</td>
<td>Smooth brome</td>
<td>Bromus inermis</td>
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<tr>
<td>20</td>
<td>Crested wheatgrass</td>
<td>Agropyron cristatum</td>
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<tr>
<td>10</td>
<td>Alside clover</td>
<td>Trifolium hybridum</td>
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</table>
APPENDIX 3a. Species list and abundance ratings for three sites in the Engelmann Spruce - Subalpine Fir Biogeoclimatic Zone

<table>
<thead>
<tr>
<th>Species</th>
<th>Badger Lake Fenced</th>
<th>Equises-McGregor Unfenced</th>
<th>Martin Mtn Unfenced</th>
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<tbody>
<tr>
<td></td>
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<td>Seedeed Unseeded</td>
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<td>Alnus virgatae</td>
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<tr>
<td>Picea engelmannii</td>
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<tr>
<td>Pinus contorta</td>
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<td>3</td>
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<td>Populus tremuloides</td>
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<td>Populus trichocarpa</td>
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<td>Pseudotsuga menziesii</td>
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<td>1-2</td>
<td>1</td>
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<tr>
<td>Salix spp.</td>
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</tr>
<tr>
<td></td>
<td>Shrubs</td>
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<td></td>
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<tr>
<td>Amelanchier alnifolia</td>
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<tr>
<td>Berberis aquifolium</td>
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### APPENDIX 3a. (Continued)

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<th>Species</th>
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<th>Martin Mtn Unfenced</th>
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<tbody>
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<td></td>
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<td>Forbs</td>
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<td>Ranunculus sp.</td>
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</table>
APPENDIX 3a. (Continued)

<table>
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<th>Species</th>
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<th>Equises-McGregor Unfenced</th>
<th>Martin Mt. Unfenced</th>
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<td>Heavy grass Light grass</td>
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<td>Seeded Unseeded</td>
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</table>

* Species of the grass mix.

¹ Bromus spp. represents cumulative abundance of Bromus vulgaris and Bromus inermis*.
APPENDIX 3b. Species list and abundance ratings for two sites in the Interior Douglas-fir Biogeoclimatic Zone

<table>
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<th>Glimpse Lake</th>
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<td>Unfenced Seeded</td>
<td>Unfenced Unseeded</td>
<td>Fenced Seeded</td>
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<tr>
<td><strong>Trees</strong></td>
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</tr>
<tr>
<td>Abies lasiocarpa</td>
<td>---</td>
<td>---</td>
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</tr>
<tr>
<td>Alnus sinuata</td>
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<td>3</td>
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<tr>
<td>Picea engelmannii</td>
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<td>1</td>
</tr>
<tr>
<td>Pinus contorta</td>
<td>2-3</td>
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<td>Populus tremuloides</td>
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<td>1-2</td>
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<tr>
<td>Pseudotsuga menziesii</td>
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<tr>
<td>Salix spp.</td>
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<tr>
<td><strong>Shrubs</strong></td>
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<td>Amelanchier alnifolia</td>
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<td>Lonicera involucrata</td>
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<td>1-2</td>
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<tr>
<td>Lonicera utahensis</td>
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<td>Ribes lacustre</td>
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<td>Rosa sp.</td>
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<td>Rubus ideois</td>
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<td>Vaccinium scoparium</td>
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<tr>
<td><strong>Forbs</strong></td>
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<td>Achillea millefolium</td>
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<td>Arnica cordifolia</td>
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<tr>
<td>Aster conspicuus</td>
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<td>Cerastium arvense</td>
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<td>Cirsium arvense</td>
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### APPENDIX 3b. (Continued)

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<th>Species</th>
<th>Dardanelles</th>
<th>Glimpse Lake</th>
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<td>Unfenced</td>
<td>Fenced</td>
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<td>Seeded</td>
<td>Unseeded</td>
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<td>Forbs (cont.)</td>
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<td>Fragaria virginiana</td>
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<td>Hieracium albiflorum</td>
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<td>Lilium columbianum</td>
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<tr>
<td>Lupinus latifolius</td>
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<tr>
<td>Osmorhiza chilensis</td>
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</tr>
<tr>
<td>Pedicularis racemosa</td>
<td>---</td>
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<tr>
<td>Pyrola secunda</td>
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<tr>
<td>Rheinanthus cristata-galli</td>
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<tr>
<td>Senecio pseudoreus</td>
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<tr>
<td>Smilacina racemosa</td>
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<td>Taraxacum officinale</td>
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<td>Thalictrum occidentale</td>
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<td>Trifolium repens</td>
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<td>Vicia americana</td>
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<td>Viola glabella</td>
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<td>Bromus inermis*</td>
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<tr>
<td>Calamagrostis rubescens</td>
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</tr>
<tr>
<td>Carex sp.</td>
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<tr>
<td>Dactylis glomerata*</td>
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</tr>
<tr>
<td>Festuca occidentalis</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Festuca ovina</td>
<td>---</td>
<td>3</td>
</tr>
<tr>
<td>Phleum pratense*</td>
<td>2-3</td>
<td>---</td>
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<tr>
<td>Poa palustris</td>
<td>1-2</td>
<td>1</td>
</tr>
<tr>
<td>Schizachne purpurascens</td>
<td>2-3</td>
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</tr>
<tr>
<td>Trisetum spicatum</td>
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APPENDIX 4. Abundance rating scale

<table>
<thead>
<tr>
<th>Abundance rating</th>
<th>Distance between plants</th>
</tr>
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<tbody>
<tr>
<td>1 (some)</td>
<td>60 m</td>
</tr>
<tr>
<td>2 (occasional)</td>
<td>15 m</td>
</tr>
<tr>
<td>3 (frequent)</td>
<td>1 m</td>
</tr>
<tr>
<td>4 (abundant)</td>
<td>15 cm</td>
</tr>
<tr>
<td>5 (very abundant)</td>
<td>8 cm</td>
</tr>
</tbody>
</table>

\(^a\text{Brown (1954).}\)
### APPENDIX 5. Species list

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abies lasiocarpa (Hook.) Nutt.</td>
<td>subalpine fir</td>
</tr>
<tr>
<td>Achillea millefolium L.</td>
<td>common yarrow</td>
</tr>
<tr>
<td>Actaea rubra (Ait.) Willd.</td>
<td>red baneberry</td>
</tr>
<tr>
<td>Agropyron caninum (L.) Beauv.</td>
<td>bearded wheatgrass</td>
</tr>
<tr>
<td>Agrostis scabra Willd.</td>
<td>winter bentgrass</td>
</tr>
<tr>
<td>Alnus sinuata (Regel) Rydb.</td>
<td>Sitka alder</td>
</tr>
<tr>
<td>Amelanchier alnifolia Nutt.</td>
<td>western serviceberry</td>
</tr>
<tr>
<td>Anaphalis margaritacea (L.) B. &amp; H.</td>
<td>common pearly-everlasting</td>
</tr>
<tr>
<td>Antennaria microphylla Rydb.</td>
<td>rosy pussy-toes</td>
</tr>
<tr>
<td>Antennaria racemosa Hook.</td>
<td>raceme pussy-toes</td>
</tr>
<tr>
<td>Aquilegia formosa Fisch.</td>
<td>red columbine</td>
</tr>
<tr>
<td>Arnica cordifolia Hook.</td>
<td>heart-leaf arnica</td>
</tr>
<tr>
<td>Aster ciliolatus Lindl.</td>
<td>Lindley aster</td>
</tr>
<tr>
<td>Aster conspicuus Lindl.</td>
<td>showy aster</td>
</tr>
<tr>
<td>Berberis aquilifolium Pursh.</td>
<td>shining oregongrape</td>
</tr>
<tr>
<td>Bromus inermis Leys.</td>
<td>smooth brome</td>
</tr>
<tr>
<td>Bromus vulgaris (Hook.) Shear</td>
<td>Columbia brome</td>
</tr>
<tr>
<td>Calamagrostis canadensis (Michx.) Beauv.</td>
<td>bluejoint reedgrass</td>
</tr>
<tr>
<td>Calamagrostis rubescens Buckl.</td>
<td>pinegrass</td>
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<tr>
<td>Carex L. sp.</td>
<td>sedge</td>
</tr>
<tr>
<td>Castilleja miniata Dougl.</td>
<td>scarlet paintbrush</td>
</tr>
<tr>
<td>Ceanothus velutinus Dougl.</td>
<td>sticky-laurel</td>
</tr>
<tr>
<td>Cerastium arvense L.</td>
<td>field chickweed</td>
</tr>
<tr>
<td>Cerastium nutans Raf.</td>
<td>nodding chickweed</td>
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<tr>
<td>Cirsium arvense (L.) Scop.</td>
<td>Canada thistle</td>
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<tr>
<td>Clintonia uniflora (Schult.) Kunth.</td>
<td>Queen's cup</td>
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<tr>
<td>Cornus canadensis L.</td>
<td>bunchberry</td>
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<tr>
<td>Cornus stolonifera Michx.</td>
<td>red osier dogwood</td>
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<tr>
<td>Dactylis glomerata L.</td>
<td>orchard-grass</td>
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<tr>
<td>Epilobium angustifolium L.</td>
<td>fireweed</td>
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<tr>
<td>Epilobium watsonii Barbey</td>
<td>Watson's willow-herb</td>
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<tr>
<td>Equisetum arvense L.</td>
<td>common horsetail</td>
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<tr>
<td>Festuca occidentalis Hook.</td>
<td>western fescue</td>
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<tr>
<td>Festuca ovina L.</td>
<td>sheep fescue</td>
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<tr>
<td>Scientific name</td>
<td>Common name</td>
</tr>
<tr>
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<tr>
<td><em>Fragaria virginiana</em> Duchesne</td>
<td>strawberry</td>
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<tr>
<td><em>Galium boreale</em> L.</td>
<td>northern bedstraw</td>
</tr>
<tr>
<td><em>Galium triflorum</em> Michx.</td>
<td>fragrant bedstraw</td>
</tr>
<tr>
<td><em>Gentiana amarella</em> L.</td>
<td>northern gentian</td>
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<tr>
<td><em>Gymnocypris dryopteris</em> (L.) Newm.</td>
<td>oak-fern</td>
</tr>
<tr>
<td><em>Hieracium albiflorum</em> Hook.</td>
<td>white flowered hawkweed</td>
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<tr>
<td><em>Juncus</em> L. sp.</td>
<td>rush</td>
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<tr>
<td><em>Lilium columbianum</em> Hanson</td>
<td>tiger lily</td>
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<tr>
<td><em>Linnaea borealis</em> L.</td>
<td>western twinflower</td>
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<tr>
<td><em>Lonicera involucrata</em> (Rich.) Banks</td>
<td>black twin-berry</td>
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<tr>
<td><em>Lonicera utahensis</em> Wats.</td>
<td>Utah honeysuckle</td>
</tr>
<tr>
<td><em>Lupinus latifolius</em> Agardh</td>
<td>broadleaf lupine</td>
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<tr>
<td><em>Mitella nuda</em> L.</td>
<td>stoloniferous mitrewort</td>
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<tr>
<td><em>Osmorhiza chilensis</em> H. &amp; A.</td>
<td>mountain sweet-root</td>
</tr>
<tr>
<td><em>Pachistima myrsinites</em> (Pursh) Raf.</td>
<td>myrtle boxwood</td>
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<tr>
<td><em>Pedicularis racemosa</em> Doug.</td>
<td>leafy lousewort</td>
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<tr>
<td><em>Petasites frigidus</em> (L.) Fries</td>
<td>sweet coltsfoot</td>
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<td><em>Phleum pratense</em> L.</td>
<td>common timothy</td>
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<tr>
<td><em>Picea engelmannii</em> Parry</td>
<td>Engelmann spruce</td>
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<tr>
<td><em>Pinus contorta</em> Doug.</td>
<td>lodgepole pine</td>
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<td><em>Poa compressa</em> L.</td>
<td>Canada bluegrass</td>
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<tr>
<td><em>Poa palustris</em> L.</td>
<td>fowl bluegrass</td>
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<tr>
<td><em>Populus tremuloides</em> Michx.</td>
<td>trembling aspen</td>
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<tr>
<td><em>Populus trichocarpa</em> T. &amp; G.</td>
<td>black cottonwood</td>
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<td><em>Pseudotsuga menzieii</em> (Mirbel) Franco.</td>
<td>Douglas fir</td>
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<td><em>Pyroa secunda</em> L.</td>
<td>one-sided wintergreen</td>
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<td><em>Ranunculus</em> L. sp.</td>
<td>buttercup</td>
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<td><em>Rhinanthus crista-galli</em> L.</td>
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<td><em>Ribes lacustre</em> (Pers.) Poir.</td>
<td>prickly currant</td>
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<td><em>Rosa</em> L. sp.</td>
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<td><em>Rubus idaeus</em> L.</td>
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<tr>
<td>Rubus pedatus J.E. Smith</td>
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<td>Schizachne purpurascens (Torr.) Swallen.</td>
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<td>Senecio pseudoaureus Rydb.</td>
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<td>Shepherdia canadensis (L.) Nutt.</td>
<td>Canada buffalo-berry</td>
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<td>Smilacina racemosa (L.) Desf.</td>
<td>false spikenard</td>
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<td>Smilacina stellata (L.) Desf.</td>
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<td>Spiraea betulifolia Pall.</td>
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<td>Symphoricarpos albus (L.) Blake</td>
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<td>Taraxacum officinale Weber</td>
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<td>Thalictrum occidentale Gray</td>
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<td>Tiarella trifoliata L.</td>
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<td>Trifolium hybridum L.</td>
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<td>Vaccinium caespitosum Michx.</td>
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<td>Viburnum edule (Michx.) Raf.</td>
<td>moosewood viburnum</td>
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<td>Vicia americana Muhl.</td>
<td>American vetch</td>
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<tr>
<td>Viola glabella Nutt.</td>
<td>stream violet</td>
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