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Long-Term Effects of Grass Seeding and Cattle Grazing on a Lodgepole Pine Clearcut

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Location	Change
P. vi. table 3	Average precent understory to Average percent understory
P.1, 3rd paragraph	(Hendrick and Keniston 1966) to (Hedrick and Keniston 1966)
P.2 1st paragraph	bareroot seedings to bareroot seedlings
P. 2 2nd paragraph last sentence	Lodgepole pine seedlings to Lodgepole pine seedling
P.2 3rd paragraph	(Baron 1961;) to (Baron 1962;)
P.3 1st paragraph	Less is know of... to Less is known of...
P.4 1st paragraph last sentence	grazed <u>season</u> <u>long</u> in... to grazed season long in

P.4 2nd paragraph	at least 5m for area to at least 5m from area
P.5 last line of legend	Control strip boundry to Control strip boundary
P.6 2nd line	clover-class system, to cover-class system,
P11. table titles	Factors (N-12) Interaction (n=6) to Factors (n=12) Interaction (n=6)
P.14 2nd paragraph	Five years after seeding to Six years after seeding
P.20 Literature Cited	Hendrick, D.W. to Hedrick, D.W.

ABSTRACT

This report is an update of a study initiated in 1971 to assess the effects of cattle grazing and seeding with a grass-legume mix on survival and growth of lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) seedlings, planted on a clearcut in the Engelmann spruce (Picea engelmanni Parry) - subalpine fir (Abies lasiocarpa (Hook.) Nutt.) zone in southern British Columbia. Pine growth parameters, tree and shrub density, understory botanical composition, and forage production were measured 12 years after the grass mix was sown and 13 years after the pine was planted.

Seeding did not affect pine diameter at breast height, basal area, or volume, but height was moderately suppressed. Presence of grazing benefited pine growth, apparently by reducing competition from herbaceous vegetation. Pine growth was best on plots grazed but not seeded. Trembling aspen (Populus tremuloides Michx.) and willow (Salix spp.) had become major competitors with the pine saplings, and brush densities were high for all treatments. Seeded species occurred more frequently on the seeded plots, but their combined cover never exceeded 15%. Total forage production had declined only slightly since the first years following seeding, but composition of production had shifted away from grasses towards shrubs and forbs.

Cattle grazing and seeding were compatible with lodgepole pine regeneration. Factors contributing to this compatibility included the establishment of lodgeple pine prior to grass seeding, and good grazing management which promoted even utilization of forage and minimized seedling injury.

Key Words: lodgepole pine, Pinus contorta, Engelmann spruce-subalpine fir zone, conifer growth, botanical composition, forage yields, cattle grazing, grass-tree competition

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INTRODUCTION

Published information on inter-specific competition between domestic grass and conifer seedlings or saplings, with or without grazing, is very sparse. Most of the work has emphasized competition for soil moisture at the establishment and immediate post-establishment period (1-5 years). Available soil moisture often is limiting on harvested forest sites at this stage and can be the source of severe competition between grasses and young conifer seedlings with shallow and poorly developed root systems. Little research has assessed long-term effects (10 or more years) of domestic grass competition on conifer growth.

Two full growing seasons after planting, Larson and Schubert (1969) showed root and top growth were significantly greater when ponderosa pine (*Pinus ponderosa* (Dougl.))[1] seedlings were grown without competition from grass. The authors cautioned that the height growth of ponderosa pine for the first 1-2 years after outplanting is a poor indicator of competition, because most of the growth during these years is on the root system.

Wheeler *et al*. (1980) found no significant difference in height of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) or ponderosa pine seedlings 12 years following planting, whether plots had been seeded to grass or left unseeded. The seedlings were taller, however, on plots subjected to grazing. Apparently grazing by cattle reduced transpirational surface of forage plants to the point where moisture stress was relatively uniform between seeded and unseeded plots. In an Oregon study, soil moisture at depths of 5 and 12 inches (13 and 30 cm, respectively) was greater on plots grazed by sheep than on ungrazed plots. Douglas-fir seedlings grew more rapidly under a carefully controlled grazing regime and their heights averaged 27% greater on grazed plots 10 years after grazing started (Hendrick and Keniston 1966). Additional indirect evidence of reduced moisture competition from grazing was reported by Baron (1962) who observed greater ponderosa pine survival on plots with grass species selectively grazed by cattle.

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[1]Nomenclature throughout the paper follows Hitchock and Cronquist (1981).

Cleary (1978), however, reported that height growth of Douglas-fir seedlings grown on grazed sites was stunted until the trees were about 1 m (3 ft) tall, but thereafter the growth rate paralleled that of trees grown on ungrazed sites. However, 10 years after planting, Douglas-fir 2+0 and 2+1 bareroot seedings produced greater height on ungrazed than on grazed areas.

Clark and McLean (1978) found that lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) height growth possibly had been restricted by grass competition where no grazing occurred. However, it also appeared that average height of seedlings with domestic grass and clover competition and grazing was similar to the average height of seedlings with grazing and no seeding competition; in other words, grazing and seeding were interacting so that the effect of grass competition was not as serious as originally suspected. In a separate study, Clark and McLean (1979) found that seedlings growing with no grass competition were significantly taller after 5 years than seedlings growing in competition with seeded grass. Also, the total biomass of seedlings on unseeded plots tended to be greater than that of seedlings on grass-seeded plots. The simulation of grazing, i.e., clipping of forage, had no significant effect on lodgepole pine seedlings survival or total seedling mass.

Cattle sometimes injure tree regeneration by browsing and trampling. Browsing is uncommon if cattle have access to abundant and palatable green forage, but incidence of injury increases when use is heavy (Cassady et al. 1955; Edgerton 1971; Pearson et al. 1971; Currie et al. 1978). Despite an abundance of palatable forage, however, cattle browsed the tender annual growth of ponderosa pine and lodgepole pine in Washington plantations (Monfore 1983).

Trampling usually causes the greatest injury to young seedlings (Baron 1961; Edgerton 1971; Adams 1975). Repeated trampling from over use of forage was blamed for high cattle-related mortality observed in some lodgepole pine - Engelmann spruce (Picea engelmanni Parry) clearcuts in British Columbia (Clark and McLean 1978), but incidence of injury was low when pastures were grazed intensively for only short durations. Other researchers have concluded that cattle grazing can be compatible with forest regeneration, provided good grazing management practices are used (Edgerton 1971); Pearson *et al*. 1971; Currie *et al*. 1978).

It is well documented that forage production is inversely related to conifer basal area, percent crown cover, and stem density (Pase and Hurd 1958; Young *et al*. 1967; Basile and Jensen 1971), which increase as the forest regenerates. Less is know of the long-term forage yield response to seeding and grazing on clearcuts, in particular to composition of forage over time and longevity of seeded species. Understory production peaked about 11 years after logging on an unseeded lodgepole pine clearcut in Montana (Basile and Jensen 1971). Maximum production for forbs and grasses occurred at about 10 and 13 years, respectively, while shrub production increased over the entire time (17 years) studied. Resident vegetation (mostly bull thistle) contributed most to herbage production the first few years following seeding on a grand fir (*Abies grandis* (Dougl.) Forbes) - Douglas-fir clearcut in Oregon, but after about 10 years, 90% of the production came from seeded species (Krueger 1983). Herbaceous yields decreased greatly about 18 years after seeding on cattle-grazed pastures where shrubs had become dominant.

For a more thorough review of tree-forage-livestock interactions, readers are advised to consult Nordstrom (1985) who has completed a detailed review of literature pertaining to temperate-forest range in North America with emphasis on British Columbia.

A study was initiated in the early 1970's to assess the effects of grazing and seeding on conifer establishment and growth on a number of clearcuts in southern British Columbia. The work reported herein is a snythesis of data collected from one lodgepole pine - Engelmann spruce clearcut (Area 1 of the study reported by Clark and McLean [1978]) 5 and 13 years following lodgepole pine planting and 4 and 12 years following domestic-grass seeding.

METHODS

A 130 ha clearcut (Community Lake) located 26 km northeast of Kamloops at 1340 m elevation was planted with lodgepole pine and Engelmann spruce during spring 1971. The whole area, with the exception of 20-ha (100 m wide) control strip running through the middle of the clearcut, was aerially sown with a Forestland mix at the rate of 4.5 kg/ha during late 1972. An exclosure, encompassing both grass-sown and unsown portions of the area, was constructed in 1972 within the area planted to lodgepole pine. Descriptions of the site (Area 1) and composition of the seeding mix were included in the 1978 study report. The stocking rate was 0.7 ha per animal unit month (AUM) for about 1 month's duration between 1973 and 1976. Cattle have grazed season long in the pasture at 1.2 ha per AUM since 1976.

In 1972, eight permanent plots were randomly located in seeded and unseeded areas of the pasture to assess seedling condition and height. Plot size was determined by the area occupied by 25 planted lodgepole pine seedlings. In 1976, total heights were measured for all surviving planted seedlings occurring in the plots and, in addition, seedling heights were measured in seeded and control areas of the exclosure. The number of seedlings observed was 73, 94, 147, and 131 for the ungrazed (exclosure)-seeded, ungrazed-unseeded, grazed-seeded, and grazed-unseeded areas, respectively. In 1984, heights and diameters at breast height (dbh) of 55 saplings were measured in each area. Trees were measured in control and seeded areas adjacent to the exclosure, rather than from the plots established in 1972, to lessen any possible site discrepancies. In each seeding-grazing treatment combination, three plots measuring 5 x 20 m were established to determine tree density, botanical cover and frequency, and forage production (Fig. 1). Plots were spaced to allow 1.5 m between plots and at least 5 m for area boundaries, i.e., sides of exclosure or seeded-unseeded interfaces. To estimate density, individuals of each conifer species were assigned to one of the following categories: seedling (less than 0.5 m tall), reproduction (greater than 0.5 m tall but dbh less than 2.5 cm) and saplings (dbh greater than 2.5 cm). Only stems of deciduous species greater than 0.5 m tall were

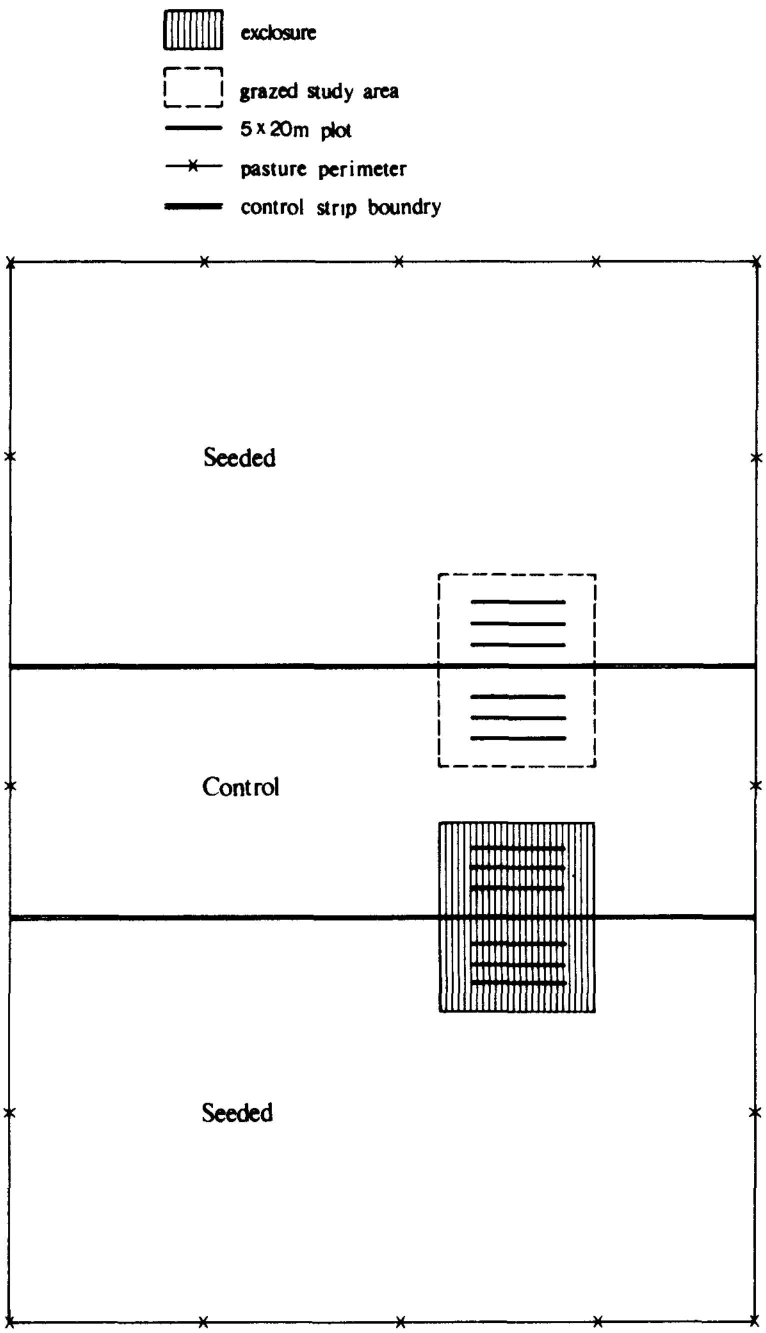

FIGURE 1. Experimental layout used for sampling in 1984. Diagram is not to scale.

counted. Cover of understory species was estimated with Daubenmire's (1959) clover-class system, and forty 0.1-m^2 frames were recorded per plot. Current year's growth was clipped from two randomly located 1-m^2 frames per plot to assess production. Herbage was separated into major forage classes and then oven-dried to a constant weight.

Individual tree volumes were calculated from an equation developed by Kovats (1977) and are for the entire stem, inside bark. Basal area was calculated for all stems for the 1984 data.

The experiment, a 2 by 2 factorial set out in a non-randomized way, was analyzed with a two-way analysis of variance (ANOVA) to examine effects of seeding and grazing on pine growth, tree density, understory cover and frequency, and forage yields. Because there was only one exclosure, there was not true replication in the experiment. Consequently, the sub-sampling variation among individual units, e.g., among the 55 trees per treatment in 1984, was used as the error term in the analysis. With a single replicate, it may be argued that apparent differences among treatments reflect site differences. In this study the portion of the field selected to represent the grazed area was similar in slope, aspect, and topography to the exclosure, and the area encompassed by the exclosure and grazed area boundaries were homogeneous, so site differences, if any, should be slight. Plates 1 - 3 depict the appearance of seed and unseeded portions of the enclosure between 1973 and 1983.

Because the possible impacts on conifers of seeding in the presence of cattle is the primary management concern, tree growth means of seeded-grazed and native-grazed areas were compared with individual degree of freedom contrasts.

PLATE 1. Exclosure 2 years after the pine was planted and 1 year following seeding (1973). A grass-legume mix was sown on the left, the right side was not seeded.

PLATE 2. Exclosure 4 years after the pine was planted and 3 years following seeding (1976). Left side is seeded; right sided is control.

PLATE 3. Exclosure 13 years after the pine was planted and 12 years following seeding (1983). Left side is seeded; right side is unseeded.

RESULTS

Lodgepole Pine Growth

Pine height data collected in 1976, 4 years after seeding, indicated a significant interaction between seeding and grazing. Seeded ($\bar{x}$=1.25 m, SE = 2.78) and unseeded ($\bar{x}$=1.20 m, SE=2.95) areas differed very little when grazed, but pine were much taller in the unseeded ($\bar{x}$=1.62 m, SE=3.48) than seeded ($\bar{x}$=1.39 m, SE=2.89) portion of the exclosure. Seedlings in the exclosure were taller than those on the grazed areas.

Eight years later, in 1984, pine heights from the grazed and ungrazed areas did not differ significantly nor did seeding interact with grazing (Table 1). Height was the only pine growth parameter significantly repressed by domestic grass competition. Trees on seeded plots averaged about 4% shorter than on the controls, a difference similar to that observed in 1976.

Tree height was the sole parameter not significantly affected by grazing; diameter, basal area, and volume were greater on grazed plots. Presumably, removal of understory growth by grazing reduced competition between herbaceous and woody species. Seeding by grazing interactions were not detected for any parameters. Individual degree of freedom tests indicated that tree heights and volume were significantly greater on native-grazed than seeded-grazed areas but dbh and basal area were not.

Tree and Shrub Density

Deciduous tree (mostly Populus tremuloides Michx.) and large shrub populations far outnumbered conifer density 13 years after planting (Table 2). Natural regeneration of Engelmann spruce and Douglas-fir was abundant with spruce numbers equaling or exceeding total number of pine stems (both planted and naturally regenerated). Douglas-fir has established more recently than spruce since only seedlings of Douglas-fir were observed. Few pine seedlings and reproduction were present.

Seeding did not significantly influence tree and shrub densities and there were no seeding by grazing interactions but there were some differences with grazing (Table 2). Douglas-fir density was significantly higher in the

TABLE 1. Average lodgepole pine growth in relation to seeding and grazing treatments 13 years following planting[a]

Factor	Height (m)	Dbh (mm)	Basal area (m^2/ha)[b]	Volume (m^3/ha)[b]
Seeding[c]	*	NS	NS	NS
Seeded $\bar{x}$	4.49	70	3.8	13.93
Unseeded $\bar{x}$	4.67	73	4.2	15.58
Grazing[c]	NS	*	*	*
Grazed $\bar{x}$	4.60	74	4.3	15.97
Ungrazed $\bar{x}$	4.57	69	3.7	13.54
SE Main factors (n=110)	0.056	1.2	0.13	0.614
Seeding x Grazing[c]	NS	NS	NS	NS
Seeded-Grazed $\bar{x}$	4.44	72	4.1	14.63
Seeded-Ungrazed $\bar{x}$	4.54	68	3.6	13.23
Unseeded-Grazed $\bar{x}$	4.75	77	4.6	17.32
Unseeded-Ungrazed $\bar{x}$	4.59	70	3.8	13.84
SE Interaction (n=55)	0.079	1.7	0.19	0.874

[a] Tree age equals years following planting plus three.

[b] Basis: 960 stems per hectare.

[c] * = significant at 5% level; NS = non-significant.

TABLE 2. Tree and shrub density (stems per hectare) in relationship to seeding and grazing treatments 13 years after lodgeple pine was planted

Species	Seeding means		Grazing means		Standard Errors	
	Seeded	Unseeded	Grazed	Ungrazed	Factors (n - 12)	Interaction (n = 6)
Coniferous						
Pine saplings	1 250	1 317	1 517	1 050[a]	63	90
Spruce reproduction	817	1 000	700	1 117	158	224
Spruce seedlings	1 933	1 250	1 083	2 100	307	434
Douglas-fir seedlings	1 334	750	667	1 417[a]	203	287
Total coniferous stems[b]	2 334	2 667	2 367	2 634	273	386
Deciduous						
Trembling aspen[b]	5 400	4 967	4 784	5 583	516	730
Willows[b]	3 367	3 933	4 050	3 250	472	667
Total deciduous stems[b]	9 533	10 184	9 350	10 367	1 120	1 584

[a] Grazed and ungrazed means differ significantly at the 5% level.

[b] All stems > 0.5 m.

exclosure, but density of pine saplings was higher on grazed plots. Possibly unequal establishment of natural regeneration soon after logging resulted in the sapling-density differences observed between the protected and grazed areas.

By 1984, competition from woody plants far exceeded that from herbaceous species, both native and seeded. Because grazing and seeding treatments had minor influence on shrub and conifer reproduction densities, competition from these sources probably would be similar on all areas. It is not known when brush species became aggressive competitors, however trembling aspen was very abundant as early as 1976, 4 years after seeding (Plate 2).

Understory Composition

Cover and frequency of herbaceous vegetation differ only slightly between grazed and ungrazed areas 12 years after seeding (Table 3). Twinflower (Linnaea borealis L.) and hawkweed (Hieracium albiflorum Hook.) were significantly more abundant on protected than on grazed areas. Seeding had little long-term effect on occurrence of native species. Shiny-leaf spirea (Spiraea betulifolia Pall.) was the only plant significantly more abundant on the unseeded plots. Three seeded species, orchard grass (Dactylis glomerata L.), timothy (Phleum pratense L.), and alsike clover (Trifolium hybridum L.), occurred more frequently on the seeded plots but were present also on the control areas. Combined cover of domestic grasses and clover never exceeded 15% and usually was less than 10%, even on the seeded plots. Seeding by grazing interactions occurred with three species, thimbleberry (Rubus parviflorus Nutt.) showy aster (Aster conspicuus Lindl.), and white clover (Trifolium repens L.), all of which were more common on the grazed-seeded plots. Broad-leaf lupine (Lupinus latifolius Agardh.) was the dominant herbaceous species regardless of seeding or grazing treatment. Pinegrass (Calamagrostics rubescens Buckl.), a native sodformer, provided equal cover on seeded and control areas. In another clearcut study (Krueger 1983) pinegrass was also unaffected by seeding, but unlike the present study, native species were reduced on seeded plots and grasses dominated the understory 14-20 years after seeding.

TABLE 3. Average[a] percent understory cover and frequency of major species for seeding and grazing treatments 12 years after seeding

	Seeding		Grazing	
	Seeded	Unseeded	Grazed	Ungrazed
Species	Cover/Freq.	Cover/Freq.	Cover/Freq.	Cover/Freq.
Graminoids				
Calamagrostis rubescens	12/28	10/54	10/44	12/38
Carex concinnoides	T[b]/7	2/10	2/12	T/6
Dactylis glomerata	4/34	T/1[c]	2/18	2/16
Phleum pratense	3/50	T/5[c]	2/38	1/17
Forbs				
Arnica cordifolia	6/39	3/22	5/30	4/30
Aster ciliolatus	6/47	6/48	7/50	5/45
Aster conspicuus	3/15	1/6	4/19	T/3
Cornus canadensis	10/61	11/70	9/56	11/75
Epilobium angustifolium	9/53	6/50	9/53	7/49
Fragaria virginiana	2/16	1/11	2/16	1/4
Hieracium albiflorum	2/17	2/18	1/8	3/26[c]
Linnaea borealis	10/38	16/52	4/20	22/71[c]
Lupinus latifolius	36/96	25/89	34/94	27/91
Petasites frigidus	8/23	4/30	4/32	4/26
Taraxacum officinale	2/34	2/35	2/41	2/28
Trifolium hybridum	3/25	T/6[c]	2/15	1/16
Trifolium repens	2/13	1/5	3/17	T/1
Low shrubs				
Rosa sp.	3/17	1/9	3/17	1/9
Rubus parviflorus	4/17	T/3	3/16	1/3
Spiraea betulifolia	2/15	10/49[c]	6/28	7/36
Vaccinium membranaceum	1/8	1/11	1/5	1/13

[a] Average based on six transects per treatment. Forty 0.1m^2 plots were sampled per transect.
[b] T = Trace $<$1% cover.
[c] F test for factor significant at 5% level for both cover and frequency.

Forage Yields

Herbage yields did not differ significantly according to seeding or grazing history, although shrub yields appeared higher on seeded plots and pinegrass production seemed greater on grazed areas (Table 4). High variability may have masked differences between treatments.

Total herbage production inside the exclosure was similar to the lowest yields obtained in the first 5 years following seeding (Table 5), which suggests that canopy closure has affected understory yields only slightly, if at all. Data are not available for the grazed areas in the early years. The composition of production changed greatly, however. Five years after seeding (1977), domestic species dominated seeded plot yields and pinegrass was an important component of the control plots (Fig. 2). By 1984, domestic and native grasses comprised less than 4 and 1% respectively of total exclosure yields. Shrubs and forbs increased to compensate for the grass losses, especially on the seeded plots. In 1984, a single forb species, broad-leaf lupine, contributed more than half the total yield on most plots inside and outside the exclosure. A tendency for shrubs to dominate production over time has been observed in other clearcut studies, but in those cases forbs peaked within the first 10 years after logging (Basile and Jensen 1971; Krueger 1983).

TABLE 4. Herbage yield (kg/ha oven-dry weight) means and standard errors for the seeding and grazing treatments 12 years after seeding. There were no significant differences at the 5% level.

Forage group	Seeding means		Grazing means		Standard Errors	
	Seeded	Unseeded	Grazed	Ungrazed	Factors (n = 12)	Interaction (n = 6)
Seeded species[a]	41	10	35	15	11.7	16.6
Native grass	40	84	113	11	43.0	60.8
Lupine	870	815	971	714	88.3	124.8
Other forbs	193	199	205	186	38.6	54.5
Shrubs[b]	555	275	309	521	107.7	152.3
Total production	1699	1383	1634	1447	128.4	181.6

[a] Grass and clover.
[b] Current year's growth, leaves, and twigs.

TABLE 5. Total production of herbage (kg/ha oven-dry weight) in seeded and unseeded portions of the exclosure 1, 2, 3, 5, and 12 years after seeding

Years after sowing	(year)	Seeded	Unseeded
1	(1973)	2240[a]	1173
2	(1974)	1752	1662
3	(1975)	2728	1219
5	(1977)	2296	1261
12	(1984)	1782	1112

[a] Yields for the 1st through 5th year after sowing are calculated from means of five 9.6-ft^2 frames while those for 1984 are calculated from means of six 1-m^2 frames.

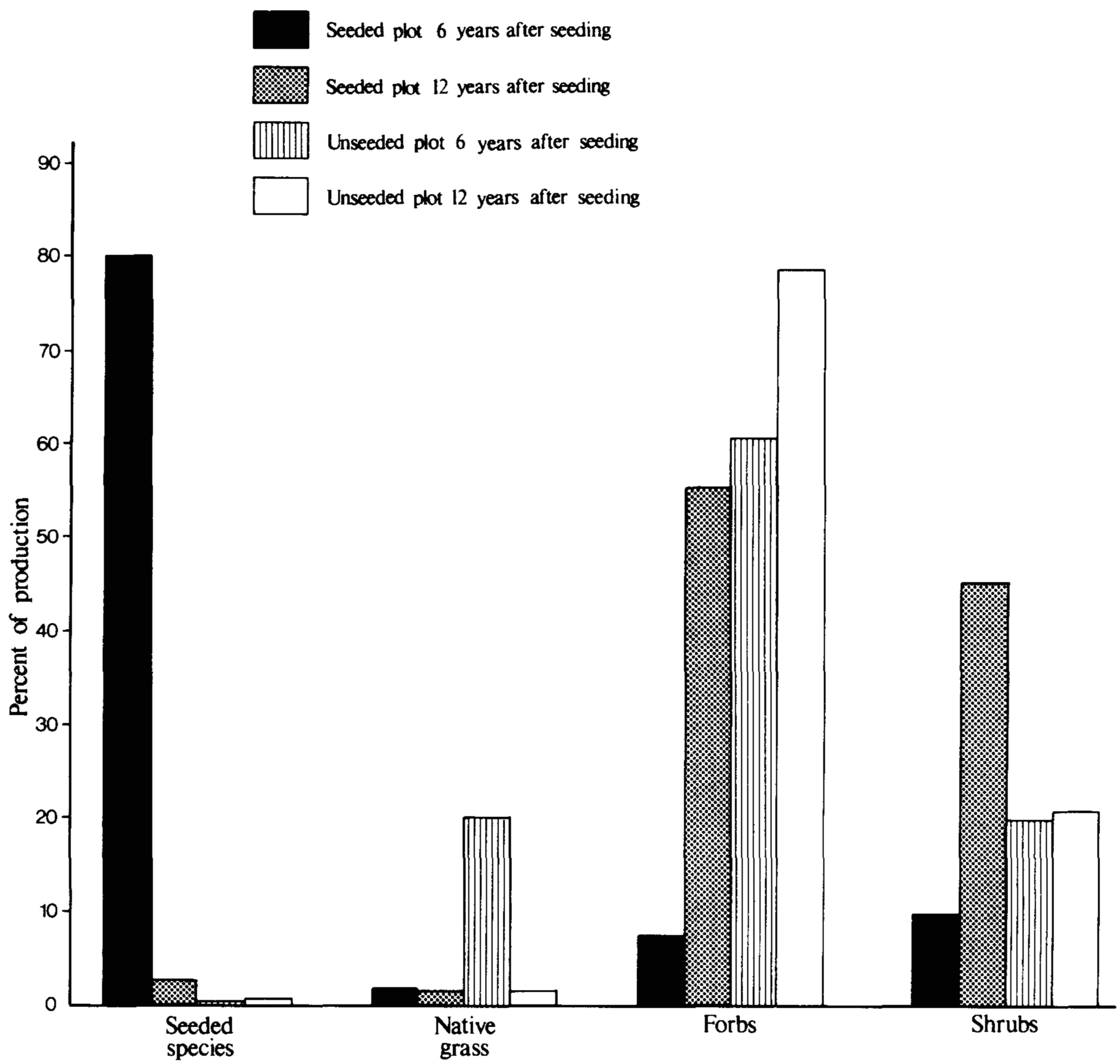

FIGURE 2. Percentage of total herbage production of major forage classes on seeded plots 6 and 12 years after seeding and on unseeded plots 6 and 12 years post seeding. Plots were located in the exclosure.

CONCLUSIONS

Twelve years after seeding, there is evidence of only minor lodgepole pine suppression from competition with seeded grasses. With the exception of height, no growth parameters were significantly reduced on seeded plots. Domestic grasses probably provided more competition than native vegetation early in the study, but the tree seedlings appeared to overcome this disadvantage once the seeded grasses declined. Growth of lodgepole pine in competition with grass might have been less favourable if the pine had been planted after and not before grass establishment. Baron (1962) observed that ponderosa pine established successfully on a hard burn when planted or direct seeded simultaneously with grass, but establishment became progressively poorer as planting or seeding was delayed.

Grazing appears to benefit tree growth by reducing competition from both native and seeded understory species. Good grazing management is required to ensure even use of forage and to minimize seedling injury. Cattle damage to pine seedlings was negligible (about 2% mortality) despite heavy stocking rates in the first 4 years of the study (Clark and McLean 1978). The light degree of damage was attributed to the short grazing period which minimized repeated trampling of the seedlings. Other lodgepole pine - Engelmann spruce clearcuts in British Columbia received extensive cattle damage, usually because of prolonged grazing periods and over use of forage (Clark and McLean 1978; McLean and Clark 1980). The authors recommended that clearcuts should be intensively grazed for only short periods of time, particularly during the 1st year of tree establishment, and grazing should be on a rotational basis if possible. Other practices that promote even use of forested range include removal or orientation of logging slash to permit livestock access, use of steers, or replacement heifers instead of cows and calves, construction of drift fences, and prudent location of water and salt (Wood 1972).

In this study, lodgepole pine obtained maximum volume when grazing was present but seeding was absent. It cannot be estimated whether the present spread in volume of about 16% between the seeded and unseeded portions of the grazed pasture will remain static, or whether further reduction of grass and other herbaceous growth with time will result in increased growth of trees in the seeded-grazed areas. Since mean volume for unseeded-grazed plots is conspicuously higher than the other three treatment combinations, and because there is virtually no difference between seeded and control plots when there is no grazing, it appears that tree growth was enhanced under the grazed-unseeded treatment regime rather than suppressed with seeding. These results suggest that the long-term effects of competition from seeded and native vegetation were similar, but that grazing reduced competition more on native plots than on seeded ones. This is difficult to explain in view of equal or heavier use on seeded plots (unpublished data) observed in the first years of the study. Perhaps increased resistance of domestic grasses to defoliation resulted in quicker resumption of growth and concomitant competition following herbage removal.

Cattle diet observations collected at the study site between 1977 and 1979 (Quinton 1984) indicated that grasses, forbs, and shrubs comprised 59, 33, and 9% of the diet respectively. These values were similar to proportions of total annual production present at that time. The shift in production away from grasses towards shrubs in recent years should result in reduced carrying capacity of the site, unless the cattle shift their diet selection accordingly, even though 1984 yields suggest herbage yields have diminished only slightly.

Management recommendations would be premature, but the above results suggest possible practical applications. In situations where native forage meets livestock requirements, grazing might be used to maximize tree growth. However, in cases where native vegetation is inadequate because of palatability, quality, or quantity for livestock, seeding may be desirable. Krueger (1983) suggests that because a full understory cover will develop if seeding is absent, seeding of palatable species in conjunction with grazing could be used to reduce competition between understory vegetation and planted tree stock.

Caution must be exercised in extrapolation of results from this project to other areas and conifer species. The present example is only a small part of a much larger population of seeding-grazing-conifer interactions. However, the results do indicate possible long-term effects of seeding and grazing on lodgepole pine productivity, while providing data on long-term yields of forage on logged areas sown with domestic grasses.

LITERATURE CITED

Adams, S.N. 1975. Sheep and cattle grazing in forests: a review. J. Appl. Ecol. 12:143-152.

Baron, F.J. 1962. Effects of different grasses on ponderosa pine seedling establishment. U.S. Dep. Agric. For. Serv. Pac. Southwest For. Range Exp. stn., Res. Note No. 199.

Basile, J.V. and C.E. Jensen. 1971. Grazing potential on lodgepole pine clearcuts in Montana. U.S. Dep. Agric. For. Serv., Res. Pap. INT-98.

Cassady, J.T., W. Hopkins, and L.B. Whitaker. 1955. Cattle damage to pine seedlings. U.S. Dep. Agric. For. Serv. Southern For. Exp. Stn., Occas. Pap. 141.

Clark, M.B. and A. McLean. 1978. Compatibility of grass seeding and coniferous regeneration of clearcuts in the south central interior of British Columbia. B.C. Min. For., Res. Note No. 83.

______________ 1979. Growth of lodgepole pine seedlings in competition with grass. B.C. Min. For., Res. Note No. 86.

Cleary, B.D. 1978. Vegetation management and its importance in reforestation. Oreg. State Univ., School of For., Corvallis, Oreg. For. Res. Lab. Res. Note 60.

Currie, P.O., C.B. Edminster, and F.W. Knott. 1978. Effects of cattle grazing on ponderosa pine regeneration in central Colorado. U.S. Dep. Agric. For. Serv., Res. Pap. RM-201.

Daubenmire, R. 1959. A canopy-coverage method of vegetational analyses. Northwest. Sci. 33:43-63.

Edgerton, P.J. 1971. The effect of cattle and big game grazing on a ponderosa pine plantation. U.S. Dep. Agric. For. Serv., Res. Note PNW-172.

Hendrick, D.W. and R.F. Keniston. 1966. Grazing and Douglas-fir growth in the Oregon white-oak type. J. For. 64:735-738.

Hitchock, C.L. and A. Cronquist. 1981. Flora of the Pacific Northwest. Univ. Wash. Press, Seattle, Wash.

Kovats, M. 1977. Estimating juvenile tree volumes for provenance and progeny testing. Can. J. For. Res. 7:335-342.

Krueger, W.C. 1983. Cattle grazing in managed forests. In Proc. of the Symposium on Forestland Grazing. B.F. Roché and D.M. Baumgartner (editors). Wash. State Univ., Pullman, Wash., pp. 29-41.

Larson, M.M. and G.H. Schubert. 1969. Root competition between ponderosa pine seedlings and grass. U.S. Dep. Agric. For. Serv., Res. Pap. RM-54.

McLean, A. and M.B. Clark. 1980. Grass, trees and cattle on clearcut-logged areas. J. Rang Manage. 33:213-217.

Monfore, J.D. 1983. Livestock - a useful tool for vegetation control in ponderosa pine and lodgepole pine plantations. In Proc. of the Symposium on Forestland Grazing. B.F. Roché and D.M. Baumgartner (editors). Wash. State Univ., Pullman, Wash., pp. 105-107.

Nordstrom, L.O. [1985]. The ecology and management of forest range in British Columbia: a review and analysis. B.C. Min. For., Land Manage. Rep. No. 19. In press.

Pase, C.P. and R.M. Hurd. 1958. Understory vegetation as related to basal area, crown cover and litter produced by immature ponderosa pine stands in the Black Hills. Proc. Ann. Meet. Soc. Am. For. 1957, pp. 156-158.

Pearson, H.A., L.B. Whitaker, and V.L. Duvall. 1971. Slash pine regeneration under regulated grazing. J. For. 69:744-746.

Quinton, D.A. 1984. Cattle diets on seeded clearcut areas in central interior British Columbia. J. Range Manage. 37:349-352.

Wheeler, W.P., W.C. Krueger, and M. Vavra. 1980. The effects of grazing on survival and growth of trees planted in a northeast Oregon clearcut. Oreg. State Univ. Agric. Exp. Stn., Spec. Rep. No. 586, pp. 28-31.

Wood, B. 1972. Forest grazing. Oreg. State Univ., Coop. Ext. Serv., Circ. No. 798.

Young, J.A., D.W. Hendrick, and R.F. Keniston. 1967. Forest cover and logging. J. For. 65:807-813.