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Effect of forage seeding on early growth and survival of lodgepole pine

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Abstract

Smooth bromegrass (*Bromus inermis Leys.*), orchardgrass (*Dactylis glomerata* L.), alsike clover (*Trifolium hybridum* L.), and a mixture by mass of 40% orchardgrass, 40% alsike clover, and 20% white clover (*Trifolium repens* L.), were sown at 0.5, 1.5, 3.0, 6.0, and 12.0 kg/ha on a forest clear-cut in the southern interior of British Columbia. The seeding treatments were monitored for 3 growing seasons following planting to determine their influence on the growth, survival and damage of planted one-year old lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) seedlings. Competing vegetation reduced lodgepole pine diameter by up to 38% ($P<0.004$) and heights by up to 30% ($P<0.005$). Lodgepole pine basal diameters ($P<0.002$), height ($P<0.02$) and survival ($P<0.03$) decreased linearly with increasing forage seeding rate. Lodgepole pines planted with smooth bromegrass had up to 59% larger ($P<0.01$) diameters and were up to 33% taller ($P<0.06$) than those planted with orchardgrass at equal seeding rates by mass. Lodgepole pine cumulative mortality was 2 to 5 times greater ($P<0.0001$) on plots sown to alsike clover compared to plots sown with smooth bromegrass or orchardgrass. Rodent damage peaked between the first and second growing seasons at 24% of the lodgepole pine seedlings; rodent damage was similar ($P>0.05$) among the treatments and controls, and conifer survival was independent ($P>0.05$) of rodent damage.

Key Words: British Columbia, clear-cut, *Pinus contorta*, rodent damage, seeding rate

Competition between conifers and seeded vegetation is a major concern on regenerating forestland in British Columbia (McLean and Clark 1980, Nordstrom 1984, Pitt 1989). Despite the important influence of seeded vegetation on range management and silviculture, there has been a lack of research done in British Columbia to quantify the competition between conifer seedlings and seeded forages, or to identify any potential positive interactions. Moreover, there remains inadequate information on the effects of forage species, seeding rates, and forage mixes on the competitive balance between conifer and forages. In British Columbia, operational seeding is conducted using rates set by mass; the influence of seeding rates in relation to the pure live seed sown needs to be clarified. The influence of vegetation on the early growth and survival of conifers in the absence of grazers is of special interest when an area has been seeded and planted, with grazing deferred during the tree and forage establishment period.

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In a laboratory study, Clark and McLean (1975) concluded that survival, height, and plant mass of 6-month-old lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) seedlings decreased as density of orchardgrass (*Dactylis glomerata* L.) increased. Lodgepole pine survival increased by 4 times, height increased by over 20%, and the average dry weight of lodgepole pine shoots plus roots increased 10 times between the highest grass seeding (9.0 kg/ha) and no grass competition. Moreover, greater competition to lodgepole pine occurred with orchardgrass, a non-rhizomatous plant, that with pinegrass (*Calamagrosits rubesens* Buckl.), which is weakly rhizomatous. The response of lodgepole pine to grass competition was independent of a 2-, 4-, or 10-day watering interval.

Forage-tree interactions have been studied in a variety of field conditions, with an assortment of conifer and forage species (Baron 1962, Squire 1977, Krieger 1983, Elliot and White 1987). The diversity of conditions under which the experiments were conducted has often yielded contradictory results, and their relevance to British Columbia's interior montane forests is debatable.

Clark and McLean (1979) conducted seeding rate and forage species field trials in the southern interior of British Columbia on a subalpine, lodgepole pine site burned and cleared of native vegetation. Tree survival was not affected by density of orchardgrass after 4 years. Total biomass of pine seedlings was reduced by 68 to 93% by presence of forages, and average stem height was reduced by 59 to 71% at forage seeding rates greater than 4.5 kg/ha. Individual forage species did not differ in their influence on the survival or growth of lodgepole pine.

Trowbridge and Holl (1992) reported that seeding alsike clover (*Trifolium hybridum* L.) at rates of 10, 20, and 30 kg/ha had no effect on the survival or height growth of planted lodgepole pine seedlings in the first 3 years. In the year 4, lodgepole pine height was reduced slightly in clover plots compared to control plots with native vegetation. Lodgepole pine diameter growth decreased with seeding rate during the first 3 growing seasons; however, differences in the diameter increment were not significant in 4 years after planting.

The objectives of this research were to determine the effects of 3 forage species and a forage mix, sown at 5 seeding rates by mass, on the early growth and survival of planted lodgepole pine. The treatments were selected to expand our understanding of seeding rates lower than 3 kg/ha and to relate the dynamics of different forage types and pure live seeding rates to operational seeding practices in British Columbia.

Study Site

This study was conducted on a 0.7-ha site in a 50-ha forest clear-cut in the Very Dry, Cool Montane Spruce (MSxk) biogeoclimatic subzone (Lloud et al. 1990), near Tunkwa Lake (120° 57' W., 50° 30' N.) in the southern interior of British Columbia. The area receives 355 to 503 mm of precipitation annually, with approximately 40% occurring during the conifer growing season (May to August). Mean annual temperature during the growing season is 11.1° C, and -12.6° C in mid-winter (January). The elevation of the site is 1,450 m, with a 3% slope and a north-west aspect. Soil is a melanic brunisol (approximate U.S. equivalent = Eutrochrept) (Canada Soil Survey Committee 1978). Before logging the site supported an overstory of lodgepole pine and Engelmann spruce (*Picea engelmannii* Parry ex. Engelm.) in approximately equal proportions. Pinegrass, heart-leaved arnica (*Arnica cordifolia* Hook.) and birch-leaved spirea (*Spirea betulifolia* Pall.) characterized the understory. Plant taxonomy follows Douglas et al. (1989).

Methods

The study site and surrounding area was clear-cut logged in the winter of 1988. Logging debris and waste were bunched and burned in the fall of 1989 as part of operational forest management. The site was enclosed with a 4-m high paige wire fence to exclude livestock and wild ungulates in spring 1990. The site contained 88, 16-m^2 (4-x 4-m) experimental units with 1-m buffer strips between the units and a minimum 4-m buffer, planted to trees, located between the perimeter and the fence. The site was scarified with hand rakes to achieve an average mineral soil exposure of approximately 25%, and to mix mineral soil with any unburned forest litter.

Forages were seeded onto the plots by hand immediately following snow-melt in May 1990. Alsike clover, orchardgrass, smooth bromegrass, and a mixture by weight of 40% orchardgrass, 40% alsike clover, and 20% white clover (*Trifolium repens* L.), were sown at 0.5, 1.5, 3.0, 6.0 and 12.0 kg/ha in all factorial combinations. Two controls were included in the randomization: a single control for both species and seeding rate, consisting of lodgepole pines with no seeded vegetation, in addition to a control for tree growth consisting of lodgepole pines with all other vegetation removed. Treatments and controls were replicated 4 times, and randomly assigned to experimental units.

Alsike and white clover were coated with a clay-*Rhizobium leguminosarum* var. *trifolii* mixture which provided an average 2,000 live *Rhizobium* cells per seed. Germination trials of the forage seed were conducted in accordance with the procedure outlined by the Association of Official Seed Analysts (1978) and were used to calculate the number of pure-live seed sown.

One-year old lodgepole pine seedlings, container-grown in polystyrofoam blocks, were shovel-planted immediately after forage seeding. Each plot contained 4 lodgepole pine seedlings at a 2.5-m spacing. Lodgepole pine and surrounding vegetation were monitored during each of the first 3 growing seasons following establishment.

Two measurements of cover, density, and height of vegetation were conducted within each experimental unit. The first was centered on a randomly selected lodgepole pine seedling to assess interaction of lodgepole pine and forages, and the second randomized in the remaining area of the experimental unit without the influence of the tree seedlings. Canopy cover was determined in 20- x 50-cm frames (Daubenmire 1959). Density was determined by counting the number of genets (Silvertown 1987) within the 20- x 50-cm frame set for cover determination. Height of all species included in the density counts was measured, to the nearest 0.1 cm, from ground level to the tip of the highest leaf extended upward on a plant ocularly estimated to be of average height within the plot (Evanko and Peterson 1955). Measurements were conducted twice annually to coincide with the beginning and end of the lodgepole pine growing season.

Forage production was determined from oven-dry samples obtained by clipping a 0.25-m^2 plot (50- x 50-cm) to a 5-cm stubble height. Sampling locations in the experimental units for forage production were selected randomly from the area not used for the other vegetation measurements or containing a lodgepole pine seedling. The area selected for clipping was determined randomly for each year, although the same location was not clipped twice during the study.

Lodgepole pine survival, height, basal diameter and damage were measured annually before the start of the lodgepole pine growing season (between snow-melt and bud-break) and immediately after the trees had set bud. Death was defined as 99% or greater necrotic needles. Damage classified as human, rodent, erosion, snow-press, lodging, frost, and other was also noted. Height was measured to the nearest 0.1 cm on every tree from the soil surface to the tip of the terminal bud. Basal diameter was measured to the nearest 0.1 mm with calipers placed around the stem immediately above the soil surface. The height/diameter ratio was calculated as an index of competition (Cole and Newton 1987). Lodgepole pine stocking was calculated based on the initial stocking, adjusted for the cumulative mortality and the natural regeneration for the site.

Statistical Analysis

The effect of forage species and seeding rate by mass on lodgepole pine height, basal diameter, and the height/diameter ratio were analyzed using a repeated measures analysis of variance for a completely random design. The variation introduced by seeding rate and species, in addition to other comparisons of interest, were separated using individual degree of freedom contrasts. Polynomial contrasts were used to determine the conifer response across years. A repeated measures analysis of variance was also conducted on tree growth variables for the following treatments only: smooth bromegrass, orchardgrass, alsike clover, and the mixture sown at 1.5, 0.5, 0.5 and 0.5 kg/ha respectively. This analysis was conducted to determine the difference between forage types at approximately equivalent pure-live seeding rates.

Lodgepole pine basal diameter increment, height increment, incremental damage and survival were regressed against the number of pure-live seeds sown, vegetation cover, height, density, and production in each plot. A separate regression was conducted for each species treatment for each of the conifer measurements.

Chi-square tests of homogeneity and distribution of the binomial means for damage and survival were used to determine if lodgepole pine survival was independent of rodent damage and survival were equally distributed among species factors and controls. An analysis of variance, modified for the unbalanced factorial (Bergerud 1989), was conducted on cumulative mortality recorded at the end of the third growing season.

Results and Discussion

Vegetation

Smooth bromegrass, orchardgrass, alsike clover, and the mixture contained 220, 700, 520 and 740 pure-live seeds/g, respectively. Height, cover, and production of the vegetation are summerized in Table 1. No strong relationships (R^2<0.10) between conifer growth increments and the cover, density, height and productions of the surrounding vegetation occurred in any of the 3 growing seasons.

Effect of Vegetation on Conifer Growth and Survival

Lodgepole pine basal diameter increased quadratically (P<0.0001) over the 3 growing seasons. Lodgepole pine without surrounding veg-

Table 1: Average canopy cover (%), height (cm) and production (kg/ha) of vegetation at Tunkwa Lake, British Columbia, 1990-1992. Numbers in parenthesis following the means indicate the standard error.

Seeding Treatment	Seed Rate	Canopy Cover 1990	Canopy Cover 1991	Canopy Cover 1992	Height 1990	Height 1991	Height 1992	Production 1990	Production 1991	Production 1992
		(%)			(cm)			(kg/ha)		
Smooth bromegrass	0.5	0.8 (0.9)	18.8 (17.1)	47.0 (19.3)	3.8 (1.3)	16.0 (13.3)	30.0 (5.9)	6.9 (8.0)	650.3 (228.6)	509.3 (232.6)
	1.5	2.3 (1.7)	6.8 (4.6)	26.3 (9.6)	1.5 (1.1)	11.0 (7.1)	25.3 (3.2)	0.8 (0.5	101.5 (104.5)	765.3 (137.6)
	3.0	6.0 (3.5)	7.5 (5.4)	51.0 (13.0)	5.8 (1.7)	11.5 (4.5)	31.8 (2.7)	0.9 (0.6)	61.2 (58.5)	642.2 (358.1)
	6.0	3.4 (0.9)	14.3 (5.9)	54.5 (18.0)	9.0 (1.8)	37.3 (15.3)	40.5 (7.4)	3.4 (1.3)	881.2 (368.2)	905.2 (226.2)
	12.0	2.3 (0.9)	11.3 (5.5)	66.3 (16.8)	4.0 (1.7)	11.5 (4.4)	30.5 (4.9)	19.5 (14.8)	499.7 (262.7)	869.8 (230.1)
Orchardgrass	0.5	2.3 (0.8)	24.3 (21.1)	43.0 (9.7)	2.3 (2.2)	20.5 (12.4)	57.3 (11.1)	15.2 (11.8)	161.9 (62.8)	1250.5 (682.6)
	1.5	1.5 (1.0)	5.3 (1.7)	35.3 (17.8)	2.0 (1.4)	14.5 (5.2)	54.3 (18.7)	8.3 (6.7)	910.4 (622.2)	1950.1 (1531.9)
	3.0	7.5 (3.0)	41.5 (17.7)	85.0 (18.1)	10.3 (2.3)	30.3 (7.3)	28.5 (3.6)	30.7 (31.9)	495.4 (153.7)	1242.7 (556.3)
	6.0	6.8 (3.3)	32.0 (14.1)	63.0 (7.2)	13.3 (4.0)	36.5 (18.4)	30.3 (1.8)	47.3 (42.7)	1084.1 (721.1)	1796.7 (942.0)
	12.0	4.5 (1.7)	40.0 (18.4)	65.0 (17.5)	7.3 (2.2)	34.0 (16.5)	38.5 (10.5)	66.9 (68.2)	364.6 (191.4)	1256.7 (752.8)
Alsike clover	0.5	3.0 (1.4)	9.0 (4.0)	80.5 (9.9)	1.5 (1.0)	5.3 (2.5)	43.0 (5.1)	0.5 (0.6)	576.0 (432.4)	792.0 (559.9)
	1.5	11.8 (10.2)	55.8 (22.6)	122.8 (26.0)	2.0 (1.0)	22.5 (9.9)	46.3 (9.5)	18.0 (12.3)	1429.7 (950.6)	2450.1 (572.6)
	3.0	2.3 (0.8)	43.0 (13.8)	93.3 (0.7)	2.5 (1.4)	24.3 (5.8)	35.0 (6.0)	6.5 (2.6)	1010.1 (697.2)	1740.1 (400.4)
	6.0	3.4 (0.9)	37.0 (15.6)	72.3 (16.8)	1.8 (0.9)	22.8 (10.2)	31.3 (7.0)	7.7 (5.8)	3069.8 (1223.7)	1112.8 (401.6)
	12.0	12.5 (9.8)	49.5 (29.2)	88.0 (9.9)	2.5 (1.4)	34.8 (19.8)	28.5 (2.6)	35.9 (33.0)	1271.8 (988.5)	631.6 (216.3)
Mixture	0.5	2.3 (1.6)	3.0 (3.5)	29.0 (11.7)	0.8 (0.9)	2.5 (2.9)	33.5 (5.2)	16.4 (10.8)	108.4 (120.9)	1161.3 (670.2)
	1.5	6.0 (4.7)	34.0 (19.0)	93.5 (21.4)	8.5 (5.3)	24.3 (10.1)	46.0 (4.6)	19.6 (22.0)	1149.1 (1284.8)	1623.5 (612.6)
	3.0	1.5 (1.7)	17.8 (11.3)	78.3 (28.1)	6.3 (7.2)	9.0 (7.4)	45.8 (4.7)	94.1 (39.9)	1121.6 (499.7)	1675.9 (803.4)
	6.0	7.5 (4.4)	43.0 (26.2)	100.5 (19.7)	5.5 (2.2)	32.5 (18.8)	44.3 (5.2)	24.3 (17.1)	925.4 (788.9)	2782.3 (1630.8)
	12.0	4.5 (1.0)	49.5 (20.1)	43.8 (18.8)	3.3 (1.4)	32.8 (5.8)	32.0 (3.1)	3.8 (2.5)	1578.4 (1322.3)	1949.1 (822.2)
Native	—	0.1 (0.1)	21.0 (16.5)	58.8 (10.1)	0.1 (0.1)	11.5 (5.4)	26.0 (0.9)	0.0 (0.0)	79.3 (69.9)	983.8 (539.7)

etation had 6.5, 23.6 and 38.5% larger ($P<0.004$) basal diameter than those without surrounding vegetation in the first, second, and third growing seasons respectively (Fig. 1). The difference in the basal diameter of trees, with and without surrounding vegetation, increased ($P<0.004$) with time. Seeded and native vegetation produced similar effects ($P>0.05$) on lodgepole pine basal diameter.

Lodgepole pine basal diameter were not affected ($P>0.05$) by species sown in the first and second growing season. Lodgepole pine basal diameter on plots sown to smooth bromegrass were 8.8 to 59.0% larger ($P<0.01$) than those on plots sown to orchardgrass in the third growing season (Fig. 2) at equivalent seeding rates by mass. The difference in lodgepole pine basal diameter response to smooth bromegrass and orchardgrass widened ($P<0.02$)over time, and initially developed in the second growing season. When compared at an equivalent pure-living seeding rate, however, there was no difference ($P>0.05$) in the effect of orchardgrass and smooth bromegrass on

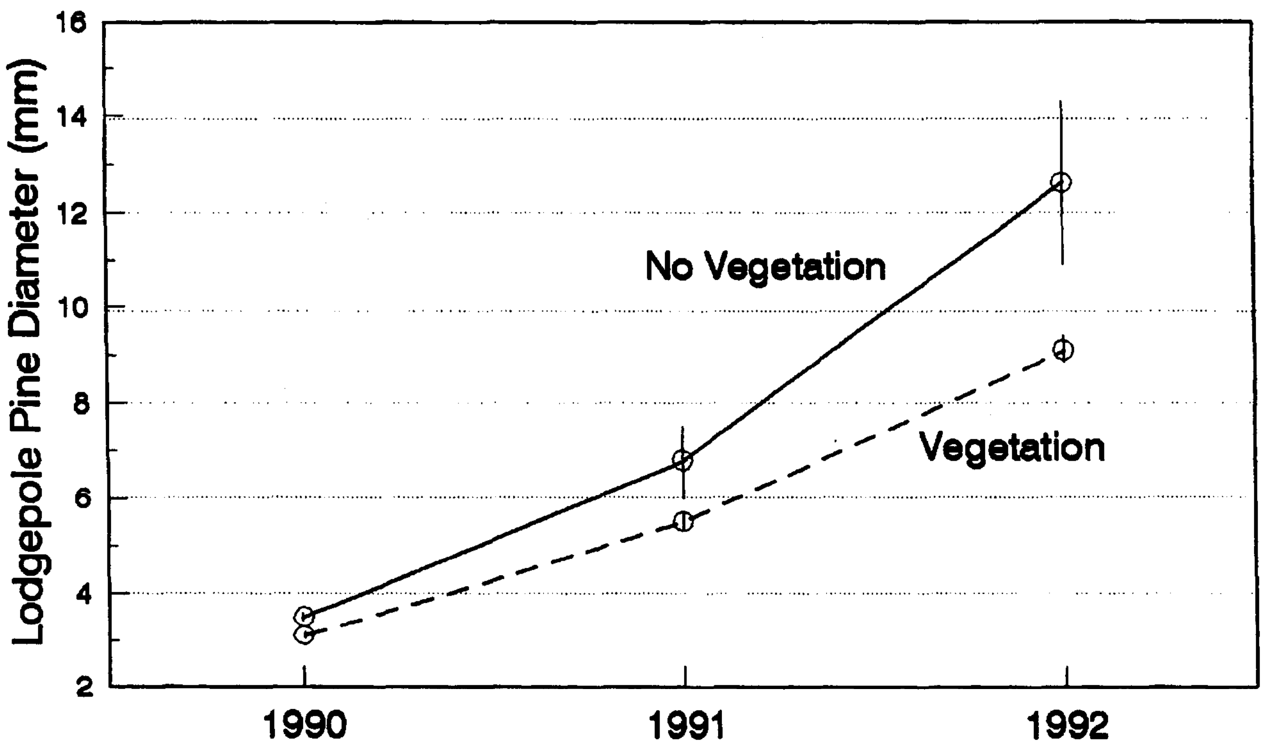

Fig. 1. The effect of vegetation on planted lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) seedling diameters (mm) at Tunkwa Lake, British Columbia, 1990-1992. Vertical lines indicate the SE.

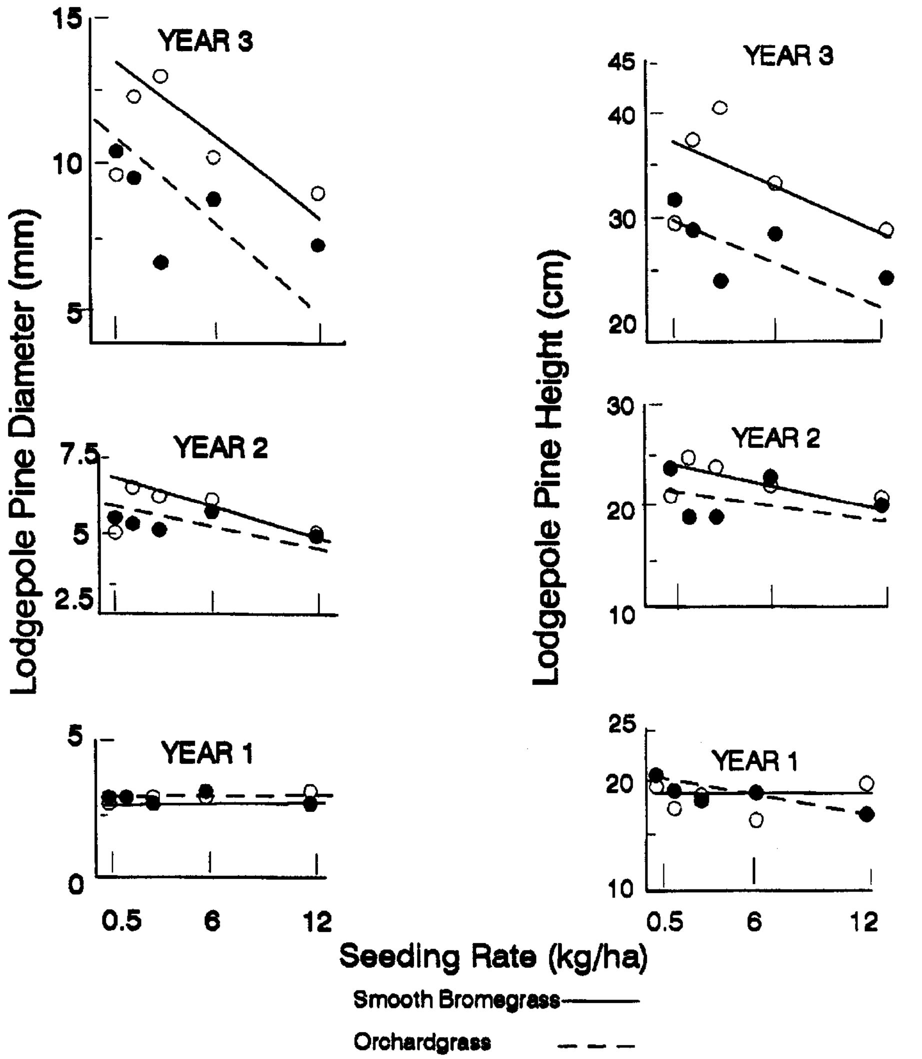

Fig. 2. The effect of smooth bromegrass (*Bromus inermis* Leys.) and orhcardgrass (*Dactylis glomerata* L.) on planted lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) seedling diameters (mm) and heights (cm) at Tunkwa Lake, British Columbia, 1990-1992. Vertical lines indicate the SE.

lodgepole pine diameter.

Lodgepole pine heights increased quadratically (P>0.0001) during the 3 growing seasons. Lodgepole pine without surrounding vegetation were 14.7, 32.7 and 30.2% taller (P<0.005) than those without surrounding vegetation in the first, second, and third growing seasons, respectively (Fig. 3). Seeded and native vegetation produced similar effects (P>0.05) on lodgepole pine heights.

Lodgepole pine heights were unaffected (P>0.05) by species sown in the first and second growing seasons. Lodgepole pine heights on plots sown to smooth bromegrass were 7.1 to 33.2% larger (P<0.06) than those on plots sown to orchardgrass in year 3 (Fig. 2) at equal seeding rates by mass. A year by smooth bromegrass-orchardgrass contrast confirmed that the differences in lodgepole pine height response to smooth bromegrass and orchardgrass increased (P<0.02) over time. As with basal diameter, the differences in height expressed in the year 3 is evident in the data trends of the year 2. When compared at an equivalent pure-live seeding rate, however, there was no difference (P>0.05) in the effect of orchardgrass and smooth bromegrass on lodgepole pine height.

The ratio of lodgepole pine height to basal diameter was unaffected (P>0.05) by seeding orchardgrass, smooth bromegrass, alsike clover, or the forage mixture, or by seeding rate in any year. The average height/diameter ratio declined (P<0.0001) in each year after planting from 63:1 to 33:1 indicating that the trees became more stocky as time progressed. Cole and Newton (1989) suggest that height/diameter ratios in exceeding 60:1 may impair the long-term growth of conifers. Given their criteria, the conifers did not have excessive stem height growth in response to competition.

Cumulative lodgepole pine mortality on plots sown to alsike clover was 2 to 5 times greater (P<0.0001) than cumulative mortality on plots sown to grasses.

Forests are usually planted at greater tree densities than are required to suitably stock an area. Natural conifer regeneration can add to the total stocking. Resource managers in integrated silvicultural systems, therefore, should be more concerned with the impact of mortality on total site stocking rather than mortality rates of the planted trees. The research site was planted at 1,600 stems/ha. Less than 10 stems/ha of natural regeneration occurred. In British Columbia, within 4 to 7 years of the initial timber harvest, the target and minimum acceptable lodgepole pine stocking for this biogeoclimatic subzone are 1,500 and 700 stems/ha respectively (Lloyd et al. 1990). All forage species and seeding rates, except for alsike clover, provided a lodgepole pine stocking at, or just below the target level (1,300 to 1,600 stems/ha). Plots sown to the alsike clover at rates of 6 kg/ha or greater resulted in lodgepole

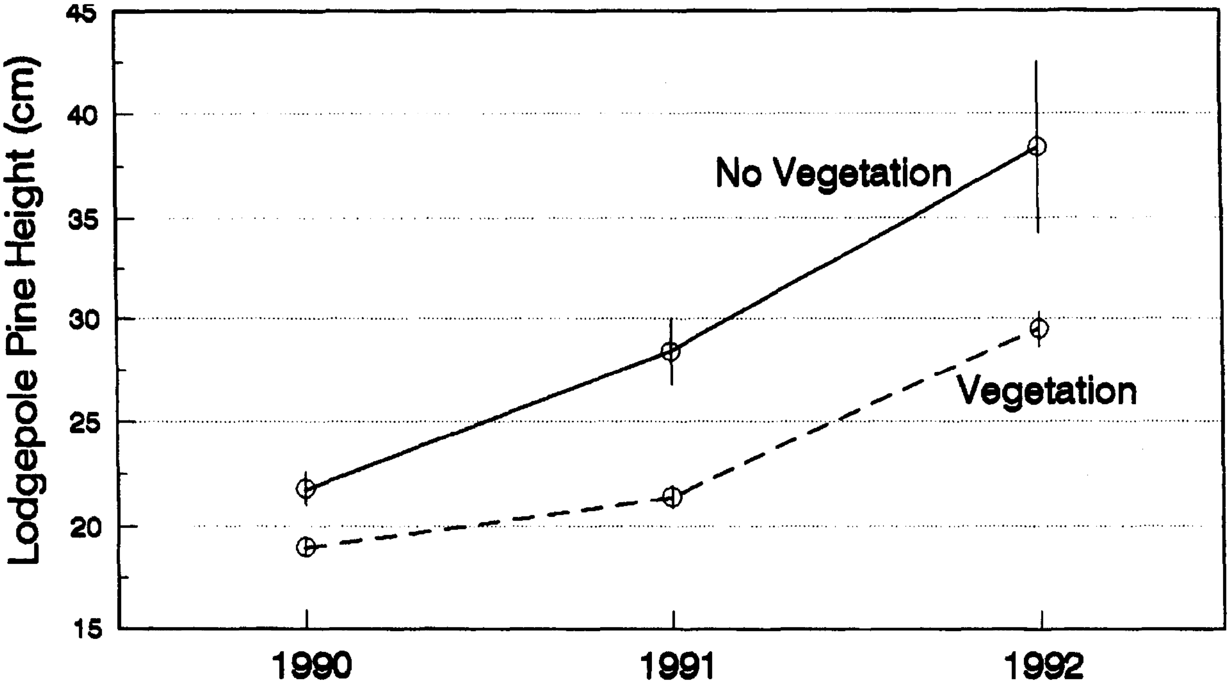

Fig. 3. The effect of vegetation on planted lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) seedling heights (cm) at Tunkwa Lake, British Columbia, 1990-1992. Vertical lines indicate the SE.

pine stocking below 700 stems/ha. Alsike clover sown above the operational rate of 3 kg/ha, therefore, resulted in unacceptable mortality. Rates and proportions of alsike clover in British Columbia's dry montane seeding mixes should be reconsidered.

Competition between lodgepole pine seedlings and the surrounding vegetation was established by contrasting the treatments with vegetation to the control with the vegetation removed. Trees with no competing vegetation had larger basal diameter and heights in all 3 growing seasons. Operationally, removing all competing vegetation from regenerating forests is not practical, nor desirable from an integrated resource management, or soil conservation perspective. Differences among types and amounts of vegetation, therefore, should be of primary concern to resource managers. Adjusting seeding rates and forage mixtures are practical methods to achieve integrated use.

Effect of Seeding Rate on Conifer Growth and Survival

Lodgepole pine basal diameter decreased linearly (P<0.002) with increasing rate (Fig.2); a year by linear seeding rate interaction indicated that increasing seeding rates reduced (P<0.003) basal diameter growth more in successive growing seasons.

Lodgepole pine height decreased linearly (P<0.02) with increasing seeding rate; increasing seeding rate reduced (P<0.02) height more in successive growing seasons (Fig. 2).

Cumulative lodgepole pine mortality after 3 growing seasons increased (P<0.03) linearly with increasing seeding rate by mass (Fig.4).

Conifer Damage By Rodents

Deer mice (*Peromyscus* spp.) and voles (*Microtus* spp.) were responsible for 56% of the tree seedling damage. Rodent damage peaked in the overwinter period between the first and second growing seasons at 24% of the lodgepole pine seedlings. Damage ranged from basal scars to complete removal of lateral or the main seedling stem. Lodgepole pine damage was equal (P>0.05) among the forage treatments and the native and no vegetation controls. Lodgepole pine survival was independent (P>0.05) of rodent damage.

Management Implications

Lodgepole pine basal diameter, height and survival declined as seeding rates increased. Cover (P<0.0002) and density (P<0.0001) of the seeded vegetation increased linearly with seedling rate. This could possibly have produced increased competition with lodgepole pine seedlings for water, light, and nutrients and resulted in the declining lodgepole pine basal diameter and heights, and increased cumulative mortality. Where practical, seeding rates lower than the current operational rate (3 kg/ha) should be considered, as they will potentially result in reduced interference with the early growth of lodgepole pine.

Lodgepole pines grown with orchardgrass grew less than those grown with smooth bromegrass at equivalent seeding rates by mass. These differences resulted from differences in the number of pure-live seeds sown, density of established plants, and in the speed of development of the 2 species. At equivalent seeding rates by mass orchardgrass treatments had over 3 times more pure-live seeds than smooth bromegrass treatments. Orchardgrass had 2.5 to 4 times greater (P<0.004) densities than smooth bromegrass at equivalent seeding rates by mass after 3 growing seasons. Moreover, smooth bromegrass is generally assumed to have slow establishment and initial development. Field observations and the vegetation data support this position. Seeded vegetation on plots sown to orchardgrass was 20 to 70% taller (P<0.002), and had 60 to 210% greater cover (P<0.002) than plots sown to smooth bromegrass after 3 growing seasons. Field observation determined that smooth bromegrass treatments contained a higher proportion of juvenile plants than on those plots sown to orchardgrass. By the end of the second growing season, only one smooth bromegrass plot contained a smooth bromegrass plant than had set seed; in comparison, all the orchardgrass plots contained at least one mature orchardgrass plant. It is anticipated that as the vegetation develops, and smooth bromegrass forms more rhizomes, the trend will reverse and smooth bromegrass may be more inhibitive to lodgepole pine growth than orchardgrass.

Differences in the number of pure-live seeds and established plants of different forage species at equivalent seeding rates by mass must be recognized. Site prescriptions and management of forage seeding in

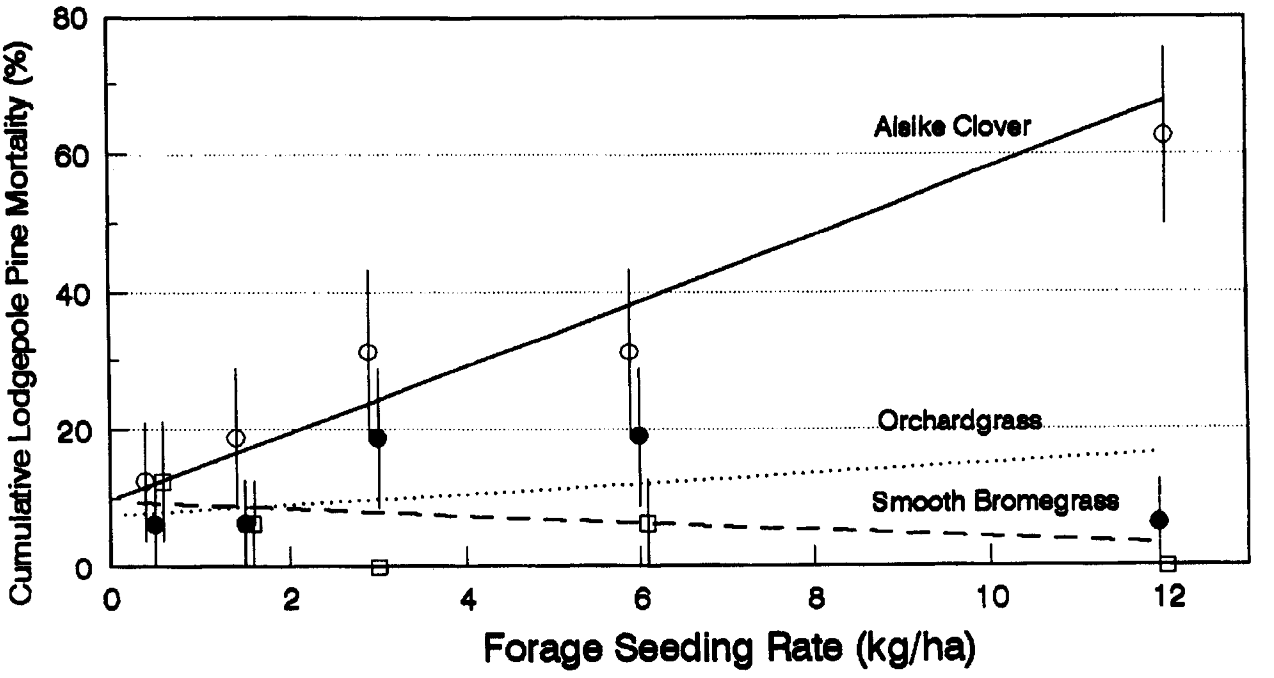

Fig. 4. The effect of smooth bromegrass (*Bromus inermis* Leys.), orchardgrass (*Dactylis glomerata* L.), and alsike clover (*Trifolium hybridum* L.) on the cumulative mortality of planted lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) Seedlings (%) at Tunkwa Lake, British Columbia, 1992. Vertical lines indicate the SE.

British Columbia should be based on cover, density and height of the established vegetation; traditional assessments based on the seeding rate by mass are inadequate to interpret interactions with regenerating trees.

This experiment, conducted without grazing, has reinforced the findings of Clark and McLean (1979) that native and seeded vegetation have the potential to reduce the early growth and survival of lodgepole pine. Controlled grazing during the establishment of lodgepole pine and surrounding vegetation, therefore, had the potential to migrate negative growth responses in the lodgepole pine, and the practice of deferring grazing during this period should be reconsidered.

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