VEGETATION MANAGEMENT BY CHEMICAL AND MECHANICAL METHODS IN ASPEN (*Populus tremuloides*) -DOMINATED CLEARCUTS:

Analysis of coniferous crop seedlings and selected competition variables

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ABSTRACT

Selected vegetation variables and competition indices were analyzed for their potential use in predicting six to eight year old lodgepole pine (n = 559) and white spruce (n = 573) growth characteristics (i.e., height, basal diameter, stem volume, and current height increment). The data for these analyses were obtained from two mixedwood forest stands, which had been clearcut in 1983 and subjected to various site preparation and conifer release treatments. As part of this analysis, 28 correlation matrices and 256 regression equations were developed. The results of the correlation analyses suggest that lodgepole pine basal diameter and, to a slightly lesser extent, height were more easily correlated with vegetation variables than stem volume or current height increment. In addition, more than half of the regression models with explained variances of at least 35 percent (r >0.59) had basal diameter as the dependent variable. Among the 26 tested vegetation variables, the total number of woody stems (number/m^2), total aspen (*Populus tremuloides*) stem length (cm/m^2), aspen basal area (cm^2/m^2) and aspen density (number/m^2) appeared to have the greatest potential for predicting lodgepole pine seedling basal diameter and height, while the height and basal diameter of the tallest aspen within 180 cm of the crop seedling were of lesser value. These variables were also prominent within the best developed simple and multiple regression equations. Poorer and less consistent results were obtained for white spruce based on the lower frequency of significant regression equations and a lower degree of explained variance for both regression and correlation analyses. Similarly poor results were also found for Conifer Release relative to Site Preparation treatment plots. Competition indices based on relative crop seedling and competing vegetation growth parameters were found to be better predictors of crop seedling growth than other indices or regression models. The best of these equations explained 80 to 85 percent and 50 to 55 percent of the variance in selected lodgepole pine and white spruce seedling growth variables, respectively.

Key words: Lodgepole pine, white spruce, competition index, vegetation management, regression analysis, modelling

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1.0 INTRODUCTION

Following the harvesting of aspen (*Populus tremuloides*) -dominated forests in Alberta, forestry companies are required by the provincial government to reforest cutovers with at least a 45 percent stocking of conifers (e.g., Anonymous 1993).[1] The successful establishment of coniferous seedlings in pioneer deciduous vegetation can be difficult, particularly if the seedlings are shade-intolerant. In such environments the density of both woody stems and vegetation cover are high which can result in intensive competition for light and other resources between the crop seedling and the native vegetation. If the crop seedling is unable to adequately compete with the native vegetation, it can result in poor growth and low survival rates.

To evaluate and potentially manage this problem, forest ecologists have attempted to determine what factors are most strongly associated with the growth of the crop seedling. Elimination of all competing vegetation is the ultimate solution to this problem, but such an approach is not considered environmentally acceptable. As a result, researchers have attempted to identify specific factors and conditions that might be effectively controlled with less overall environmental impact as well as indicate under what conditions significant levels of competition occur. These assessments have often involved the development of indices and ratios with selected crop seedling characteristics. Among the variables that have been used to assess competition and growth relationships are dimensional characteristics and distances or proximity measures between the crop tree and neighboring species (e.g., Braathe 1989; Daniels 1976; Hegyi 1974; Lorimer 1983; Moore et al. 1973), stem densities (e.g., Simard 1990a,b), foliar cover (e.g., La Roi et al. 1988; Wagner and Radosevich 1987), and light transmittance (e.g., Comeau et al. 1993; MacDonald et al. 1990) as well as niche overlap considerations (e.g., Bella 1971).

The primary conifer crop trees in Alberta and northeastern British Columbia are lodgepole pine (*Pinus contorta*) and white spruce (*Picea glauca*). However, few studies have attempted to quantify the relationship between conifer growth and competing vegetation (Alemdag 1978), and even fewer have assessed these trees as juveniles. Morris and MacDonald (1991) evaluated competition indices for four year old white spruce, while Navratil and MacIsaac (1993) assessed five to 15 year old lodgepole pine. The latter authors concluded from their analysis that basal area increment was more responsive and therefore a better measure for assessing competition between lodgepole pine and aspen than was seedling height or height increment. Navratil et al. (1990, p. 7) and Navratil and MacIsaac (1993, p. 6) also suggested that the relationship between the seedling and competing vegetation may change with time and poorest relationships were expected with younger seedlings.

The primary objective of this study was to analyze selected vegetation and tree characteristics from the Grande Prairie area to determine which variables were best for predicting six to eight year old lodgepole pine and white spruce stem height, basal diameter, stem volume, and current height increment. This analysis represents a continuation of work by Navratil and MacIsaac (1993), although data were from a different source. In this study, the crop seedling and the corresponding vegetation data were collected in experimental plots established in mixedwood

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[1] Vascular plant nomenclature follows Moss (1983).

clearcuts for the purpose of assessing the effects of various site preparation and conifer release techniques on native vegetation and conifer crop seedling responses.

2.0 METHODS

2.1 Introduction

Data for this study were collected from two experimental treatment sites located approximately 23 km (Cutblock 4007) and 30 km (Cutblock 4004) south of Grande Prairie in west-central Alberta (Figure 1). These study sites were located within clearcuts approximately 130 ha and 85 ha in size that were logged in July and March of 1983, respectively. The general study area occurs within the Boreal South Cordilleran (SCb) Ecoclimatic region (Zoltai and Strong 1989), or the Lower Boreal-Cordilleran Ecoregion (Strong 1992), which is a climatic and biological transition zone between coniferous Cordilleran and deciduous Boreal forest biomes. Before harvesting, the cutblock vegetation most likely belonged to the aspen facies of the White Spruce/Mooseberry/Wild Sarsaparilla (LB5c) ecosystem described by Corns and Annas (1986), or its equivalent, the Aspen-White Spruce-Lodgepole Pine/Low-bush Cranberry (11-D3.4) community-type, described by Beckingham (1994). The untreated or control vegetation in these sites was dominated by 350 to 500 cm tall aspen with the understory vegetation primarily composed of marsh reedgrass (*Calamagrostis canadensis*), wild rose (*Rosa acicularis*), showy aster (*Aster conspicuus*), and fireweed (*Epilobium angustifolium*) when the field data were collected. Strong et al. (1995) should be consulted for a detailed description of the pre-treatment (1986) and the most recent post-treatment (1992-4) vegetation survey summaries on the two study sites, respectively.

2.2 Original Study Design

Three replicate experimental blocks were laid out in a nonrandomized complete block design three years after each cutblock was harvested. Each experimental block was divided into several treatment plots. Within the central portion of each treatment plot, 5 m x 5 m subplots were located along line transects at five metre intervals. Individual subplots were marked with a metal post to allow their re-location. A portion of Cutblock 4007 was used to evaluate the effects of various site preparation treatments on native vegetation. The tested treatments included two levels of herbicide dosage (2 and 4 kg/ha of hexazinone), Rome double disking, and disk trenching as well as a control. Cutblock 4004 was used to compare selected site preparation and conifer release methods. In each treatment block was a control, Rome double disking, and three disk trenched plots. The disk trenched plots were either treated with 2 or 4 kg/ha of hexazinone, or brushsawed. Table 1 summarizes the types of treatment that were applied in each of the cutblocks and when the treatments occurred. Sidhu and Feng (1991) should be consulted for additional details with respect to the experimental design.

A conifer seedling was planted in each subplot quadrant (i.e., NW, NE, SW, SE) during May 1987. Normally, a separate row of lodgepole pine and white spruce seedlings were planted parallel to each transect line. Seedlings were grown by the Alberta Forest Service and consisted

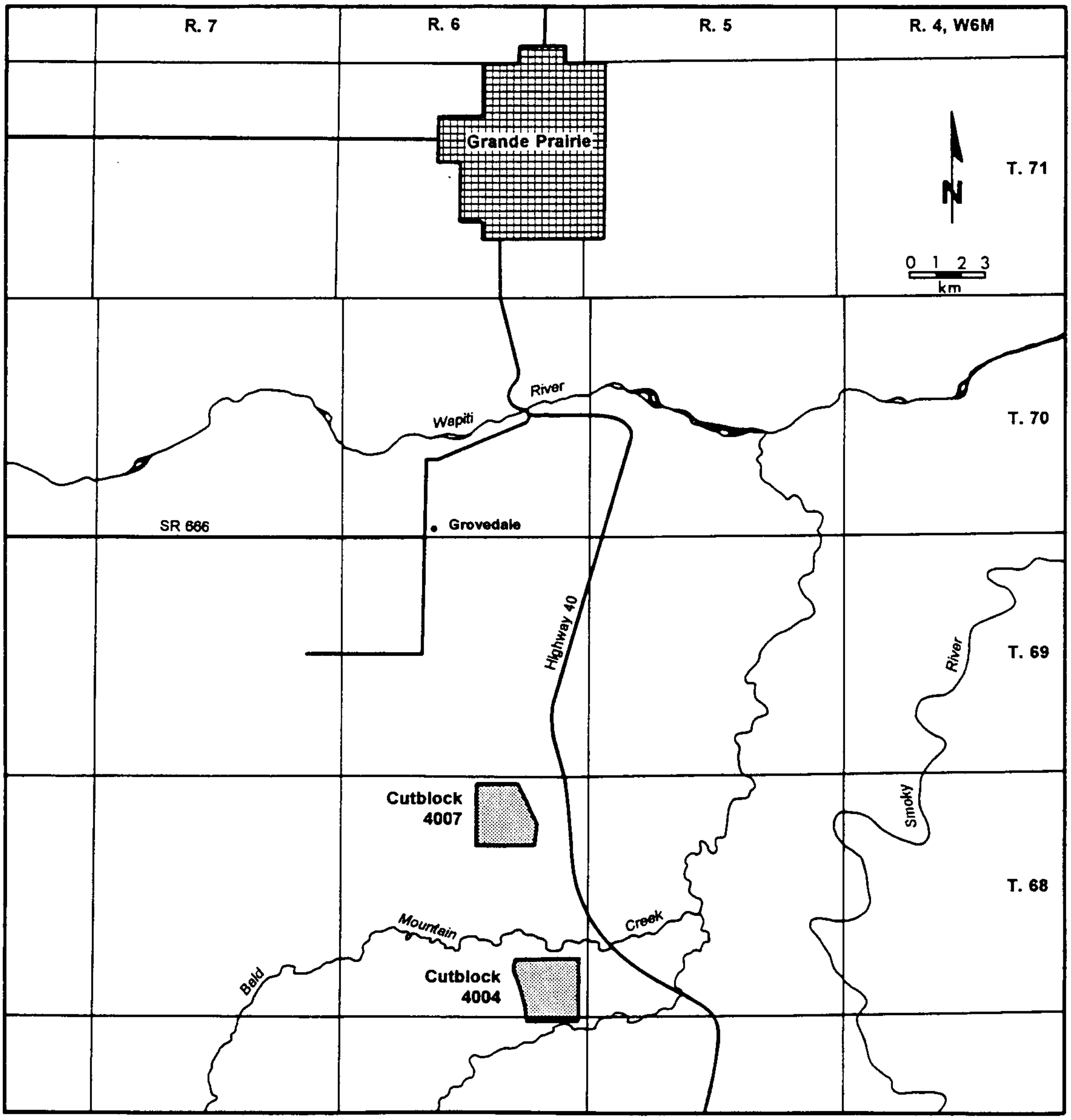

Figure 1. Location of Cutblocks 4004 and 4007 relative to Grande Prairie, Alberta.

Table 1. The type and timing of various treatments by experimental method.

Site Preparation Experiment (Cutblock 4007)

Treatment	Date of Treatment
Control	No treatment
2 kg/ha hexazinone	28 August 1986
4 kg/ha hexazinone	28 August 1986
Rome double disking	12 - 18 May 1987
Disk trenching	12 - 15 May 1987

Conifer Release Experiment (Cutblock 4004)

Control	No treatment
Disk trenching followed by application of 2 kg/ha hexazinone	12 - 15 May 1987 with chemical application on 30 May 1989
Disk trenching followed by application of 4 kg/ha hexazinone	12 - 15 May 1987 with chemical application on 30 May 1989
Rome double disking	12 - 15 May 1987
Disk trenching followed by brushsawing	12 - 15 May 1987 with brush-sawing in mid-May to mid-June 1989

of plug +1 white spruce (i.e., bare root stock) and Spencer-Lemaire container-grown lodgepole pine. At the time of planting, white spruce and lodgepole pine were 171 mm (standard deviation 4.0) and 150 mm (4.1) tall with basal diameters of 4.2 mm (0.9) and 2.9 mm (0.6), respectively (Todd and Brace 1987).

2.3 Vegetation Sampling

The composition and frequency of woody stems and species composition and percent cover data were assessed in the Site Preparation treatments in mid to late July of 1992 and 1993, while Conifer Release experiment blocks were surveyed in late July and early August of 1993 and 1994. Woody plant stem density estimates were based on complete tallies of woody stems greater than 50 cm in height. Stems were separated according to species and three height classes: >50 to 150 cm, >150 to 300 cm, and >300 cm. In addition, a representative height was determined for each species by height class. These assessments were made in the northeast and southwest quadrants (2.5 x 2.5 m) of the 5 m x 5 m subplots. The total length of woody stems in each quadrant was determined by multiplying stem frequencies by their representative height. To avoid the exaggeration of small variations in stem frequencies within individual quadrants, stem frequencies and lengths were summarized on a square metre rather than a hectare basis (i.e., n/m^2 and cm/m^2, respectively). The cover of growthforms (e.g., C-stratum) or individual species were estimated within a 1 m x 1 m quadrant located in the central area of each quadrant or that portion not occupied by the target or crop seedling.

Coniferous seedling height, basal diameter, and current height increment (Conifer Release plots only) were measured within the same subplot quadrants where woody stem counts and species cover were assessed. When the seedling was absent, however, an alternate quadrant was assessed (i.e., NE → SE; SW → NW). For example, if the seedling was absent in the NE quadrant, the SE quadrant was searched and if found the seedling was measured. In addition, the following measures were made in conjunction with crop seedlings:

1. stem to stem distance from the crop seedling to the nearest aspen within 180 cm;
2. basal diameter and height of nearest aspen;
3. stem to stem distance from the crop seedling to the tallest aspen within 180 cm;
4. basal diameter and height of tallest aspen;
5. stem to stem distance from the crop seedling to the nearest woody shrub >50 cm tall within 180 cm; and
6. basal diameter and height of nearest shrub.

No adjustments were made in crop seedling or competing vegetation measurements when field sampling occurred in two different years, since changes in either are presumably linked and reflective of each other.

2.4 Data Characterization

The vegetation variables were assessed for normality based on measures of skewness (range of acceptance -0.9 to 0.9) and kurtosis (-0.4 to 1.8) (Wetherill 1981). Since all the data were not normally distributed, nonparametric statistical techniques were used to characterize the various variables. Medians (or the 50th percentile) and first and third quartile (or 25th and 75th percentile, respectively) values were used as measures of central tendency and sample variability.

Kruskal-Wallis tests were used to determine whether differences occurred among treatments. When significant statistical differences ($P < 0.05$) occurred within a set of treatments, nonparametric Scheffe' multiple range tests (Miller 1966, p. 166) were used to determine which treatments were different ($P < 0.05$):

$$\text{Scheffe' test} = \quad |\bar{R}_i - \bar{R}_{i'}| \leq \chi^2 * \sqrt{N(N+1)/12} * \sqrt{1/n_i + 1/n_{i'}}$$

$\bar{R}_i$ = Mean rank of the *i*th group

χ^2 = Chi-square value (k-1) at a given probability

N = Total number of cases in compared groups

n_i = Number of cases in *i*th group

2.5 Correlation Analysis and Regression Modelling

Regression models were developed to identify individual or combinations of variables which might be useful as estimators of crop seedling competition stress as reflected by various crop seedling growth characteristics. Development of these regression models was a multi-step and iterative process.

Step 1. Independent variables (x-variables) were correlated with lodgepole pine and white spruce seedling height, basal diameter, stem volume, and current height increment (dependent or y-variables), when available. These correlations were stratified by experimental treatment or combination of treatments. Selected competition indices were also included in the correlation analysis for comparison with previous work by Navratil and MacIsaac (1993). The purpose of these analyses was to identify which variables were most strongly associated with a selected crop seedling characteristic and whether any major differences occurred among treatments. Table 2 identifies the specific variables which were included in the analysis and how they were determined.

Step 2. Initially, simple linear regressions were developed for variables with significant ($P<0.05$) correlation coefficients (r-values). This step also involved the review of scatter diagrams to assess whether the independent variable should be transformed (e.g., $\log_{10}$, square rooted, etc.) to improve the fit of the regression line to the data. Polynomial regression models were also developed, but simple regression equations with transformed independent variables were found to have an equivalent or greater level of variance explanation (r^2, also referred to as coefficient of determination).

Step 3. Development of multiple regression equations first involved running step-wise multiple regression sequences using all available data to identify the most likely candidate variables. Duplicate independent variables (e.g., untransformed and transformed) and variables with overlapping characteristics (e.g., total number of woody stems and total number of aspen stems) were eliminated from the data set, if they occurred in the step-wise regressions. In these situations, the variable with the least amount of explained variance was dropped and the regression analysis process was repeated. Only *beta* coefficients with significant ($P < 0.05$) probability values based on analysis of variance tests and those that substantially (e.g., at least an additional three to five percent explained variance) contributed to the overall prediction of the dependent variable were included in the final multiple regression equations. An attempt was made to develop at least five models for each crop species and seedling growth characteristic in each experimental treatment type with only the best models being presented. The "best" equations were those with the largest amount of explained variance.

Calculation of descriptive statistics; Kruskal-Wallis, t-, Chi-square Goodness of Fit and Mann-Whitney tests; and correlation and regression analyses were performed with StatView 512+ computer programs (Anonymous 1986), while nonparametric Scheffe' multiple range tests were performed manually.

Table 2. Variables included in correlation and regression analyses of lodgepole pine and white spruce seedling data from Site Preparation and Conifer Release experimental treatment plots in the Grande Prairie area.

Variable	Definition
Nearest Aspen - Distance	Stem to stem distance (cm) from crop seedling to nearest aspen within 180 cm
Nearest Aspen - Height	Height (cm) of the nearest aspen
Nearest Aspen - Basal Diameter	Basal diameter (mm) of the nearest aspen
Tallest Aspen - Distance	Stem to stem distance (cm) from crop seedling to tallest aspen within 180 cm
Tallest Aspen - Height	Height (cm) of the tallest aspen
Tallest Aspen - Basal Diameter	Basal diameter (mm) of the tallest aspen
Aspen Stem Density	Average number of aspen stems >50 cm tall per square metre based on summation within a 5 m x 5 m quadrant
Aspen Stem Length	Average total length of woody stems >50 cm per square metre determined by multiplying stem frequencies by their representative height within a 5 m x 5 m quadrant
Effective Aspen Density	10,000 / Distance (cm) to nearest aspen (i.e., number of stems per square metre)
Aspen Basal Area	An extrapolated variable developed from a regression analysis of nearest and tallest aspen height, and basal diameter data (see Appendix I). This variable was estimated by determining and summing the basal area (cm^2) of individual aspen stems based on their representative height. The analysis was based on 5 m x 5 m quadrants, but was summarized according to cm^2/m^2.
Shrub >50 cm tall - Distance	Stem to stem distance (cm) from crop seedling to nearest woody plant other then aspen >50 cm tall within 180 cm
Shrub >50 cm tall - Height	Height (cm) of nearest shrub
Shrub >50 cm tall - Basal Diameter	Basal diameter (mm) of nearest shrub
Shrub Stem Density	Average number of woody non-aspen stems >50 cm tall per square metre based on summation within a 5 m x 5 m quadrant
Shrub Stem Length	Average total length of woody stems >50 cm per square metre determined by multiplying stem frequencies by their representative height within a 5 m x 5 m quadrant
Percent Cover Aspen - C stratum	Percent foliar cover of aspen >300 cm tall
Percent Cover Aspen - B stratum	Percent foliar cover of aspen >150 cm to 300 cm tall
Percent Cover Aspen - A stratum	Percent foliar cover of aspen >50 cm to 150 cm tall
Percent Cover - Total C stratum	Percent foliar cover of all plants >300 cm tall
Percent Cover - Total B stratum	Percent foliar cover of all plants >150 cm to 300 cm tall
Percent Cover - Total A stratum	Percent foliar cover of all plants >50 cm to 150 cm tall
Percent Cover - *Calamagrostis canadensis*	Percent foliar cover of marsh reedgrass

Table 2. Concluded.

Variable	Definition
CI-1 (Tallest Aspen)	Competition Index number 1 based on tallest aspen; modified from index developed by Braathe (1989); CI-1 = Height (cm) of tallest aspen within 180 cm of crop seedling minus crop seedling height (cm) / Distance (cm) to tallest aspen
CI-2 (Nearest Aspen)	Competition Index number 2 based on nearest aspen; modified from index developed by Braathe (1989); CI-2 = Height (cm) of nearest aspen within 180 cm of crop seedling minus crop seedling height (cm) / Distance (cm) to nearest aspen
CI-3a (Aspen - C stratum)	Competition Index number 3a based on percent cover of aspen in C stratum; modified from index developed by Wagner and Radosevich (1987); CI-3a = Percent cover of aspen in C stratum / (Distance (cm) to nearest aspen)^2
CI-3b (Aspen - B stratum)	Competition Index number 3b based on percent cover of aspen in B stratum; modified from index developed by Wagner and Radosevich (1987); CI-3b = Percent cover of aspen in B stratum / (Distance (cm) to nearest aspen)^2
CI-4	Competition Index number 4; modified from index developed by Daniels (1976); CI-4 = (Basal diameter (mm) of nearest aspen / Basal diameter (mm) of crop seedling) / Distance (cm) to nearest aspen
CI-5	Competition Index number 5; modified from index developed by Lorimer (1983); CI-5 = Basal diameter (mm) of nearest aspen / Basal diameter (mm) of crop seedling
CI-6	Competition Index number 6; developed by Lorimer (1983) and modified by Navratil and MacIsaac (1993); CI-6 = Basal diameter (mm) of tallest aspen / Basal diameter (mm) of crop seedling
RelHT2[2]	Crop seedling height (cm) / Height of tallest aspen (cm)
Shrub Basal Diameter/Conifer Basal Diameter	Basal diameter (mm) of nearest shrub >50 cm tall / Basal diameter (mm) of crop seedling (from Strong et al. 1995)
HT (Height)	Height (cm) of the crop seedling
BD (Basal diameter)	Cross-sectional width (mm) of the crop seedling stem at the root collar
VOL (Volume)	Crop seedling stem volume (cm^3) based on the conical model 1/3 (A_bH); where A_b is equal to 3.1416 multiplied by (stem radius)^2 and H is the height of the seedling (Hursch et al. 1982)
CG (Current height growth increment)	The amount of crop seedling leader growth (cm) at the time of measurement

[2] Index suggested by Dan MacIsaac, Canadian Forest Service, Northern Forest Centre, Edmonton, Alberta.

3.0 RESULTS

As background information, Appendices II through V summarize the characteristics of each assessed vegetation variable and identify where differences occur among the various treatments, while Appendix VI summarizes selected lodgepole pine and white spruce seedling characteristics. The following sections provide the results of the correlation and regression analysis based on lodgepole pine and white spruce seedling height, basal diameter, stem volume, and current height growth values.

3.1 Correlation Analysis

3.1.1 Site Preparation - Lodgepole Pine

Five of the nine tested competition indices consistently produced statistically significant correlation coefficients (r) in the Site Preparation experiment blocks, usually with values of at least 0.30 (Tables 3, 4 and 5), whether the dependent variable was lodgepole pine height, basal diameter or volume. These indices included CI-4, CI-5, CI-6, RelHT2, and shrub basal diameter/conifer basal diameter. Of these variables, CI-6 and RelHT2 were most consistently and strongly correlated with the dependent variable. RelHT2 was the better of the two variables based on the overall amount of explained variance, except when basal diameter was the dependent variable. Competition indices CI-1 and CI-2 also produced significant ($P < 0.01$) and moderately strong[3] correlation coefficients, except in the control plots. The degree of correlation between the seedling growth characteristics and the competition indices tended to be lowest within the Rome double disking treatment (Tables 3, 4, and 5).

Among the tree dimension and density variables, aspen stem density, stem length, and basal area most consistently produced significant ($P < 0.05$) correlations among the different treatments. A similar but less consistent set of coefficients was produced for total woody stem densities and lengths, which also included aspen in their totals. All of these correlations tended to be strongest when associated with seedling basal diameter, although seedling height was very similar. Within these variables, weaker and insignificant correlations were more often associated with Rome double disking than the other treatments, probably because aspen was of low abundance (0.3 stems/m^2) and small (83 cm tall) compared to the other treatments (Appendix II). While decreased aspen stem densities, stem lengths, and basal area were typically associated with increased seedling size and volume, this trend was reversed in the Rome double disking plots (Tables 3 and 5). Correlation coefficients were substantially weaker and less consistent when shrub or cover values were correlated with seedling growth as opposed to tree characteristics.

The 2 kg/ha hexazinone, chemical series (i.e., Control, 2 kg/ha and 4 kg/ha hexazinone treatments), and an aggregate of all treatment plots had the strongest correlation coefficients

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[3] The following qualitative terms were used when describing the relative strength of correlation coefficients: weak ($r = 0$ to 0.25); moderately strong ($r = 0.26$ to 0.50); strong ($r = 0.51$ to 0.80); and very strong ($r = 0.81$ to 1.00).

Table 3. Summary of correlation coefficients for selected variables from Site Preparation treatment plots (1992/3 data) with lodgepole pine seedling height as the dependent variable. An "*" and "**" indicate a significant coefficient at P <0.05 or P <0.01, respectively. ND - no data available.

Independent Variables	Control	2 kg/ha Hexa-zinone	4 kg/ha Hexa-zinone	Rome Double Disking	Disk Trench-ing	Chemical Dosage Series	All Treat-ments
Nearest Aspen - Distance (cm)	-0.03	+0.33*	+0.16	+0.09	+0.17	+0.22**	+0.30**
Nearest Aspen - Height (cm)	-0.03	-0.26	-0.10	+0.11	+0.08	-0.19*	-0.31**
Nearest Aspen - Basal Diameter (mm)	-0.01	-0.17	-0.06	+0.17	+0.07	-0.11	-0.25**
Tallest Aspen - Distance (cm)	-0.07	+0.25	+0.06	+0.20	+0.10	+0.09	+0.10
Tallest Aspen - Height (cm)	-0.02	-0.43**	-0.22	+0.34**	-0.15	-0.34**	-0.49**
Tallest Aspen - Basal Diameter (mm)	-0.05	-0.49**	-0.24	+0.15	-0.15	-0.31**	-0.47**
Aspen Stem Density (number/m²)	-0.21	-0.60**	-0.39**	+0.30**	-0.33*	-0.48**	-0.49**
Aspen Stem Length (cm/m²)	-0.22	-0.56**	-0.42**	+0.32**	-0.37**	-0.50**	-0.54**
Effective Aspen Density (number/m²)	+0.03	-0.32*	-0.14	-0.21	-0.06	-0.11	-0.04
Aspen Basal Area (cm²/m²)	-0.20	-0.51**	-0.40**	+0.33**	-0.38**	-0.47**	-0.52**
Shrub >50 cm tall - Distance (cm)	-0.01	+0.18	-0.02	+0.15	+0.13	+0.10	+0.21**
Shrub >50 cm tall - Height (cm)	+0.11	+0.13	+0.09	+0.15	+0.01	+0.05	+0.01
Shrub >50 cm tall - Basal Diameter (mm)	+0.06	+0.40**	+0.24	+0.20	-0.06	+0.25**	+0.16**
Shrub Stem Density (number/m²)	+0.04	-0.34*	-0.01	-0.03	-0.14	-0.04	-0.18**
Shrub Stem Length (cm/m²)	-0.11	-0.26	-0.06	+0.10	-0.19	-0.05	-0.15*
Density of Woody Stems (number/m²)	-0.08	-0.55**	-0.10	+0.09	-0.26	-0.21**	-0.34**
Total Woody Stem Length (cm/m²)	-0.26	-0.56**	-0.23	+0.24*	-0.38**	-0.40**	-0.48**
Percent Cover Aspen - C stratum	+0.09	-0.45**	-0.19	ND	+0.18	-0.30**	-0.30**
Percent Cover Aspen - B stratum	+0.04	-0.27	0	+0.31**	-0.03	-0.08	-0.26**
Percent Cover Aspen - A stratum	+0.10	-0.04	-0.28*	+0.05	-0.01	-0.09	-0.09
Percent Cover - Total C stratum	+0.06	-0.45**	-0.15	ND	+0.18	-0.30**	-0.30**
Percent Cover - Total B stratum	-0.11	-0.28*	-0.08	+0.28**	+0.11	-0.14	-0.22**
Percent Cover - Total A stratum	+0.26	-0.08	-0.08	+0.18	+0.10	0	-0.08
Percent Cover - *Calamagrostis canadensis*	+0.31*	+0.09	-0.06	-0.51**	+0.09	-0.07	+0.05
CI-1 (Tallest Aspen)	-0.04	-0.52**	-0.52**	-0.39**	-0.49**	-0.38**	-0.56**
CI-2 (Nearest Aspen)	-0.21	-0.57**	-0.54**	-0.55**	-0.56**	-0.44**	-0.60**
CI-3a (Aspen - C stratum)	-0.01	-0.43**	-0.17	ND	+0.09	-0.15	-0.19**
CI-3b (Aspen - B stratum)	+0.07	-0.15	+0.02	+0.28*	-0.03	-0.07	-0.22**
CI-4	-0.36**	-0.60**	-0.60**	-0.27**	-0.36**	-0.46**	-0.50**
CI-5	-0.44**	-0.64**	-0.60**	-0.39**	-0.38**	-0.50**	-0.54**
CI-6	-0.57**	-0.72**	-0.64**	-0.42**	-0.71**	-0.62**	-0.68**
RelHT2	+0.91**	+0.78**	+0.88**	+0.50**	+0.94**	+0.80**	+0.75**
Shrub Basal Diameter/Conifer Basal Diameter	-0.48**	-0.50**	-0.62**	-0.45**	-0.57**	-0.51**	-0.59**
Number of Samples	48-58	44-51	53-63	76-87	49-63	145-172	270-315

Table 4. Summary of correlation coefficients for selected variables from Site Preparation treatment plots (1992/3 data) with lodgepole pine basal diameter as the dependent variable. An "*" and "**" indicate a significant coefficient at P <0.05 and P <0.01, respectively. ND - no data available.

Independent Variables	Control	2 kg/ha Hexa-zinone	4 kg/ha Hexa-zinone	Rome Double Disking	Disk Trench-ing	Chemical Dosage Series	All Treat-ments
Nearest Aspen - Distance (cm)	+0.30*	+0.39**	+0.08	+0.15	+0.10	+0.28**	+0.34**
Nearest Aspen - Height (cm)	+0.01	-0.30*	-0.22	+0.03	-0.08	-0.26**	-0.39**
Nearest Aspen - Basal Diameter (mm)	+0.07	-0.15	-0.10	+0.10	-0.07	-0.12	-0.27**
Tallest Aspen - Distance (cm)	+0.02	+0.30*	-0.02	+0.14	+0.14	+0.10	+0.08
Tallest Aspen - Height (cm)	-0.23	-0.50**	-0.35**	+0.23*	-0.18	-0.48**	-0.57**
Tallest Aspen - Basal Diameter (mm)	-0.05	-0.51**	-0.29*	+0.13	-0.20	-0.36**	-0.52**
Aspen Stem Density (number/m^2)	-0.24	-0.61**	-0.41**	+0.13	-0.33*	-0.52**	-0.52**
Aspen Stem Length (cm/m^2)	-0.33*	-0.58**	-0.45**	+0.13	-0.37**	-0.55**	-0.56**
Effective Aspen Density (number/m^2)	-0.07	-0.27	-0.07	-0.16	-0.01	-0.13**	-0.02
Aspen Basal Area (cm^2/m^2)	-0.38**	-0.53**	-0.43**	+0.13	-0.40**	-0.53**	-0.55**
Shrub >50 cm tall - Distance (cm)	+0.14	+0.33*	+0.12	+0.25*	+0.14	+0.28**	+0.32**
Shrub >50 cm tall - Height (cm)	+0.10	+0.17	-0.09	+0.24*	-0.03	+0.01	+0.02
Shrub >50 cm tall - Basal Diameter (mm)	+0.16	+0.52**	+0.20	+0.28**	+0.01	+0.34**	+0.24**
Shrub Stem Density (number/m^2)	+0.13	-0.45**	-0.21	-0.07	-0.24	-0.18*	-0.26**
Shrub Stem Length (cm/m^2)	-0.10	-0.38**	-0.23	+0.05	-0.29*	-0.18*	-0.23*
Density of Woody Stems (number/m^2)	-0.01	-0.63**	-0.29*	-0.01	-0.34*	-0.35**	-0.43**
Total Woody Stem Length (cm/m^2)	-0.36*	-0.61**	-0.39**	+0.10	-0.43**	-0.52**	-0.54**
Percent Cover Aspen - C stratum	-0.22	-0.45**	-0.20	ND	+0.06	-0.39**	-0.36**
Percent Cover Aspen - B stratum	-0.12	-0.33**	-0.03	+0.25*	-0.02	-0.15	-0.28**
Percent Cover Aspen - A stratum	+0.36*	-0.08	-0.25	+0.03	0	-0.04	-0.07
Percent Cover - Total C stratum	-0.22	-0.45**	-0.17	ND	+0.06	-0.38**	-0.35**
Percent Cover - Total B stratum	-0.21	-0.37**	-0.11	+0.30**	+0.13	-0.21*	-0.25**
Percent Cover - Total A stratum	+0.41**	-0.18	-0.26	+0.02	+0.02	-0.09	-0.16**
Percent Cover - *Calamagrostis canadensis*	+0.24	+0.06	+0.11	-0.58**	+0.09	-0.12	-0.03
CI-1 (Tallest Aspen)	-0.08	-0.57**	-0.47**	-0.27*	-0.49**	-0.42**	-0.57**
CI-2 (Nearest Aspen)	-0.21	-0.56**	-0.49**	-0.37**	-0.64**	-0.46**	-0.58**
CI-3a (Aspen - C stratum)	-0.20	-0.45**	-0.15	ND	+0.02	-0.20*	-0.21**
CI-3b (Aspen - B stratum)	-0.16	-0.12	+0.02	+0.21	-0.02	-0.11	-0.24**
CI-4	-0.56**	-0.65**	-0.66**	-0.28*	-0.44**	-0.58**	-0.55**
CI-5	-0.58**	-0.70**	-0.73**	-0.57**	-0.48**	-0.61**	-0.60**
CI-6	-0.78**	-0.81**	-0.77**	-0.54**	-0.79**	-0.75**	-0.74**
RelHT2	+0.66**	+0.81**	+0.79**	+0.41**	+0.87**	+0.78**	+0.74**
Shrub Basal Diameter/Conifer Basal Diameter	-0.58**	-0.48**	-0.78**	-0.45**	-0.58**	-0.58**	-0.60**
Number of Samples	48-58	44-51	53-63	76-87	49-63	145-172	270-315

Table 5. Summary of correlation coefficients for selected variables from Site Preparation treatment plots (1992/3 data) with lodgepole pine stem volume as the dependent variable. An "*" and "**" indicate a significant coefficient at P<0.05 or P<0.01, respectively. ND - no data available.

Independent Variables	Control	2 kg/ha Hexa-zinone	4 kg/ha Hexa-zinone	Rome Double Disking	Disk Trench-ing	Chemical Dosage Series	All Treat-ments
Nearest Aspen - Distance (cm)	+0.18	+0.34*	+0.03	+0.08	+0.07	+0.19*	-0.26**
Nearest Aspen - Height (cm)	-0.02	-0.23	-0.09	-0.02	+0.01	-0.19*	+0.30**
Nearest Aspen - Basal Diameter (mm)	+0.01	-0.15	-0.01	+0.09	+0.01	-0.09	-0.21**
Tallest Aspen - Distance (cm)	+0.04	+0.22	-0.05	+0.13	+0.15	+0.06	+0.06
Tallest Aspen - Height (cm)	-0.04	-0.42**	-0.29	+0.29**	-0.23	-0.39**	-0.44**
Tallest Aspen - Basal Diameter (mm)	+0.04	-0.49**	-0.27	+0.14	-0.26*	-0.33**	-0.43**
Aspen Stem Density (number/m^2)	-0.25	-0.44**	-0.36**	+0.19	-0.26	-0.41**	-0.37**
Aspen Stem Length (cm/m^2)	-0.31*	-0.38**	-0.40**	+0.22*	-0.30*	-0.40**	-0.40**
Effective Aspen Density (number/m^2)	-0.04	-0.26	-0.08	-0.15	-0.03	-0.11	-0.05
Aspen Basal Area (cm^2/m^2)	-0.35*	-0.33*	-0.39**	+0.24*	-0.33*	-0.37**	-0.38**
Shrub >50 cm tall - Distance (cm)	+0.15	+0.32*	+0.10	+0.13	+0.14	+0.26**	+0.26**
Shrub >50 cm tall - Height (cm)	+0.03	+0.31*	-0.04	+0.28**	-0.09	+0.11	+0.08
Shrub >50 cm tall - Basal Diameter (mm)	+0.09	+0.69**	+0.17	+0.29**	-0.04	+0.50**	+0.29**
Shrub Stem Density (number/m^2)	+0.14	-0.29*	-0.13	-0.03	-0.15	-0.14	-0.20**
Shrub Stem Length (cm/m^2)	-0.17	-0.25	-0.15	+0.08	-0.20	-0.13	-0.16**
Density of Woody Stems (number/m^2)	-0.01	-0.43**	-0.20	+0.05	-0.24	-0.27**	-0.31**
Total Woody Stem Length (m/m^2)	-0.39**	-0.40**	-0.29*	+0.17	-0.34*	-0.37**	-0.38**
Percent Cover Aspen - C stratum	-0.14	-0.26	-0.20	ND	-0.01	-0.26**	-0.24**
Percent Cover Aspen - B stratum	-0.10	-0.28	+0.01	+0.35**	-0.06	-0.12	-0.22**
Percent Cover Aspen - A stratum	+0.20	-0.12	-0.22	+0.08	-0.01	-0.10	-0.06
Percent Cover - Total C stratum	-0.15	-0.26	-0.16	ND	-0.01	-0.25**	-0.24**
Percent Cover - Total B stratum	-0.18	-0.28*	-0.05	+0.31**	+0.23	-0.15	-0.15**
Percent Cover - Total A stratum	+0.34*	-0.15	-0.16	+0.11	+0.02	-0.11	-0.12*
Percent Cover - *Calamagrostis canadensis*	+0.31*	+0.03	-0.06	-0.53**	+0.05	-0.13	-0.09
CI-1 (Tallest Aspen)	-0.10	-0.45**	-0.45**	-0.25*	-0.48**	-0.37**	-0.46**
CI-2 (Nearest Aspen)	-0.26*	-0.45**	-0.43**	-0.41**	-0.47**	-0.39**	-0.47**
CI-3a (Aspen - C stratum)	-0.18	-0.26	-0.15	ND	-0.05	-0.16	-0.14*
CI-3b (Aspen - B stratum)	-0.16	-0.16	+0.06	+0.29*	-0.03	-0.07	-0.18**
CI-4	-0.36**	-0.44**	-0.50**	-0.23*	-0.23	-0.38**	-0.35**
CI-5	-0.35**	-0.48**	-0.55**	-0.48**	-0.27*	-0.40**	-0.38**
CI-6	-0.47**	-0.57**	-0.59**	-0.43**	-0.54**	-0.50**	-0.49**
RelHT2	+0.72**	+0.82**	+0.81**	+0.37**	+0.83**	+0.79**	+0.68**
Shrub Basal Diameter/Conifer Basal Diameter	-0.37**	-0.19	-0.57**	-0.32**	-0.42**	-0.30**	-0.39**
Number of Samples	45-58	44-51	53-63	76-87	49-63	145-172	270-315

(Tables 3, 4 and 5). It is interesting to note that r-values in the 2 kg/ha hexazinone treatment were stronger and more frequent than in either the control or the 4 kg/ha treatment. The control plots tended to have fewer significant correlation coefficients than other treatments, although they were more frequent when crop seedling basal diameter was the dependent variable.

In summary, tree dimensional properties such as total aspen stem length, aspen density, and aspen basal area were the better variables for estimating lodgepole pine growth characteristics, particularly when basal diameter and, to a lesser degree, height were the dependent variables. These variables were negatively correlated with lodgepole pine seedling basal diameter, i.e., as the total amount of aspen increases the size of the seedling decreases ($P < 0.01$). When all treatments were combined for analysis, these variables separately explained 27 to 31 percent of the variance in seedling basal diameter ($r = 0.52$ to 0.56). Between 270 to 315 lodgepole pine seedlings were included in these analyses.

3.1.2 Site Preparation - White Spruce

Four of the nine tested competition indices tended to more consistently produce statistically significant correlation coefficients for white spruce height, basal diameter, and volume than did the other indices. These competition indices included CI-5, CI-6, RelHT2, and shrub basal diameter/conifer basal diameter (Tables 6, 7, and 8). RelHT2 as a predictor of white spruce seedling height produced a consistent pattern of strong correlations among the various treatments. However, CI-6 was a more versatile predictor of crop seedling growth characteristics. The competition index correlations associated with seedling volume tended to be poorer than either height or basal diameter.

None of the variables associated with the tree dimensional and proximity measures consistently produced significant correlations for the various Site Preparation treatments. In addition, those correlations that were statistically significant tended to be moderately strong at best. The independent variables with the greatest potential as estimators of white spruce seedling height were aspen stem length and basal area (Table 6). When all experimental treatments were combined for analysis, these two variables were also the best estimators of seedling height, basal diameter, and volume among the non-competition index variables.

The shrub, woody plant stem, and percent cover variables were more poorly associated with white spruce seedling characteristics than were the tree dimension and distance measures. A total of 23 statistically significant correlation coefficients occurred among the 210 possibilities (i.e., 3 dependent variables x 5 treatments x 14 independent variables). Half of these could have occurred by chance based on a probability level of five percent. When all experimental treatments were combined or treatments were aggregated according to a chemical dosage series for analysis, a larger portion of the shrub, woody plant stem, and percent cover variables had significant r-values, but were weak.

Within the five treatment plots, only one significant correlation occurred in the Rome double disking treatment based on 24 independent and three dependent variables. More frequent significant correlations occurred in control and 2 kg/ha hexazinone plots when height was the

Table 6. Summary of correlation coefficients for selected variables from Site Preparation treatment plots (1992/3 data) with white spruce seedling height as the dependent variable. An "*" and "**" indicate a significant coefficient at P <0.05 and P <0.01, respectively. ND - no data available.

Independent Variables	Control	2 kg/ha Hexa-zinone	4 kg/ha Hexa-zinone	Rome Double Disking	Disk Trench-ing	Chemical Dosage Series	All Treat-ments
Nearest Aspen - Distance (cm)	+0.29**	+0.32**	+0.21	-0.09	+0.13	+0.29**	+0.19**
Nearest Aspen - Height (cm)	+0.01	+0.16	-0.21	-0.05	+0.01	-0.06	-0.07
Nearest Aspen - Basal Diameter (mm)	+0.03	+0.26*	-0.03	-0.04	+0.05	+0.06	+0.02
Tallest Aspen - Distance (cm)	+0.14	-0.06	+0.26*	-0.07	+0.04	+0.11	+0.07
Tallest Aspen - Height (cm)	+0.05	+0.04	-0.26*	+0.22	-0.09	-0.14*	-0.12*
Tallest Aspen - Basal Diameter (mm)	-0.01	+0.11	-0.27*	+0.13	-0.22	-0.09	-0.10
Aspen Stem Density (number/m^2)	-0.25*	-0.45**	+0.08	0	-0.12	-0.06	-0.08
Aspen Stem Length (cm/m^2)	-0.24*	-0.38**	-0.31**	+0.01	-0.27	-0.35**	-0.31**
Effective Aspen Density (number/m^2)	-0.08	-0.10	-0.13	-0.10	-0.01	-0.09	-0.08
Aspen Basal Area (cm^2/m^2)	-0.24*	-0.34**	-0.31**	+0.03	-0.31*	-0.33**	-0.31**
Shrub >50 cm tall - Distance (cm)	-0.05	+0.04	+0.17	-0.24	+0.01	+0.13*	+0.05
Shrub >50 cm tall - Height (cm)	+0.10	-0.03	+0.13	+0.09	-0.19	+0.05	-0.01
Shrub >50 cm tall - Basal Diameter (mm)	+0.31**	-0.01	+0.34**	-0.02	-0.20	+0.15*	+0.07
Shrub - Stem Density (number/m^2)	+0.16	-0.17	+0.09	+0.22	+0.13	+0.01	+0.02
Shrub - Stem Length (cm/m^2)	+0.17	-0.11	+0.31**	+0.16	+0.12	+0.13*	+0.11*
Density of Woody Stems (number/m^2)	+0.02	-0.36**	+0.20	+0.19	+0.07	-0.05	-0.04
Total Woody Stem Length (cm/m^2)	-0.09	-0.39**	-0.01	+0.14	-0.14	-0.21**	-0.19**
Percent Cover Aspen - C stratum	-0.05	-0.23	-0.21	ND	-0.03	-0.21**	-0.20**
Percent Cover Aspen - B stratum	-0.24*	-0.12	-0.41**	+0.28	+0.02	-0.27**	-0.22**
Percent Cover Aspen - A stratum	-0.06	-0.27*	+0.13	-0.01	-0.16	+0.01	-0.03
Percent Cover - Total C stratum	-0.07	-0.23	-0.21	ND	+0.01	-0.22**	-0.20**
Percent Cover - Total B stratum	-0.18	-0.14	-0.35**	+0.17	-0.08	-0.23**	-0.21**
Percent Cover - Total A stratum	-0.02	-0.16	+0.22	+0.21	+0.16	+0.06	+0.06
Percent Cover - *Calamagrostis canadensis*	-0.05	+0.18	+0.13	0	+0.06	-0.05	+0.01
CI-1 (Tallest Aspen)	-0.20	-0.10	-0.38**	-0.29*	-0.29*	-0.26**	-0.27**
CI-2 (Nearest Aspen)	-0.24*	-0.18	-0.19	-0.55**	-0.36**	-0.17**	-0.17**
CI-3a (Aspen - C stratum)	+0.03	-0.30*	-0.20	ND	-0.19	-0.20**	-0.19**
CI-3b (Aspen - B stratum)	-0.08	-0.10	-0.32**	+0.30*	+0.11	-0.07	-0.06
CI-4	-0.29**	-0.15	-0.20	-0.34*	-0.55**	-0.14*	-0.14**
CI-5	-0.22*	-0.40**	-0.53**	-0.57**	-0.51**	-0.37**	-0.41**
CI-6	-0.34**	-0.51**	-0.64**	-0.51**	-0.71**	-0.51**	-0.53**
RelHT2	+0.87**	+0.53**	+0.76**	+0.59**	+0.83**	+0.71**	+0.52**
Shrub Basal Diameter/Conifer Basal Diameter	-0.09	-0.29**	-0.44**	-0.58**	-0.56**	-0.27**	-0.37**
Number of Samples	72-84	67-76	67-80	49-57	52-63	206-240	307-356

Table 7. Summary of correlation coefficients for selected variables from Site Preparation treatment plots (1992/3 data) with white spruce basal diameter as the dependent variable. An "*" and "**" indicate a significant coefficient at P <0.05 and P <0.01, respectively. ND - no data available.

Independent Variables	Control	2 kg/ha Hexa-zinone	4 kg/ha Hexa-zinone	Rome Double Disking	Disk Trench-ing	Chemical Dosage Series	All Treat-ments
Nearest Aspen - Distance (cm)	-0.03	+0.18	+0.23*	-0.19	+0.10	+0.20**	+0.10
Nearest Aspen - Height (cm)	+0.08	-0.07	-0.17	-0.17	+0.04	-0.11	-0.09
Nearest Aspen - Basal Diameter (mm)	+0.17	-0.03	+0.01	-0.05	+0.12	+0.02	+0.02
Tallest Aspen - Distance (cm)	-0.04	+0.03	+0.11	-0.26	-0.01	+0.06	+0.01
Tallest Aspen - Height (cm)	+0.16	-0.07	-0.37**	+0.21	-0.17	-0.23**	-0.16**
Tallest Aspen - Basal Diameter (mm)	+0.13	-0.06	-0.36**	+0.20	-0.27*	-0.17**	-0.13*
Aspen Stem Density (number/m^2)	-0.03	-0.15	+0.03	+0.03	-0.20	-0.01	-0.02
Aspen Stem Length (cm/m^2)	-0.07	-0.18	-0.30*	+0.03	-0.35**	-0.24**	-0.22**
Effective Aspen Density (number/m^2)	-0.05	-0.12	-0.06	-0.01	-0.02	-0.06	-0.06
Aspen Basal Area (cm^2/m^2)	-0.10	-0.18	-0.28*	+0.04	-0.35*	-0.24**	-0.22**
Shrub >50 cm tall - Distance (cm)	+0.06	+0.06	+0.23*	-0.16	-0.01	+0.20**	+0.14**
Shrub >50 cm tall - Height (cm)	+0.04	-0.13	-0.01	+0.04	-0.14	-0.05	-0.05
Shrub >50 cm tall - Basal Diameter (mm)	+0.07	-0.07	+0.32**	-0.09	-0.07	+0.09	+0.06
Shrub Stem Density (number/m^2)	+0.22	-0.16	-0.11	+0.05	+0.11	-0.11	-0.09
Shrub Stem Length (cm/m^2)	+0.22	-0.10	-0.02	+0.05	+0.17	-0.02	-0.01
Density of Woody Stems (number/m^2)	+0.21	-0.22	-0.11	+0.06	+0.01	-0.13**	-0.12*
Total Woody Stem Length (cm/m^2)	+0.11	-0.21	-0.23*	+0.06	-0.18	-0.22**	-0.19**
Percent Cover Aspen - C stratum	-0.04	-0.14	-0.15	ND	-0.14	-0.16*	-0.15**
Percent Cover Aspen - B stratum	-0.15	+0.10	-0.29*	+0.20	+0.02	-0.15*	-0.12*
Percent Cover Aspen - A stratum	+0.08	+0.05	+0.12	-0.10	-0.18	+0.14*	+0.08
Percent Cover - Total C stratum	-0.07	-0.14	-0.15	ND	-0.12	-0.17*	-0.15**
Percent Cover - Total B stratum	-0.11	-0.10	-0.31**	+0.14	-0.07	-0.14*	-0.13*
Percent Cover - Total A stratum	+0.11	-0.09	+0.01	+0.04	+0.26	+0.01	+0.02
Percent Cover - *Calamagrostis canadensis*	-0.09	+0.03	-0.02	-0.19	+0.06	-0.12	-0.09
CI-1 (Tallest Aspen)	+0.14	-0.12	-0.30**	+0.26	-0.21	-0.17*	-0.14**
CI-2 (Nearest Aspen)	+0.01	-0.18	-0.09	-0.23	-0.24	-0.11	-0.10
CI-3a (Aspen - C stratum)	+0.11	-0.19	-0.16	ND	-0.25	-0.14*	-0.13*
CI-3b (Aspen - B stratum)	-0.06	-0.12	-0.18	+0.21	+0.06	-0.07	-0.06
CI-4	-0.45**	-0.15	-0.12	-0.35**	-0.57**	-0.12	-0.12*
CI-5	-0.47**	-0.43**	-0.52**	-0.64**	-0.54**	-0.43**	-0.44**
CI-6	-0.61**	-0.49**	-0.57**	-0.59**	-0.78**	-0.53**	-0.52*
RelHT2	+0.21	+0.23*	+0.48**	+0.30*	+0.72**	+0.43**	+0.31**
Shrub Basal Diameter/Conifer Basal Diameter	-0.49**	-0.32**	-0.52**	-0.68**	-0.58**	-0.36**	-0.40**
Number of Samples	72 - 84	67 - 76	67 - 80	49 - 57	52 - 63	206-240	307-356

Table 8. Summary of correlation coefficients for selected variables from Site Preparation treatment plots (1992/3 data) with white spruce stem volume as the dependent variable. An "*" and "**" indicate a significant coefficient at $P < 0.05$ and $P < 0.01$, respectively. ND - no data available.

Independent Variables	Control	2 kg/ha Hexa-zinone	4 kg/ha Hexa-zinone	Rome Double Disking	Disk Trench-ing	Chemical Dosage Series	All Treat-ments
Nearest Aspen - Distance (cm)	+0.06	+0.10	+0.18	-0.14	-0.02	+0.17**	+0.09
Nearest Aspen - Height (cm)	+0.05	-0.09	-0.15	-0.26	+0.07	-0.13*	-0.10*
Nearest Aspen - Basal Diameter (mm)	+0.12	-0.06	+0.02	-0.16	+0.14	-0.01	-0.01
Tallest Aspen - Distance (cm)	-0.02	+0.02	+0.13	-0.20	-0.09	+0.08	+0.03
Tallest Aspen - Height (cm)	+0.14	-0.01	-0.32**	+0.21	-0.10	-0.23**	-0.15**
Tallest Aspen - Basal Diameter (mm)	+0.10	+0.02	-0.29**	+0.11	-0.21	-0.17**	-0.12*
Aspen Stem Density (number/m^2)	-0.11	-0.13	+0.02	+0.11	-0.13	-0.01	-0.01
Aspen Stem Length (cm/m^2)	-0.12	-0.15	-0.29*	+0.05	-0.32*	-0.24**	-0.21**
Effective Aspen Density (number/m^2)	-0.06	-0.06	-0.05	-0.07	+0.04	-0.04	-0.04
Aspen Basal Area (cm^2/m^2)	-0.13	-0.16	-0.27*	+0.03	-0.32*	-0.23**	-0.21**
Shrub >50 cm tall - Distance (cm)	+0.01	+0.05	+0.26*	-0.19	+0.05	+0.23**	+0.17**
Shrub >50 cm tall - Height (cm)	+0.10	-0.11	-0.03	+0.04	-0.14	-0.05	-0.05
Shrub >50 cm tall - Basal Diameter (mm)	+0.18	-0.08	+0.35**	-0.08	-0.08	+0.12	+0.09
Shrub Stem Density (number/m^2)	+0.26*	-0.16	-0.11	+0.08	+0.14	-0.12	-0.10
Shrub Stem Length (cm/m^2)	+0.27*	-0.13	-0.02	+0.04	+0.21	-0.03	-0.02
Density of Woody Stems (number/m^2)	+0.21	-0.21	-0.13	+0.12	+0.07	-0.15*	-0.12*
Total Woody Stem Length (cm/m^2)	+0.10	-0.20	-0.23*	+0.06	-0.12	-0.22**	-0.18**
Percent Cover Aspen - C stratum	-0.01	-0.13	-0.15	ND	-0.12	-0.16*	-0.14*
Percent Cover Aspen - B stratum	-0.14	+0.09	-0.26*	+0.31*	+0.14	-0.14*	-0.11*
Percent Cover Aspen - A stratum	+0.01	+0.06	+0.16	-0.05	-0.12	+0.17*	+0.12*
Percent Cover - Total C stratum	-0.02	-0.13	-0.15	ND	-0.11	-0.16*	-0.14*
Percent Cover - Total B stratum	-0.09	+0.08	-0.28*	+0.22	+0.10	-0.15*	-0.11*
Percent Cover - Total A stratum	+0.14	-0.10	+0.02	+0.10	+0.35*	+0.02	+0.04
Percent Cover - *Calamagrostis canadensis*	-0.09	+0.01	-0.02	-0.11	+0.07	-0.12	-0.09
CI-1 (Tallest Aspen)	+0.07	-0.09	-0.27*	+0.01	-0.10	-0.19**	-0.16**
CI-2 (Nearest Aspen)	-0.09	-0.12	-0.08	-0.46**	-0.08	-0.08	-0.08
CI-3a (Aspen - C stratum)	+0.13	-0.17	-0.14	ND	-0.17	-0.13	-0.12*
CI-3b (Aspen - B stratum)	-0.07	-0.06	-0.14	+0.32*	+0.16	-0.03	-0.03
CI-4	-0.40**	-0.09	-0.11	-0.32*	-0.33**	-0.08	-0.08
CI-5	-0.37**	-0.34**	-0.45**	-0.53**	-0.37**	-0.31**	-0.31**
CI-6	-0.50**	-0.35**	-0.46**	-0.48**	-0.52**	-0.37**	-0.35**
RelHT2	+0.39**	+0.17	+0.46**	+0.38**	+0.64**	+0.43**	+0.30**
Shrub Basal Diameter/Conifer Basal Diameter	-0.36**	-0.26*	-0.45**	-0.52**	-0.39**	-0.26**	-0.28**
Number of Samples	72 - 84	67 - 76	67 - 80	49 - 57	53 - 63	206-240	307-356

dependent variable, while 35 to 40 percent of the independent variables in the 4 kg/ha hexazinone plots were significantly associated with one or more of the crop seedling growth characteristics. The poorest correlation coefficients were associated with seedling stem volume.

In general, the relationship between the vegetation variables and white spruce seedling growth characteristics were poor relative to lodgepole pine. In other words, fewer variables were significant and those that were statistically significant had weaker correlation coefficients. When all individual treatments were combined or grouped to form a chemical series, more independent variables were significant but most were weakly correlated with white spruce seedling height, basal diameter, or volume. However, seedling height tended to be a better dependent variable.

3.1.3 Conifer Release - Lodgepole Pine

Only RelHT2 produced significant ($P < 0.05$) correlations with all four (stem height, basal diameter, current height increment, and volume) lodgepole pine seedling attributes in the Conifer Release experiment blocks. Significant correlations were also produced for CI-2, CI-4, CI-5, CI-6, and shrub basal diameter/conifer basal diameter indices, but only for crop seedling height and basal diameter (Tables 9, 10, 11, and 12). These competition indices typically had correlation coefficients that ranged from 0.30 to 0.80 with the strongest values associated with RelHT2 and CI-6. Among the five conifer release methods, RelHT2 worked best for predicting lodgepole pine seedling characteristics in the control plots ($r = 0.70$ to 0.94). On a relative basis, seedling characteristics were ranked in terms of their predictability as follows: basal diameter > height > volume > current height growth.

None of the non-competition index variables were consistently correlated with any of the lodgepole pine seedling characteristics among the five conifer release techniques. Within the chemical series, two-thirds or more of the independent variables were significantly correlated with seedling height, basal diameter, and stem volume, but were best correlated with seedling basal diameter. When seedling basal diameter or height were the dependent variables, the three best correlations ($r > 0.60$, $n = 79$ to 115) were related to total aspen stem densities, total woody stem densities and lengths (cm/m^2). The height of the tallest aspen, and aspen stem length and basal area were the next best variables (Tables 9 and 10). The remaining statistically significant variables tended to have moderately strong correlations with lodgepole pine growth characteristics. A similar but weaker correlation pattern occurred when all treatments were analyzed as a group. The poorest correlations were associated with current height increment (Table 11).

In general, the frequency and strength of the vegetation variables when correlated with lodgepole pine seedling characteristics in the Conifer Release experiment blocks were lower and weaker than those associated with the Site Preparation treatments. Seedling basal diameter followed by height were the better dependent variables. Height of the tallest aspen, aspen basal area, and variables related to stem length and densities were variables with the greatest potential for inclusion in competition index models. All competition indices, except CI-3, were more strongly related to seedling characteristics than individual variables.

Table 9. Summary of correlation coefficients for selected variables from Conifer Release treatment plots (1993/4 data) with lodgepole pine seedling height as the dependent variable. An "*" and "**" indicate a significant coefficient at P <0.05 and P <0.01, respectively.

Independent Variables	Control	Disk Trenching & 2 kg/ha Hexazinone	Disk Trenching & 4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching & Brushsawing	Chemical Dosage Series	All Treatments
Nearest Aspen - Distance (cm)	+0.30	+0.02	0	-0.04	-0.11	+0.23*	+0.07
Nearest Aspen - Height (cm)	-0.14	+0.10	+0.03	+0.11	-0.07	-0.17	-0.04
Nearest Aspen - Basal Diameter (mm)	-0.13	+0.18	+0.10	+0.03	-0.06	-0.01	+0.02
Tallest Aspen - Distance (cm)	+0.19	-0.19	-0.28	+0.04	-0.09	-0.03	-0.07
Tallest Aspen - Height (cm)	-0.27	+0.11	-0.53**	+0.13	-0.35**	-0.41**	-0.19**
Tallest Aspen - Basal Diameter (mm)	+0.02	+0.06	-0.37	+0.05	-0.07	-0.25*	-0.11
Aspen Stem Density (number/m^2)	-0.30	-0.16	-0.26	-0.13	-0.17	-0.50**	-0.13
Aspen Stem Length (cm/m^2)	-0.37	-0.08	-0.36*	+0.20	-0.26	-0.47**	-0.23**
Effective Aspen Density (number/m^2)	-0.32	-0.15	-0.13	-0.12	-0.17	-0.15	-0.09
Aspen Basal Area (cm^2/m^2)	-0.37	-0.07	-0.41*	+0.23	-0.31*	-0.45**	-0.24**
Shrub >50 cm tall - Distance (cm)	+0.35	+0.02	+0.12	-0.21	-0.05	+0.29**	+0.13*
Shrub >50 cm tall - Height (cm)	+0.12	+0.16	-0.17	+0.08	+0.05	-0.03	+0.02
Shrub >50 cm tall - Basal Diameter (mm)	+0.10	+0.02	-0.37*	-0.12	+0.30*	-0.19*	-0.08
Shrub Stem Density (number/m^2)	+0.01	+0.03	-0.29	+0.18	-0.02	-0.37**	-0.07
Shrub Stem Length (cm/m^2)	+0.02	-0.02	-0.11	+0.10	-0.12	-0.31**	-0.19**
Density of Woody Stems (number/m^2)	-0.11	-0.03	-0.35*	+0.15	-0.09	-0.49**	-0.28**
Total Woody Stem Length (cm/m^2)	-0.29	-0.06	-0.29	+0.19	-0.25	-0.49**	-0.28**
Percent Cover Aspen - C stratum	-0.31	-0.01	-0.46**	+0.05	-0.25	-0.39**	-0.22**
Percent Cover Aspen - B stratum	+0.31	+0.13	+0.04	+0.07	-0.32*	-0.06	-0.06
Percent Cover Aspen - A stratum	-0.22	-0.18	-0.04	-0.08	-0.08	-0.26**	-0.19**
Percent Cover - Total C stratum	-0.40	-0.05	-0.46**	+0.08	-0.29*	-0.42**	-0.23**
Percent Cover - Total B stratum	+0.29	+0.22	+0.52**	+0.28*	-0.12	+0.12	+0.12
Percent Cover - Total A stratum	+0.08	-0.04	-0.27	+0.02	+0.19	-0.31**	-0.14*
Percent Cover - *Calamagrostis canadensis*	-0.19	+0.05	+0.09	-0.09	+0.04	-0.21*	-0.13
CI-1 (Tallest Aspen)	-0.28	-0.25	-0.71**	-0.23	-0.32*	-0.50**	-0.34**
CI-2 (Nearest Aspen)	-0.42*	-0.49**	-0.65**	-0.32**	-0.37**	-0.48**	-0.37**
CI-3a (Aspen - C stratum)	-0.23	-0.27	-0.52*	-0.15	-0.16	-0.27*	-0.21**
CI-3b (Aspen - B stratum)	+0.21	+0.05	0	-0.23	-0.29*	+0.09	-0.09
CI-4	-0.56**	-0.39**	-0.58**	-0.29*	-0.29*	-0.42**	-0.34**
CI-5	-0.69**	-0.33*	-0.68**	-0.51**	-0.52**	-0.52**	-0.47**
CI-6	-0.63**	-0.49**	-0.81**	-0.60**	-0.58**	-0.60**	-0.55**
RelHT2	+0.94**	+0.76**	+0.77**	+0.43**	+0.49**	+0.82**	+0.57**
Shrub Basal Diameter/Conifer Basal Diameter	-0.62**	-0.63**	-0.69**	-0.28*	-0.41**	-0.67**	-0.38**
Number of Samples	24-26	34-48	21-41	58-70	51-59	79-115	188-244

Table 10. Summary of correlation coefficients for selected variables from Conifer Release treatment plots (1993/4 data) with lodgepole pine basal diameter as the dependent variable. An "*" and "**" indicate a significant coefficient at P <0.05 and P <0.01, respectively.

Independent Variables	Control	Disk Trenching and 2 kg/ha Hexazinone	Disk Trenching and 4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching followed by Brushsawing	Chemical Dosage Series	All Treatments
Nearest Aspen - Distance (cm)	+0.31	+0.09	-0.07	+0.06	-0.08	+0.27**	-0.16*
Nearest Aspen - Height (cm)	-0.26	-0.05	-0.03	-0.08	-0.12	-0.30**	-0.16*
Nearest Aspen - Basal Diameter (mm)	-0.30	+0.02	+0.07	-0.14	-0.07	-0.12	-0.06
Tallest Aspen - Distance (cm)	+0.11	-0.14	-0.36	-0.02	-0.08	-0.02	-0.05
Tallest Aspen - Height (cm)	-0.37	-0.04	-0.51**	-0.15	-0.37**	-0.55**	-0.34**
Tallest Aspen - Basal Diameter (mm)	-0.11	-0.11	-0.39*	-0.19	-0.09	-0.38**	-0.22**
Aspen Stem Density (number/m^2)	-0.50*	-0.30	-0.23	-0.11	-0.16	-0.60**	-0.15*
Aspen Stem Length (cm/m^2)	-0.53**	-0.26	-0.33	-0.07	-0.22	-0.57**	-0.39**
Effective Aspen Density (number/m^2)	-0.31	-0.21	-0.15	-0.14	-0.11	-0.14	-0.10
Aspen Basal Area (cm^2/m^2)	-0.50*	-0.18	-0.38*	-0.05	-0.31*	-0.54**	-0.38**
Shrub >50 cm tall - Distance (cm)	+0.39	+0.05	+0.16	-0.02	-0.12	+0.35**	+0.21**
Shrub >50 cm tall - Height (cm)	+0.08	+0.11	-0.09	+0.02	-0.02	-0.04	-0.03
Shrub >50 cm tall - Basal Diameter (mm)	+0.03	+0.06	-0.31*	-0.10	+0.18	-0.17	-0.08
Shrub Stem Density (number/m^2)	+0.04	+0.03	-0.35*	+0.05	-0.12	-0.47**	-0.16*
Shrub Stem Length (cm/m^2)	+0.03	-0.02	-0.22	-0.09	-0.20	-0.40**	-0.29**
Density of Woody Stems (number/m^2)	-0.17	-0.08	-0.41*	-0.15	-0.19	-0.61**	-0.44**
Total Woody Stem Length (cm/m^2)	-0.42*	-0.17	-0.36*	-0.11	-0.31*	-0.61**	-0.45**
Percent Cover Aspen - C stratum	-0.21	-0.13	-0.41*	-0.12	-0.28*	-0.44**	-0.28**
Percent Cover Aspen - B stratum	+0.20	-0.07	-0.15	0	-0.22	-0.23*	-0.17*
Percent Cover Aspen - A stratum	-0.14	-0.15	-0.04	-0.16	-0.05	-0.24*	-0.21**
Percent Cover - Total C stratum	-0.26	-0.12	-0.41*	-0.13	-0.28*	-0.46**	-0.28**
Percent Cover - Total B stratum	+0.14	-0.07	+0.45**	+0.10	-0.19	-0.05	-0.05
Percent Cover - Total A stratum	-0.05	+0.18	-0.29	+0.07	+0.11	-0.34**	-0.18**
Percent Cover - *Calamagrostis canadensis*	+0.01	-0.14	-0.02	+0.01	-0.01	-0.29**	-0.21**
CI-1 (Tallest Aspen)	-0.07	-0.34*	-0.69**	-0.29*	-0.32*	-0.55**	-0.40**
CI-2 (Nearest Aspen)	-0.44*	-0.54**	-0.59**	-0.38**	-0.33*	-0.51**	-0.39**
CI-3a (Aspen - C stratum)	-0.23	-0.31	-0.43	-0.23	-0.18	-0.25*	-0.20**
CI-3b (Aspen - B stratum)	+0.09	-0.11	-0.07	-0.27*	-0.20	+0.03	-0.10
CI-4	-0.60**	-0.54**	-0.52**	-0.37**	-0.29*	-0.44**	-0.37**
CI-5	-0.86**	-0.46**	-0.67**	-0.65**	-0.58**	-0.58**	-0.52**
CI-6	-0.74**	-0.65**	-0.77**	-0.77**	-0.71**	-0.62**	-0.59**
RelHT2	+0.86**	+0.76**	+0.76**	+0.55**	+0.49**	+0.86**	+0.61**
Shrub Basal Diameter/Conifer Basal Diameter	-0.71**	-0.73**	-0.65**	-0.29*	-0.60**	-0.66**	-0.38**
Number of Samples	24-26	34-48	21-41	58-70	51-59	79-115	188-244

Table 11. Summary of correlation coefficients for selected variables from Conifer Release treatment plots (1993/4 data) with lodgepole pine current growth increment as the dependent variable. An "*" and "**" indicate a significant coefficient at P <0.05 and P <0.01, respectively.

Independent Variables	Control	Disk Trenching and 2 kg/ha Hexazinone	Disk Trenching and 4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching followed by Brush-sawing	Chemical Dosage Series	All Treatments
Nearest Aspen - Distance (cm)	+0.08	+0.08	-0.23	-0.03	-0.04	+0.08	0
Nearest Aspen - Height (cm)	-0.04	+0.04	-0.12	+0.01	-0.17	-0.14	-0.07
Nearest Aspen - Basal Diameter (mm)	-0.02	+0.14	-0.10	-0.05	-0.04	-0.05	-0.03
Tallest Aspen - Distance (cm)	+0.16	-0.13	-0.22	+0.10	+0.14	-0.03	+0.02
Tallest Aspen - Height (cm)	-0.11	+0.22	-0.42*	+0.07	-0.41**	-0.22*	-0.12
Tallest Aspen - Basal Diameter (mm)	+0.12	+0.14	-0.35	+0.05	-0.03	-0.14	-0.05
Aspen Stem Density (number/m^2)	-0.16	0	-0.14	-0.15	-0.19	-0.25*	-0.12
Aspen Stem Length (cm/m^2)	-0.24	+0.06	-0.20	+0.17	-0.34*	-0.26*	-0.13
Effective Aspen Density (number/m^2)	-0.27	-0.22	+0.13	-0.05	-0.21	-0.10	-0.06
Aspen Basal Area (cm^2/m^2)	-0.25	+0.09	-0.23	+0.16	-0.37**	-0.25*	-0.14*
Shrub >50 cm tall - Distance (cm)	+0.40*	+0.01	-0.12	-0.13	+0.05	+0.06	+0.02
Shrub >50 cm tall - Height (cm)	+0.03	+0.15	-0.22	+0.06	-0.18	-0.06	-0.04
Shrub >50 cm tall - Basal Diameter (mm)	+0.14	-0.01	-0.20	-0.01	+0.12	-0.10	-0.01
Shrub Stem Density (number/m^2)	-0.06	+0.04	-0.16	+0.21	-0.19	-0.18	0
Shrub Stem Length (cm/m^2)	-0.11	+0.02	+0.06	+0.05	-0.23	-0.12	-0.12
Density of Woody Stems (number/m^2)	-0.12	+0.04	-0.19	+0.17	-0.28*	-0.24*	-0.15*
Total Woody Stem Length (cm/m^2)	-0.27	+0.05	-0.06	+0.14	-0.39**	-0.24*	-0.17*
Percent Cover Aspen - C stratum	-0.22	+0.02	-0.32	+0.08	-0.21	-0.24*	-0.12
Percent Cover Aspen - B stratum	+0.41*	+0.15	+0.18	+0.09	-0.39**	+0.10	0
Percent Cover Aspen - A stratum	-0.31	-0.03	+0.07	-0.03	-0.02	-0.12	-0.08
Percent Cover - Total C stratum	-0.35	-0.03	-0.32	0	-0.25	-0.28**	-0.16*
Percent Cover - Total B stratum	+0.40	+0.22	+0.50**	+0.34**	-0.25	+0.25*	+0.16*
Percent Cover - Total A stratum	-0.09	-0.04	-0.24	-0.06	+0.14	-0.21*	-0.09
Percent Cover - *Calamagrostis canadensis*	-0.41*	+0.18	-0.06	-0.01	-0.10	-0.18	-0.09
CI-1 (Tallest Aspen)	-0.23	-0.13	-0.67**	-0.16	-0.32*	-0.37**	-0.27**
CI-2 (Nearest Aspen)	-0.32	-0.45**	-0.74**	-0.30*	-0.41**	-0.42**	-0.35**
CI-3a (Aspen - C stratum)	+0.21	-0.31	-0.36	-0.14	-0.14	-0.26*	-0.19*
CI-3b (Aspen - B stratum)	-0.34	-0.06	+0.26	-0.17	-0.28*	+0.19	-0.06
CI-4	-0.36	-0.38*	-0.35	-0.25*	-0.31*	-0.33**	-0.28**
CI-5	-0.36	-0.20	-0.49*	-0.39**	-0.32*	-0.36**	-0.32**
CI-6	-0.32	-0.33*	-0.57*	-0.40**	-0.37**	-0.41**	-0.36**
RelHT2	+0.70**	+0.56**	+0.58**	+0.29*	+0.42**	+0.56**	+0.42**
Shrub Basal Diameter/Conifer Basal Diameter	-0.36	-0.49**	-0.38*	-0.09	-0.28*	-0.44**	-0.20**
Number of Samples	24-26	34-48	21-41	58-70	51-59	79-115	188-244

Table 12. Summary of correlation coefficients for selected variables from Conifer Release treatment plots (1993/4 data) with lodgepole pine stem volume as the dependent variable. An "*" and "**" indicate a significant coefficient at P <0.05 or P <0.01, respectively.

Independent Variables	Control	Disk Trenching and 2 kg/ha Hexazinone	Disk Trenching and 4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching followed by Brushsawing	Chemical Dosage Series	All Treatments
Nearest Aspen - Distance (cm)	+0.22	+0.03	-0.15	+0.04	-0.10	+0.17	+0.13
Nearest Aspen - Height (cm)	-0.43*	+0.04	-0.09	-0.03	-0.11	-0.22*	-0.09
Nearest Aspen - Basal Diameter (mm)	-0.49*	+0.19	0	-0.10	-0.06	-0.05	+0.02
Tallest Aspen - Distance (cm)	+0.27	-0.19	-0.32	0	-0.14	-0.07	-0.05
Tallest Aspen - Height (cm)	-0.25	+0.03	-0.38	-0.07	-0.32*	-0.44*	-0.24**
Tallest Aspen - Basal Diameter (mm)	+0.05	-0.01	-0.31	-0.14	+0.06	-0.31**	-0.15*
Aspen Stem Density (number/m^2)	-0.42*	-0.26	-0.06	-0.10	-0.09	-0.41**	-0.11
Aspen Stem Length (cm/m^2)	-0.52**	-0.20	-0.16	+0.10	-0.15	-0.38**	-0.25**
Effective Aspen Density (number/m^2)	-0.26	-0.12	-0.12	-0.15	-0.10	-0.08	-0.07
Aspen Basal Area (cm^2/m^2)	-0.52**	-0.19	-0.21	+0.11	-0.21	-0.37**	-0.24**
Shrub >50 cm tall - Distance (cm)	+0.44*	-0.02	+0.15	-0.08	-0.17	+0.31**	+0.18**
Shrub >50 cm tall - Height (cm)	+0.20	+0.11	-0.13	+0.01	-0.06	-0.06	-0.05
Shrub >50 cm tall - Basal Diameter (mm)	+0.15	0	-0.24	-0.05	+0.21	-0.17	-0.07
Shrub Stem Density (number/m^2)	-0.10	+0.05	-0.33	+0.08	-0.11	-0.43**	-0.14*
Shrub Stem Length (cm/m^2)	-0.08	-0.03	-0.26	-0.09	-0.21	-0.36**	-0.25**
Density of Woody Stems (number/m^2)	-0.28	-0.05	-0.34	-0.06	-0.15	-0.50**	-0.37**
Total Woody Stem Length (cm/m^2)	-0.49*	-0.14	-0.30	-0.01	-0.28*	-0.47**	-0.34**
Percent Cover Aspen - C stratum	-0.29	-0.06	-0.25	-0.03	-0.17	-0.31**	-0.18**
Percent Cover Aspen - B stratum	+0.28	-0.12	-0.14	+0.06	-0.05	-0.21**	-0.14*
Percent Cover Aspen - A stratum	-0.17	-0.15	+0.01	-0.08	-0.11	-0.19	-0.18**
Percent Cover - Total C stratum	-0.35	-0.12	-0.25	-0.09	-0.18	-0.33**	-0.19**
Percent Cover - Total B stratum	+0.23	+0.04	+0.50**	+0.20	-0.02	+0.04	+0.02
Percent Cover - Total A stratum	-0.16	+0.04	-0.32	+0.04	+0.06	-0.37**	-0.24**
Percent Cover - *Calamagrostis canadensis*	-0.05	-0.07	-0.05	-0.02	-0.10	-0.22*	-0.22**
CI-1 (Tallest Aspen)	-0.19	-0.30	-0.65**	-0.30*	-0.27*	-0.48**	-0.34**
CI-2 (Nearest Aspen)	-0.44*	-0.47**	-0.53**	-0.32*	-0.32*	-0.37**	-0.28**
CI-3a (Aspen - C stratum)	-0.22	-0.21	-0.27	-0.15	-0.13	-0.15	-0.11
CI-3b (Aspen - B stratum)	+0.21	-0.12	-0.10	-0.17	-0.15	0	-0.06
CI-4	-0.48*	-0.35*	-0.35	-0.29	-0.24	-0.27**	-0.22**
CI-5	-0.72**	-0.29	-0.47*	-0.52**	-0.44**	-0.37**	-0.31**
CI-6	-0.48*	-0.48**	-0.54**	-0.63**	-0.50**	-0.40**	-0.36**
RelHT2	+0.78**	+0.74**	+0.71**	+0.48**	+0.49**	+0.81**	+0.52**
Shrub Basal Diameter/Conifer Basal Diameter	-0.50**	-0.59**	-0.44**	-0.22	-0.44**	-0.45**	-0.24**
Number of Samples	24-26	34-48	21-34	58-70	51-59	79-115	188-244

3.1.4 Conifer Release - White Spruce

Of the 33 independent variables used in the analysis of white spruce seedling characteristics, only RelHT2 had statistically significant correlation coefficients for all treatments (Tables 13, 14, 15, and 16). These coefficients typically ranged from 0.60 to 0.85, except when current height increment was the dependent variable. In this case, the correlation coefficients were lower but still moderately strong. Other competition indices including CI-5, CI-6, and shrub basal diameter/conifer basal diameter commonly produced correlation values that ranged from 0.45 to 0.60, but sometimes they were not significant (i.e., Rome double disking treatment).

None of the non-competition index variables consistently produced significant correlations for all of the Conifer Release treatments. The most frequent significant correlations occurred when white spruce basal diameter was the dependent variable (Table 14). Within the basal diameter data, height of the tallest aspen was the most frequent variable among treatments as well as a variety with moderately strong correlation coefficients.

All of the individual Conifer Release treatments had independent variables which were poorly correlated with either white spruce height, basal diameter, current height increment, or stem volume. Among the five treatments, the disk trenching plot which was treated with 4 kg/ha of hexazinone tended to have a larger number of significant correlations when based on basal diameter. A variety of variables were correlated with white spruce growth attributes when treatments were analyzed as a chemical series or a group. These coefficients were weak to moderately strong and without exception were larger in the Chemical Dosage Series than in the group with all treatments. Among the dependent variables, white spruce basal diameter tended to produce stronger correlations.

Table 13. Summary of correlation coefficients for selected variables from Conifer Release treatment plots (1993/4 data) with white spruce seedling height as the dependent variable. An "*" and "**" indicate a significant coefficient at P <0.05 and P <0.01, respectively. ND - no data available.

Independent Variables	Control	Disk Trench-ing and 2 kg/ha Hexa-zinone	Disk Trench-ing and 4 kg/ha Hexa-zinone	Rome Double Disking	Disk Trench-ing followed by Brush-sawing	Chem-ical Dosage Series	All Treat-ments
Nearest Aspen - Distance (cm)	+0.01	-0.13	-0.19	+0.25	-0.22	0	+0.01
Nearest Aspen - Height (cm)	-0.06	+0.02	-0.38	+0.02	+0.06	-0.25**	-0.15*
Nearest Aspen - Basal Diameter (mm)	-0.06	+0.08	-0.20	+0.03	+0.04	-0.16	-0.07
Tallest Aspen - Distance (cm)	+0.10	+0.05	-0.14	+0.10	-0.07	+0.17	+0.10
Tallest Aspen - Height (cm)	-0.01	-0.24	-0.29	-0.11	-0.16	-0.34**	-0.18*
Tallest Aspen - Basal Diameter (mm)	+0.02	-0.15	-0.20	-0.12	+0.03	-0.19*	-0.06
Aspen Stem Density (number/m^2)	+0.08	-0.22	-0.10	-0.29	+0.14	-0.29**	-0.23**
Aspen Stem Length (cm/m^2)	+0.09	-0.28	-0.22	-0.21	-0.09	-0.31**	-0.22**
Effective Aspen Density (number/m^2)	-0.03	+0.03	+0.37	-0.07	+0.33*	+0.05	+0.02
Aspen Basal Area (cm^2/m^2)	+0.03	-0.26	-0.26	-0.17	+0.02	-0.32**	-0.22**
Shrub >50 cm tall - Distance (cm)	+0.14	-0.11	-0.04	-0.21	+0.07	+0.01	0
Shrub >50 cm tall - Height (cm)	-0.02	+0.19	-0.31	+0.19	+0.08	-0.11	-0.06
Shrub >50 cm tall - Basal Diameter (mm)	-0.21	+0.06	-0.36*	-0.05	+0.06	-0.19*	-0.09
Shrub Stem Density (number/m^2)	-0.25	-0.19	-0.36	-0.06	-0.22	-0.27**	-0.24**
Shrub Stem Length (cm/m^2)	-0.26	-0.18	-0.41*	-0.14	-0.18	-0.30**	-0.25**
Density of Woody Stems (number/m^2)	-0.18	-0.24	-0.36	-0.19	-0.21	-0.34**	-0.31**
Total Woody Stem Length (cm/m^2)	-0.08	-0.32*	-0.41*	-0.22	-0.17	-0.40**	-0.33**
Percent Cover Aspen - C stratum	0	-0.19	-0.25	-0.13	ND	-0.30**	-0.19**
Percent Cover Aspen - B stratum	+0.06	-0.05	+0.09	-0.16	-0.08	-0.02	-0.01
Percent Cover Aspen - A stratum	+0.22	+0.03	-0.05	-0.14	-0.04	+0.04	-0.06
Percent Cover - Total C stratum	-0.03	-0.15	-0.23	+0.03	ND	-0.31**	-0.19**
Percent Cover - Total B stratum	-0.19	-0.01	+0.16	-0.16	-0.20	-0.08	-0.07
Percent Cover - Total A stratum	+0.03	+0.23	-0.28	+0.19	-0.12	-0.09	-0.09
Percent Cover - *Calamagrostis canadensis*	0	-0.24	-0.29	-0.05	-0.08	-0.29**	-0.26**
CI-1 (Tallest Aspen)	-0.17	-0.38**	-0.37	0	-0.36*	-0.36**	-0.23**
CI-2 (Nearest Aspen)	-0.13	-0.34*	-0.44*	-0.08	-0.36*	-0.38**	-0.19**
CI-3a (Aspen - C stratum)	-0.19	+0.04	-0.30	-0.14	ND	+0.03	+0.03
CI-3b (Aspen - B stratum)	+0.11	+0.04	+0.38	+0.06	+0.21	+0.05	+0.06
CI-4	-0.44**	-0.22	-0.33	-0.07	-0.05	-0.37**	-0.17*
CI-5	-0.45**	-0.46**	-0.61**	-0.12	-0.69**	-0.54**	-0.43**
CI-6	-0.62**	-0.59**	-0.69**	-0.31	-0.64**	-0.65**	-0.50**
RelHT2	+0.71**	+0.57**	+0.79**	+0.57**	+0.81**	+0.70**	+0.60**
Shrub Basal Diameter/Conifer Basal Diameter	-0.56**	-0.50**	-0.57**	-0.11	-0.62**	-0.55**	-0.37**
Number of Samples	49-54	43-53	20-37	25-31	33-42	112-144	170-217

Table 14. Summary of correlation coefficients for selected variables from Conifer Release treatment plots (1993/4 data) with white spruce basal diameter as the dependent variable. An "*" and "**" indicate a significant coefficient at P <0.05 and P <0.01, respectively. ND - no data available.

Independent Variables	Control	Disk Trenching & 2 kg/ha Hexazinone	Disk Trenching & 4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching & Brushsawing	Chemical Dosage Series	All Treatments
Nearest Aspen - Distance (cm)	+0.18	+0.04	-0.18	+0.50**	-0.22	+0.15	+0.13
Nearest Aspen - Height (cm)	-0.16	-0.02	-0.38	-0.33	+0.10	-0.34**	-0.26**
Nearest Aspen - Basal Diameter (mm)	-0.03	+0.14	-0.12	-0.20	+0.18	-0.14	-0.09
Tallest Aspen - Distance (cm)	+0.12	+0.29*	0	+0.10	-0.06	+0.34**	+0.23**
Tallest Aspen - Height (cm)	-0.05	-0.38**	-0.45*	-0.50**	-0.18	-0.50**	-0.35**
Tallest Aspen - Basal Diameter (mm)	+0.05	-0.27	-0.36	-0.37*	+0.07	-0.30**	-0.19**
Aspen Stem Density (number/m^2)	+0.06	-0.29	-0.22	-0.37	+0.20	-0.44**	-0.35**
Aspen Stem Length (cm/m^2)	+0.04	-0.34*	-0.37*	-0.30	+0.11	-0.46**	-0.36**
Effective Aspen Density (number/m^2)	-0.15	+0.15	+0.37	-0.25	+0.22	+0.11	+0.04
Aspen Basal Area (cm^2/m^2)	-0.02	-0.34*	-0.42*	-0.26	+0.02	-0.46**	-0.36**
Shrub >50 cm tall - Distance (cm)	+0.20	-0.10	-0.01	-0.09	+0.06	+0.05	+0.04
Shrub >50 cm tall - Height (cm)	-0.06	-0.06	-0.21	+0.32	+0.03	-0.14	-0.10
Shrub >50 cm tall - Basal Diameter (mm)	-0.21	-0.03	-0.16	+0.04	+0.07	-0.06	-0.03
Shrub Stem Density (number/m^2)	-0.14	-0.16	-0.40*	+0.02	-0.30	-0.27**	-0.24**
Shrub Stem Length (cm/m^2)	-0.14	-0.22	-0.39*	-0.08	-0.27	-0.30**	-0.26**
Density of Woody Stems (number/m^2)	-0.09	-0.23	-0.42*	-0.18	-0.29	-0.39**	-0.34**
Total Woody Stem Length (cm/m^2)	-0.05	-0.38*	-0.47**	-0.24	-0.26	-0.51**	-0.43**
Percent Cover Aspen - C stratum	-0.11	-0.28	-0.30	-0.29	ND	-0.43**	-0.34**
Percent Cover Aspen - B stratum	+0.15	-0.15	-0.21	-0.08	+0.05	-0.13	-0.09
Percent Cover Aspen - A stratum	+0.30*	-0.03	-0.28	+0.02	+0.02	-0.03	-0.05
Percent Cover - Total C stratum	-0.10	-0.31*	-0.24	-0.22	ND	-0.45**	-0.34**
Percent Cover - Total B stratum	+0.02	-0.17	+0.03	-0.13	-0.14	-0.14	-0.11
Percent Cover - Total A stratum	-0.09	+0.19	-0.32	+0.16	-0.08	-0.16	-0.12
Percent Cover - *Calamagrostis canadensis*	+0.04	-0.20	-0.42*	+0.14	-0.17	-0.38**	-0.32**
CI-1 (Tallest Aspen)	-0.20	-0.49**	-0.55**	-0.18	-0.35*	-0.47**	-0.36**
CI-2 (Nearest Aspen)	-0.31*	-0.43**	-0.54**	-0.33	-0.26	-0.50**	-0.29**
CI-3a (Aspen - C stratum)	-0.31*	+0.16	-0.30	-0.34	ND	+0.09	+0.08
CI-3b (Aspen - B stratum)	+0.10	+0.16	-0.05	-0.04	+0.23	+0.12	+0.11
CI-4	-0.62**	-0.32*	-0.45*	-0.32	-0.13	-0.49**	-0.26**
CI-5	-0.58**	-0.52**	-0.58**	-0.40*	-0.66**	-0.58*	-0.51**
CI-6	-0.75**	-0.72**	-0.77**	-0.61**	-0.69**	-0.74**	-0.62**
RELHT2	+0.62**	+0.62**	+0.87**	+0.78**	+0.73**	+0.79**	+0.67**
Shrub Basal Diameter/Conifer Basal Diameter	-0.64**	-0.61**	-0.50**	-0.05	-0.68**	-0.53**	-0.35**
Number of Samples	49-54	43-53	20-37	25-31	33-42	112-144	170-217

Table 15. Summary of correlation coefficients for selected variables from Conifer Release treatment plots (1993/4 data) with white spruce current height increment as the dependent variable. An "*" and "**" indicate a significant coefficient at P <0.05 and P <0.01, respectively. ND - no data available.

Independent Variables	Control	Disk Trenching & 2 kg/ha Hexazinone	Disk Trenching & 4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching & Brushsawing	Chemical Dosage Series	All Treatments
Nearest Aspen - Distance (cm)	+0.03	-0.01	+0.12	+0.13	-0.23	+0.19*	+0.15*
Nearest Aspen - Height (cm)	-0.03	+0.06	-0.29	-0.11	-0.01	-0.23**	-0.13
Nearest Aspen - Basal Diameter (mm)	-0.06	+0.03	-0.17	-0.11	+0.03	-0.15	-0.06
Tallest Aspen - Distance (cm)	+0.12	+0.18	+0.15	+0.02	+0.05	+0.31**	+0.19**
Tallest Aspen - Height (cm)	+0.03	-0.14	-0.17	-0.20	-0.06	-0.30**	-0.13
Tallest Aspen - Basal Diameter (mm)	+0.04	-0.08	0	-0.23	+0.15	-0.09	+0.02
Aspen Stem Density (number/m^2)	0	-0.18	-0.04	+0.02	+0.19	-0.34**	-0.23**
Aspen Stem Length (cm/m^2)	+0.03	-0.19	-0.08	-0.01	+0.15	-0.33**	-0.21**
Effective Aspen Density (number/m^2)	-0.04	+0.03	+0.34	-0.26	+0.47**	+0.03	-0.03
Aspen Basal Area (cm^2/m^2)	-0.05	-0.18	-0.09	-0.03	+0.09	-0.35**	-0.21**
Shrub >50 cm tall - Distance (cm)	+0.07	-0.11	-0.03	-0.21	-0.03	+0.02	-0.01
Shrub >50 cm tall - Height (cm)	+0.10	+0.07	-0.43**	+0.39*	-0.06	-0.19*	-0.13*
Shrub >50 cm tall - Basal Diameter (mm)	+0.02	+0.01	-0.49**	+0.11	+0.01	-0.23**	-0.08
Shrub Stem Density (number/m^2)	-0.24	-0.23	-0.27	+0.14	-0.32	-0.26**	-0.22**
Shrub Stem Length (cm/m^2)	-0.38**	-0.22	-0.30	+0.10	-0.27	-0.31**	-0.25**
Density of Woody Stems (number/m^2)	-0.21	-0.27	-0.26	+0.11	-0.30	-0.35**	-0.28**
Total Woody Stem Length (cm/m^2)	-0.22	-0.30*	-0.26	+0.06	-0.25	-0.43**	-0.32**
Percent Cover Aspen - C stratum	+0.06	-0.13	-0.08	+0.04	ND	-0.29**	-0.17*
Percent Cover Aspen - B stratum	+0.02	-0.12	-0.21	+0.06	-0.06	-0.15	-0.09
Percent Cover Aspen - A stratum	+0.14	-0.16	-0.14	+0.11	-0.03	-0.08	-0.08
Percent Cover - Total C stratum	+0.02	-0.05	-0.10	+0.18	ND	-0.29**	-0.15*
Percent Cover - Total B stratum	-0.05	-0.08	0	+0.16	-0.20	-0.13	-0.08
Percent Cover - Total A stratum	+0.12	+0.05	-0.17	+0.21	-0.17	-0.12	-0.10
Percent Cover - *Calamagrostis canadensis*	-0.04	-0.28	-0.18	-0.22	+0.09	-0.31**	-0.30**
CI-1 (Tallest Aspen)	-0.12	-0.27	-0.27	+0.05	-0.39*	-0.33**	-0.20**
CI-2 (Nearest Aspen)	-0.11	-0.25	-0.38	-0.29	-0.30	-0.36**	-0.24**
CI-3a (Aspen - C stratum)	-0.11	+0.03	-0.09	-0.10	ND	0	+0.01
CI-3b (Aspen - B stratum)	+0.07	+0.04	-0.10	+0.19	+0.15	+0.02	+0.03
CI-4	-0.31*	-0.21	-0.37	-0.29	+0.09	-0.36**	-0.22**
CI-5	-0.27*	-0.38**	-0.49*	-0.21	-0.55**	-0.43**	-0.33**
CI-6	-0.33*	-0.42**	-0.44*	-0.35	-0.43**	-0.44**	-0.31**
RelHT2	+0.38**	+0.38**	+0.51**	+0.60**	+0.61**	+0.53**	+0.45**
Shrub Basal Diameter/Conifer Basal Diameter	-0.22	-0.44**	-0.59**	+0.07	-0.49**	-0.47**	-0.29**
Number of Samples	49-54	43-53	20-37	25-31	33-42	112-144	170-217

Table 16. Summary of correlation coefficients for selected variables from Conifer Release treatment plots (1993/4 data) with white spruce stem volume as the dependent variable. An "*" and "**" indicate a significant coefficient at P <0.05 and P <0.01, respectively. ND - no data available.

Independent Variables	Control	Disk Trench-ing & 2 kg/ha Hexa-zinone	Disk Trench-ing & 4 kg/ha Hexa-zinone	Rome Double Disking	Disk Trench-ing & Brush-sawing	Chem-ical Dosage Series	All Treat-ments
Nearest Aspen - Distance (cm)	+0.07	0	-0.24	+0.48**	-0.25	+0.08	+0.08
Nearest Aspen - Height (cm)	-0.17	-0.06	-0.43*	-0.22	+0.04	-0.28**	-0.19**
Nearest Aspen - Basal Diameter (mm)	-0.04	-0.02	-0.23	-0.13	+0.07	-0.17*	-0.09
Tallest Aspen - Distance (cm)	+0.20	+0.10	+0.03	+0.15	-0.03	+0.24**	+0.16*
Tallest Aspen - Height (cm)	0	-0.20	-0.43*	-0.38*	-0.13	-0.39**	-0.23**
Tallest Aspen - Basal Diameter (mm)	+0.08	-0.15	-0.33	-0.30	+0.08	-0.24**	-0.10
Aspen Stem Density (number/m^2)	+0.02	-0.16	-0.12	-0.36	+0.23	-0.33**	-0.26**
Aspen Stem Length (cm/m^2)	+0.02	-0.21	-0.23	-0.28	+0.18	-0.34**	-0.25**
Effective Aspen Density (number/m^2)	-0.09	+0.05	+0.52**	-0.17	+0.31*	+0.06	+0.02
Aspen Basal Area (cm^2/m^2)	-0.02	-0.22	-0.26	-0.24	+0.10	-0.34**	-0.24**
Shrub >50 cm tall - Distance (cm)	+0.14	-0.06	+0.02	-0.04	+0.01	+0.04	+0.03
Shrub >50 cm tall - Height (cm)	+0.06	-0.04	-0.18	+0.25	+0.01	-0.11	-0.08
Shrub >50 cm tall - Basal Diameter (mm)	-0.13	-0.02	-0.16	-0.01	+0.05	-0.06	-0.04
Shrub Stem Density (number/m^2)	-0.18	-0.10	-0.41*	-0.01	-0.37*	-0.24**	-0.22**
Shrub Stem Length (cm/m^2)	-0.17	-0.13	-0.41*	-0.10	-0.33	-0.25**	-0.22**
Density of Woody Stems (number/m^2)	-0.14	-0.13	-0.41*	-0.19	-0.35*	-0.32**	-0.29**
Total Woody Stem Length (cm/m^2)	-0.09	-0.23	-0.42*	-0.24	-0.31	-0.39**	-0.33**
Percent Cover Aspen - C stratum	+0.01	-0.19	-0.18	-0.21	ND	-0.31**	-0.21**
Percent Cover Aspen - B stratum	+0.02	-0.07	-0.10	-0.15	+0.04	-0.11	-0.07
Percent Cover Aspen - A stratum	+0.27	+0.08	-0.18	-0.07	-0.04	-0.01	-0.06
Percent Cover - Total C stratum	-0.01	-0.19	-0.19	-0.13	ND	-0.33**	-0.22**
Percent Cover - Total B stratum	-0.03	-0.09	+0.10	-0.18	-0.20	-0.09	-0.07
Percent Cover - Total A stratum	+0.07	+0.13	-0.38*	+0.19	-0.11	-0.18*	-0.15*
Percent Cover - *Calamagrostis canadensis*	+0.06	-0.13	-0.26	+0.09	-0.06	-0.27**	-0.26**
CI-1 (Tallest Aspen)	-0.20	-0.29*	-0.51**	-0.15	-0.38*	-0.35**	-0.25**
CI-2 (Nearest Aspen)	-0.28	-0.33*	-0.52**	-0.23	-0.29	-0.40**	-0.22**
CI-3a (Aspen - C stratum)	-0.19	+0.05	-0.21	-0.24	ND	+0.03	+0.04
CI-3b (Aspen - B stratum)	+0.04	+0.05	+0.07	-0.03	+0.29	+0.05	+0.06
CI-4	-0.48**	-0.18	-0.32	-0.22	-0.03	-0.31**	-0.17*
CI-5	-0.49**	-0.31*	-0.52**	-0.31	-0.61**	-0.41**	-0.34**
CI-6	-0.61**	-0.38**	-0.62**	-0.52**	-0.55**	-0.49**	-0.38**
RELHT2	+0.60**	+0.47**	+0.88**	+0.75**	+0.71**	+0.71**	+0.56**
Shrub Basal Diameter/Conifer Basal Diameter	-0.50**	-0.34*	-0.39*	-0.08	-0.55**	-0.36**	-0.24**
Number of Samples	49-54	43-53	20-37	25-31	33-42	112-144	170-217

3.2 Regression Analysis

Tables 17 through 30 include 256 regression models which were developed from the same variables as used for correlation analysis (Tables 3 through 16), excluding all of the competition indices except CI-3. These tables were organized according to the type of experiment (i.e., Site Preparation or Conifer Release), crop species (i.e., lodgepole pine and white spruce), seedling growth characteristic used as the dependent variable (i.e., height, basal area, volume, and current height increment), and type of experimental treatment. Six different experimental treatment types were recognized for regression analysis:

- Control Plots;
- Rome Double Disking Treatment;
- Disk Trenching Treatment (Site Preparation block only);
- Disk Trenched and Brushsawed Treatment (Conifer Release block only);
- Chemical Dosage Series; and
- All Treatments Combined.

Relative to the correlation analyses, only the 2 kg/ha and 4 kg/ha hexazinone plots were not analyzed separately, since they were already included in the Chemical Dosage Series.

The final regression models included both simple and multiple equations. Correlation coefficients (r) for the 256 regression equations ranged up to 0.72 (Eq. 154 and 177) with values most commonly between 0.33 and 0.50. More than 75 percent of these coefficients were significant at the $P < 0.01$ level, but all were significant at the $P < 0.05$ level. Twenty-three equations explained more than 35 percent of the variance associated with their respective dependent variables, while an additional 46 equations explained more than 25 percent of the variance. Thirteen (57 percent) of these equations had basal diameter as the dependent variable, although they represented only 30 percent of the total number of developed equations. This difference in frequency was statistically significant ($\chi^2 = 28.7$; $P < 0.001$). The number of equations associated with seedling height as the dependent variable was below the expected frequency. The average correlation coefficient produced by either simple or multiple regression was larger for lodgepole pine seedlings than white spruce ($t = 5.4$; $p < 0.001$). Correlation coefficients were also smaller ($t = 3.31$; $P < 0.01$) for the Conifer Release than the Site Preparation experimental blocks, which included significantly lower r-values in the control plots ($t = 2.45$; $p < 0.02$) of the Conifer Release experiments.

The 256 equations included in Tables 17 through 30 represent approximately 88 different combinations of 27 variables (e.g., height and basal diameter of the tallest aspen; basal area of aspen; density and length of woody stems, aspen, and shrubs on a per meter basis). Appendix VII summarizes the general form and identifies specific examples associated with each type of regression equation. Among the more frequently occurring equations were those based on aspen basal area (POP.ba - 28 occurrences), length of aspen stems (POP.cm/m^2 - 20 occurrences), and total length of woody stems (STEM.cm/m^2 - 20 occurrences).

The regression equations developed from the aggregation of data from different treatments potentially represent more robust models than do those developed for a specific treatment, due to an inclusion of a broader spectrum of vegetation conditions.

Table 17. Regression models for predicting *Pinus contorta* seedling height in Site Preparation experimental treatment blocks.

Regression Equation Components		Regression Equation Components	
ba	basal area (cm^2/m^2)	NPOP	nearest aspen
bd	basal diameter (mm)	POP	Aspen
CACA	percent cover *Calamagrostis canadensis*	SHB	nearest shrub
dis	distance (cm)	STEM	all woody stems >50 cm tall
ht	height (cm)	Ta	percent cover A-stratum
HT	seedling height (cm)	Tb	percent cover B-stratum
cm/m^2	stem length per square metre	Tc	percent cover C-stratum
n/m^2	number of stems per square metre	TPOP	tallest aspen

Eq.	Regression Equation	P	r or R	r^2 or R^2
CONTROL PLOTS (n = 47)				
1	HT = 36.555 + 0.33 CACA	0.032	+0.31	0.10
2	HT = 30.828 + 0.236 Ta + 0.345 CACA	0.014	+0.41	0.17
ROME DOUBLE DISKING TREATMENT (n = 72 to 84)				
3	HT = 163.197 - 10.315 √CACA	0.001	-0.55	0.30
4	HT = 101.146 + 0.537 (Ta + Tb) - 8.439 √CACA + 0.449 ([TPOP.dis + NPOP.dis + SHB.dis]/3) + 1.481 POP.ba	0.001	+0.68	0.46
DISK TRENCHING TREATMENT (n = 48 to 49)				
5	HT = 106.655 - 19.825 POP.n/m^2	0.019	-0.33	0.11
6	HT = 105.703 - 0.1 POP.cm/m^2	0.008	-0.37	0.14
7	HT = 113.099 - 0.074 STEM.cm/m^2	0.007	-0.38	0.14
8	HT = 103.530 - 0.628 POP.ba	0.006	-0.38	0.14
9	HT = -54.184 + 1.361 ([TPOP.dis + NPOP.dis + SHB.dis]/3) + 0.738 (Ta + Tb + Tc)	0.005	+0.45	0.20
10	HT = 18.442 + 63.101 $\log_{10}$([Ta + Tb + Tc] ÷ STEM.n/m^2)	0.001	+0.48	0.23
CHEMICAL DOSAGE SERIES - (n = 145 to 171)				
11	HT = 94.493 - 0.133 TPOP.ht	0.001	-0.34	0.12
12	HT = 102.485 - 0.348 (STEM.cm/m^2 ÷ STEM.n/m^2)	0.001	-0.45	0.20
13	HT = 105.642 - 37.805 √POP.n/m^2	0.001	-0.51	0.26
14	HT = 103.089 - 2.485 √POP.cm/m^2	0.001	-0.55	0.30
ALL TREATMENTS COMBINED (n = 258 to 314)				
15	HT = 131.423 - 1.719 TPOP.bd	0.001	-0.47	0.22
16	HT = 128.697 - 0.2 TPOP.ht	0.001	-0.49	0.24
17	HT = 104.847 - 0.089 POP.cm/m^2	0.001	-0.54	0.29
18	HT = 142.001 - 0.389 (POP.cm/m^2 ÷ POP.n/m^2)	0.001	-0.57	0.32
19	HT = 117.914 - 7.324 √POP.ba	0.001	-0.58	0.34
20	HT = 128.795 - 0.061 POP.cm/m^2 - 1.016 TPOP.bd	0.001	-0.58	0.34

Table 18. Regression models for predicting *Pinus contorta* seedling basal diameter in Site Preparation experimental treatment blocks.

Regression Equation Components		Regression Equation Components	
ba	basal area (cm^2/m^2)	NPOP	nearest aspen
bd	basal diameter (mm)	POP	aspen
BD	seedling basal diameter (mm)	SHB	nearest shrub
CACA	percent cover *Calamagrostis canadensis*	STEM	all woody stems >50 cm tall
dis	distance (cm)	Ta	percent cover A-stratum
ht	height (cm)	Tb	percent cover B-stratum
cm/m^2	stem length per square metre	Tc	percent cover C-stratum
n/m^2	number of stems per square metre	TPOP	tallest aspen

Eq.	Regression Equation	P	r or R	r^2 or R^2
CONTROL PLOTS (n = 44 to 57)				
21	BD = 6.367 + 0.07 NPOP.dis	0.021	+0.30	0.09
22	BD = 12.546 - 0.005 POP.cm/m^2	0.023	-0.33	0.11
23	BD = 6.524 + 4.308 $\log_{10}$ (Ta ÷ SHB.n/m^2)	0.004	+0.42	0.17
24	BD = 6.043 + 0.823 $\sqrt{Ta}$	0.002	+0.43	0.18
25	BD = 2.129 + 0.085 NPOP.dis + 0.818 $\sqrt{Ta}$ + 0.091 CACA - 0.398 $\sqrt{Tc}$	0.001	+0.71	0.50
ROME DOUBLE DISKING TREATMENT (n = 69 to 84)				
26	BD = 18.582 + 0.089 ([TPOP.dis + NPOP.dis + SHB.dis]/3)	0.024	+0.26	0.07
27	BD = 32.174 + 0.09 ([Tb + Tc] ÷ POP.n/m^2) - 0.263 CACA	0.001	-0.61	0.37
28	BD = 32.229 - 0.278 CACA + 0.218 Tb	0.001	-0.62	0.38
DISK TRENCHING TREATMENT (n = 46 to 49)				
29	BD = 18.081 - 0.014 SHB.cm/m^2	0.042	-0.29	0.08
30	BD = 20.564 - 0.2 (POP.ba ÷ POP.n/m^2)	0.040	-0.29	0.08
31	BD = 19.482 - 0.015 POP.cm/m^2	0.009	-0.37	0.14
32	BD = 19.166 - 0.092 POP.ba	0.007	-0.38	0.14
33	BD = 21.410 - 0.012 STEM.cm/m^2	0.002	-0.43	0.18
CHEMICAL DOSAGE SERIES (n = 150)				
34	BD = 22.237 - 1.205 $\sqrt{(Ta + Tb + Tc)}$	0.001	-0.45	0.20
35	BD = 21.401 - 3.756 POP.n/m^2	0.001	-0.52	0.27
36	BD = 24.857 - 0.583 $\sqrt{POP.cm/m^2}$	0.001	-0.61	0.37
37	BD = 26.851 - 0.554 $\sqrt{STEM.cm/m^2}$	0.001	-0.62	0.38
38	BD = 24.096 - 1.396 $\sqrt{POP.ba}$	0.001	-0.63	0.40
ALL TREATMENTS COMBINED (n = 259 to 314)				
39	BD = 29.358 - 0.376 TPOP.bd	0.001	-0.52	0.27
40	BD = 24.136 - 0.014 STEM.cm/m^2	0.001	-0.54	0.30
41	BD = 23.504 - 0.019 POP.cm/m^2	0.001	-0.56	0.31
42	BD = 29.604 - 0.047 TPOP.ht	0.001	-0.57	0.32
43	BD = 31.589 - 0.085 (POP.cm/m^2 ÷ POP.n/m^2)	0.001	-0.61	0.37
44	BD = 30.215 - 0.007 STEM.cm/m^2 - 0.036 TPOP.ht	0.001	-0.64	0.41

Table 19. Regression models for predicting *Pinus contorta* stem volume in Site Preparation experimental treatment blocks.

Regression Equation Components

ba	basal area (cm^2/m^2)
bd	basal diameter (mm)
CACA	percent cover *Calamagrostis canadensis*
cm/m^2	stem length per square metre
ht	height (cm)
n/m^2	number of stems per square metre
POP	aspen
SHB	nearest shrub
STEM	all woody stems >50 cm tall
Ta	percent cover A-stratum
Tb	percent cover B-stratum
Tc	percent cover C-stratum
TPOP	tallest aspen
VOL	seedling stem volume (cm^3)

Eq.	Regression Equation	P	r or R	r^2 or R^2
CONTROL PLOTS (n = 47)				
45	VOL = 8.117 + 0.274 Ta	0.019	+0.34	0.12
46	VOL = 25.928 - 0.125 POP.ba	0.015	-0.35	0.12
47	VOL = 54.154 - 3.288 $\sqrt{(STEM.cm/m^2 \div STEM.n/m^2)}$	0.008	-0.38	0.14
48	VOL = 32.517 - 0.023 $STEM.cm/m^2$	0.007	-0.39	0.15
49	VOL = 1.609 + 7.414 $SHB.n/m^2$ + 0.432 CACA - 0.079 $SHB.cm/m^2$	0.001	+0.61	0.37
ROME DOUBLE DISKING TREATMENT (n = 84 to 86)				
50	VOL = 474.248 - (1247.862 ÷ SHB.bd)	0.003	-0.31	0.10
51	VOL = 593.456 - 70.738 $\sqrt{CACA}$	0.001	-0.59	0.35
DISK TRENCHING TREATMENT (n = 49)				
52	VOL = 145.917 - 0.223 $POP.cm/m^2$	0.031	-0.30	0.09
53	VOL = 143.489 - 1.46 POP.ba	0.020	-0.33	0.11
54	VOL = 318.439 - 0.182 $STEM.cm/m^2$ - 3.537 TPOP.bd	0.007	-0.43	0.19
CHEMICAL DOSAGE SERIES (n = 139)				
55	VOL = 171.043 - 0.379 TPOP.ht	0.001	-0.39	0.15
56	VOL = 167.206 - 0.565 $(POP.cm/m^2 \div POP.n/m^2)$	0.001	-0.40	0.16
57	VOL = 227.307 - 121.594 $\sqrt{POP.n/m^2}$	0.001	-0.47	0.22
58	VOL = 227.252 - 0.389 TPOP.ht - 38.392 $\sqrt{POP.n/m^2}$	0.001	-0.50	0.25
ALL TREATMENTS COMBINED (n = 256 to 314)				
59	VOL = 324.076 - 6.162 TPOP.bd	0.001	-0.43	0.18
60	VOL = 313.596 - 0.716 TPOP.ht	0.001	-0.44	0.19
61	VOL = 265.011 - 23.851 $\sqrt{POP.ba}$	0.001	-0.45	0.20
62	VOL = 343.307 - 1.273 $(POP.cm/m^2 \div POP.n/m^2)$	0.001	-0.46	0.21
63	VOL = 376.746 + 1.52 $([Tb + Tc] \div POP.n/m^2)$ - 1.962 CACA - 7.479 TPOP.bd	0.001	-0.49	0.24
64	VOL = 415.934 - 0.791 $(POP.cm/m^2 \div POP.n/m^2)$ - 3.903 TPOP.bd - 1.999 CACA	0.001	-0.50	0.25

Table 20. Regression models for predicting *Picea glauca* seedling height in Site Preparation experimental treatment blocks.

Regression Equation Components		Regression Equation Components	
ba	basal area (cm^2/m^2)	POP	aspen
bd	basal diameter (mm)	SHB	nearest shrub
CI-3a	Competition Index 3a	STEM	all woody stems >50 cm tall
cm/m^2	stem length per square metre	Ta	percent cover A-stratum
dis	distance (cm)	Tb	percent cover B-stratum
HT	seedling height (cm)	Tc	percent cover C-stratum
n/m^2	number of stems per square metre	TPOP	tallest aspen
NPOP	nearest aspen		

Eq.	Regression Equation	P	r or R	r^2 or R^2
CONTROL PLOTS (n = 71 to 83)				
65	HT = 42.432 + 0.31 NPOP.dis	0.008	+0.29	0.08
66	HT = 41.361 + 2.072 SHB.bd	0.004	+0.31	0.10
67	HT = 80.315 - 2.707 √POP.ba	0.005	-0.33	0.11
68	HT = 70.622 - 3.134 √POP.Tb	0.003	-0.34	0.12
69	HT = 25.618 + 0.339 NPOP.dis + 2.183 SHB.bd	0.001	+0.45	0.20
ROME DOUBLE DISKING TREATMENT (n = 41 to 51)				
70	HT = 105.704 - 3.978 (NPOP.ht ÷ NPOP.dis) - 0.333 ([TPOP.dis + NPOP.dis + SHB.dis]/3)	0.034	-0.36	0.13
71	HT = 114.397 - 57.799/(POP.ba ÷ POP.n/m²) - 0.367 ([NPOP.dis + TPOP.dis + SHB.dis]/3)	0.007	-0.47	0.22
72	HT = 155.959 - 7.659 (NPOP.ht ÷ NPOP.dis) - 0.611 ([TPOP.dis + NPOP.dis + SHB.dis]/3) - 86.741÷ (POP.ba ÷ POP.n/m²)	0.001	-0.64	0.41
DISK TRENCHING TREATMENT (n = 50 to 51)				
73	HT = 155.666 - 34.127 log_{10} POP.cm/m²	0.046	-0.28	0.08
74	HT = 102.696 - 0.245 (STEM.cm/m² ÷ STEM.n/m²)	0.025	-0.31	0.10
75	HT = 84.748 - 0.265 POP.ba	0.027	-0.31	0.10
CHEMICAL DOSAGE SERIES (n = 213 to 238)				
76	HT = 47.624 + 0.282 NPOP.dis	0.001	+0.29	0.08
77	HT = 73.669 - 0.267 (Tb + Tc)	0.001	-0.32	0.10
78	HT = 84.582 - 1.104 √POP.cm/m²	0.001	-0.37	0.14
79	HT = 82.295 - 2.943 √POP.ba	0.001	-0.37	0.14
80	HT = 82.677 - 3.294 √(POP.Ta + POP.Tb + POP.Tc)	0.001	-0.37	0.14
81	HT = 79.099 - 3.126 √(POP.Tb + POP.Tc)	0.001	-0.39	0.15
ALL TREATMENTS COMBINED (n = 254 to 318)				
82	HT = 67.930 - 71.188 √CI-3a	0.001	-0.23	0.05
83	HT = 72.627 - 0.257 (POP.Tb + POP.Tc)	0.001	-0.29	0.08
84	HT = 74.964 - 0.025 POP.cm/m²	0.001	-0.31	0.10
85	HT = 73.597 - 0.137 POP.ba	0.001	-0.31	0.10
86	HT = 91.618 - 19.147 log_{10} (POP.Ta + POP.Tb + POP.Tc)	0.001	-0.37	0.14
87	HT = 88.612 - 19.652 log_{10} (POP.Tc + POP.Tb + POP.Tc) + 0.018 SHB.cm/m²	0.001	-0.37	0.14

Table 21. Regression models for predicting *Picea glauca* seedling basal diameter in Site Preparation experimental treatment blocks.

Regression Equation Components		Regression Equation Components	
ba	basal area (cm^2/m^2)	NPOP	nearest aspen
bd	basal diameter (mm)	POP	aspen
BD	Seedling basal diameter (mm)	SHB	nearest shrub
CACA	percent cover *Calamagrostis canadensis*	STEM	all woody stems >50 cm tall
dis	distance (cm)	Ta	percent cover A-stratum
ht	height (cm)	Tb	percent cover B-stratum
cm/m^2	stem length per square metre	Tc	percent cover C-stratum
n/m^2	number of stems per square metre	TPOP	tallest aspen

Eq.	Regression Equation	P	r or R	r^2 or R^2
CONTROL PLOTS (n = 69 to 71)				
88	BD = 3.449 + 3.102 $\log_{10}$ SHB.cm/m^2	0.014	+0.29	0.08
89	BD = 12.849 - 0.171 ([Ta + Tb + Tc] ÷ STEM.n/m^2)	0.011	-0.30	0.09
ROME DOUBLE DISKING TREATMENT (n = 51 to 53)				
90	BD = 32.422 - 9.701 $\log_{10}$ TPOP.dis	0.027	-0.30	0.09
91	BD = 21.573 - 1.044 (NPOP.ht ÷ NPOP.dis) - 0.079 ([TPOP.dis + NPOP.dis + SHB.dis]/3)	0.030	-0.37	0.14
DISK TRENCHING TREATMENT (n = 50 to 62)				
92	BD = 19.228 - 0.169 TPOP.bd	0.031	-0.27	0.07
93	BD = 14.798 - 0.052 POP.ba	0.010	-0.35	0.12
94	BD = 30.412 - 7.39 $\log_{10}$ POP.cm/m^2	0.009	-0.36	0.13
95	BD = 30.057 - 8.259 $\log_{10}$ POP.cm/m^2 + 0.117 NPOP.bd	0.005	-0.45	0.20
96	BD = 11.005 + 4.001 POP.n/m^2 + 0.153 NPOP.bd - 0.026 POP.cm/m^2	0.001	+0.54	0.29
CHEMICAL DOSAGE SERIES (n = 200 to 237)				
97	BD = -12.187 + 13.57 $\log_{10}$ ([TPOP.dis + NPOP.dis + SHB.dis]/3)	0.001	+0.22	0.05
98	BD = 19.153 - 0.03 (POP.cm/m^2 ÷ POP.n/m^2)	0.002	-0.22	0.05
99	BD = 27.187 - 0.805 √TPOP.ht	0.002	-0.24	0.06
100	BD = 14.455 - 6.687 $\log_{10}$ POP.n/m^2	0.004	-0.25	0.06
101	BD = 17.624 - 0.609 √POP.ba	0.001	-0.27	0.07
102	BD = -3.473 - 1.253 POP.n/m^2 + 10.299 $\log_{10}$ ([TPOP.dis + NPOP.dis + SHB.dis]/3)	0.001	+0.27	0.07
ALL TREATMENTS COMBINED (n = 317)				
103	BD = 14.669 - 0.03 POP.ba	0.001	-0.22	0.05
104	BD = 14.933 - 0.005 POP.cm/m^2	0.001	-0.22	0.05
105	BD = 15.723 - 0.033 POP.ba - 0.079 CACA	0.001	-0.26	0.07

Table 22. Regression models for predicting *Picea glauca* stem volume in Site Preparation experimental treatment blocks.

Regression Equation Components		Regression Equation Components	
ba	basal area (cm^2/m^2)	POP	aspen
CACA	percent cover *Calamagrostis canadensis*	SHB	nearest shrub
cm/m^2	stem length per square metre	STEM	all woody stems >50 cm tall
dis	distance (cm)	Ta	percent cover A-stratum
ht	height (cm)	Tc	percent cover C-stratum
n/m^2	number of stems per square metre	TPOP	tallest aspen
NPOP	nearest aspen	VOL	seedling stem volume (cm^3)

Eq.	Regression Equation	P	r or R	r^2 or R^2
CONTROL PLOTS (n = 70 to 71)				
106	VOL = 12.626 + 2.866 SHB.n/m^2	0.025	+0.26	0.07
107	VOL = 4.762 + 1.113 SHB.cm/m^2	0.007	+0.32	0.10
ROME DOUBLE DISKING TREATMENT (n = 51 to 54)				
108	VOL = -13.36 + (5090.331 ÷ NPOP.ht)	0.018	+0.32	0.10
109	VOL = 143.29 - 0.896 ([TPOP.dis + NPOP.dis + SHB.dis]/3) - 10.774 (NPOP.ht ÷ NPOP.dis)	0.013	-0.40	0.16
DISK TRENCHING TREATMENT (n = 51)				
110	VOL = 64.497 - 0.071 POP.cm/m^2	0.022	-0.32	0.10
111	VOL = 61.310 - 0.408 POP.ba	0.020	-0.32	0.10
112	VOL = 21.168 + 0.838 Ta	0.010	+0.35	0.12
113	VOL = 27.373 + 0.689 Ta - 0.526 POP.ba + 7.349 (NPOP.ht ÷ NPOP.dis)	0.001	+0.57	0.32
CHEMICAL DOSAGE SERIES (n = 214 to 233)				
114	VOL = -23.861 + 0.963 ([TPOP.dis + NPOP.dis + SHB.dis]/3)	0.001	+0.24	0.06
115	VOL = 99.909 - 6.644 √POP.ba	0.001	-0.26	0.07
116	VOL = 105.144 - 2.898 √POP.cm/m^2	0.001	-0.27	0.07
117	VOL = 42.193 + 1.337 POP.Ta + 0.385 SHB.dis - 0.052 POP.cm/m^2	0.001	+0.32	0.10
ALL TREATMENTS COMBINED (n = 317)				
118	VOL = 72.147 - 0.709 CACA + 0.896 POP.Ta - 0.06 POP.cm/m^2	0.001	-0.27	0.07

Table 23. Regression models for predicting *Pinus contorta* seedling height in Conifer Release experimental treatment blocks.

Regression Equation Components		Regression Equation Components	
ba	basal area (cm^2/m^2)	n/m^2	number of stems per square meter
bd	basal diameter (mm)	POP	aspen
CI-3a	Competition Index 3a	SHB	nearest shrub
CI-3b	Competition Index 3b	STEM	all woody stems >50 cm tall
EPD	effective aspen density (n/m^2)	Ta	percent cover A-stratum
ht	height (cm)	Tb	percent cover B-stratum
HT	seedling height (cm)	Tc	percent cover C-stratum
cm/m^2	stem length per square metre	TPOP	tallest aspen

Eq.	Regression Equation	P	r or R	r^2 or R^2
CONTROL PLOTS (n = 23)				
119	HT = 102.075 - 5.826 $\sqrt{\text{Tc}}$	0.045	-0.41	0.17
120	HT = 139.586 - 0.253 (POP.cm/m^2 ÷ POP.n/m^2)	0.042	-0.42	0.18
121	HT = 143.259 - 3.381 $\sqrt{\text{POP.cm/m}^2}$	0.042	-0.42	0.18
122	HT = 135.885 - 7.144 $\sqrt{\text{POP.ba}}$	0.036	-0.43	0.18
ROME DOUBLE DISKING TREATMENT (n = 57 to 61)				
123	HT = 105.001 + 5.695 $\sqrt{\text{Tb}}$	0.014	+0.31	0.10
124	HT = 114.188 - 0.696 EPD + 0.763 POP.ba	0.003	+0.43	0.18
DISK TRENCHING FOLLOWED BY BRUSHSAWING TREATMENT (n = 50 to 58)				
125	HT = 53.299 + 4.319 SHB.bd	0.023	+0.30	0.09
126	HT = 102.064 - 0.596 POP.ba	0.029	-0.31	0.10
127	HT = 129.476 - 0.211 TPOP.ht	0.007	-0.35	0.12
128	HT = 176.252 - 0.782 (STEM.cm/m^2 ÷ STEM.n/m^2)	0.001	-0.46	0.21
129	HT = 134.186 + 5.374 SHB.bd - 1.069 (STEM.cm/m^2 ÷ STEM.n/m^2) - 140.313 CI-3b + 5.787 $\sqrt{(\text{Ta + Tb + Tc})}$	0.001	-0.70	0.49
CHEMICAL DOSAGE SERIES (n = 35 to 95)				
130	HT = 0.103 + 61.549 $\log_{10}$ ([Tb + Tc] ÷ POP.n/m^2)	0.013	+0.33	0.11
131	HT = 162.864 - 0.181 TPOP.ht	0.001	-0.41	0.17
132	HT = 176.216 - 48.605 $\sqrt{\text{SHB.n/m}^2}$	0.001	-0.45	0.20
133	HT = 15.806 - 0.874 (POP.ba ÷ POP.n/m^2) + 73.423 $\log_{10}$ ([Tb + Tc] ÷ POP.n/m^2)	0.002	+0.46	0.21
134	HT = 137.281 - 0.139 POP.cm/m^2	0.001	-0.47	0.22
135	HT = 180.793 - 3.979 $\sqrt{\text{STEM.cm/m}^2}$	0.001	-0.53	0.28
136	HT = 104.380 + 0.966 Tb - 39.275 POP.n/m^2 + 0.443 SHB.dis	0.001	-0.58	0.34
137	HT = 12.325 - 40.804 ($\log_{10}$ CI-3a)	0.001	-0.58	0.34
ALL TREATMENTS COMBINED (n = 197 to 208)				
138	HT = 70.341 + 35.994 $\log_{10}$ ([Ta + Tb + Tc] ÷ STEM.n/m^2)	0.001	+0.22	0.05
139	HT = 130.088 - 5.009 $\sqrt{\text{POP.ba}}$	0.001	-0.27	0.07
140	HT = 152.102 - 2.273 $\sqrt{\text{STEM.cm/m}^2}$	0.001	-0.33	0.11
141	HT = 124.602 + 0.631 Tb - 60.926 $\log_{10}$ STEM.n/m^2	0.001	-0.39	0.15

Table 24. Regression models for predicting *Pinus contorta* basal diameter in Conifer Release experimental treatment blocks.

Regression Equation Components		Regression Equation Components	
ba	basal area (cm^2/m^2)	NPOP	nearest aspen
bd	basal diameter (mm)	POP	aspen
BD	seedling basal diameter (mm)	STEM	all woody stems >50 cm tall
dis	distance (cm)	Ta	percent cover A-stratum
ht	height (cm)	Tb	percent cover B-stratum
cm/m^2	stem length per square metre	Tc	percent cover C-stratum
n/m^2	number of stems per square metre	TPOP	tallest aspen

Eq.	Regression Equation	P	r or R	r^2 or R^2
CONTROL PLOTS (n = 23)				
142	BD = 18.956 - 4.11 POP.n/m^2	0.012	-0.50	0.25
143	BD = 23.163 - 1.251 √POP.ba	0.004	-0.56	0.32
144	BD = 52.929 - 15.59 log_{10} POP.cm/m^2	0.001	-0.62	0.38
ROME DOUBLE DISKING TREATMENT		No significant equations		
DISK TRENCHING FOLLOWED BY BRUSHSAWING TREATMENT (n = 50)				
145	BD = 19.104 - 0.111 POP.ba	0.028	-0.31	0.10
146	BD = 20.893 - 0.007 STEM.cm/m^2	0.025	-0.31	0.10
147	BD = 32.742 - 0.144 (STEM.cm/m^2 ÷ STEM.n/m^2)	0.001	-0.45	0.20
CHEMICAL DOSAGE SERIES (n = 77 to 95)				
148	BD = 31.437 - 0.489 TPOP.bd + 0.309 ([Ta + Tb + Tc] ÷ STEM.n/m^2)	0.001	-0.57	0.32
149	BD = 30.529 - 0.038 POP.cm/m^2	0.001	-0.57	0.32
150	BD = 33.264 - 2.309 √POP.ba	0.001	-0.59	0.35
151	BD = 32.558 - 11.24 POP.n/m^2	0.001	-0.60	0.36
152	BD = 31.392 - 0.422 TPOP.bd + 0.318 ([Ta + Tb + Tc] ÷ STEM.n/m^2) - 0.444 (NPOP.ht ÷ NPOP.dis)	0.001	-0.60	0.36
153	BD = 42.899 - 1.112 √STEM.cm/m^2	0.001	-0.66	0.44
154	BD = 43.374 - 0.033 TPOP.ht - 1.502 √POP.Ta - 2.883 STEM.n/m^2	0.001	-0.72	0.52
ALL TREATMENTS COMBINED (n = 186 to 208)				
155	BD = 28.070 - 1.672 √POP.ba	0.001	-0.45	0.20
156	BD = 29.146 - 0.713 √POP.cm/m^2	0.001	-0.46	0.21
157	BD = 23.833 - 0.27 TPOP.bd + 0.336 ([Ta + Tb + Tc] ÷ STEM.n/m^2) - 0.242 (NPOP.ht ÷ NPOP.dis)	0.001	-0.47	0.22
158	BD = 30.793 - 1.763 √CACA - 0.07 POP.ba - 0.821 √(POP.Ta + POP.Tb + POP.Tc)	0.001	-0.51	0.26
159	BD = 34.756 - 0.723 √STEM.cm/m^2	0.001	-0.52	0.27
160	BD = 31.726 - 0.017 TPOP.ht - 14.8 log_{10} STEM.n/m^2	0.001	-0.56	0.31

Table 25. Regression models for predicting *Pinus contorta* current growth increment in Conifer Release experimental treatment blocks.

Regression Equation Components		Regression Equation Components	
ba	basal area (cm^2/m^2)	n/m^2	number of stems per square metre
CACA	percent cover *Calamagrostis canadensis*	POP	aspen
CG	current seedling growth (cm)	SHB	nearest shrub
CI-3a	Competition Index 3a	STEM	all woody stem >50 cm tall
cm/m^2	stem length per square metre	Tb	percent cover B-stratum
dis	distance (cm)	Tc	percent cover C-stratum
EPD	effective aspen density (n/m^2)	TPOP	tallest aspen
ht	height (cm)		

Eq.	Regression Equation	P	r or R	r^2 or R^2
CONTROL PLOTS (n = 23 to 25)				
161	CG = 8.815 + 0.214 SHB.dis	0.041	+0.40	0.16
162	CG = 13.713 + 0.279 POP.Tb	0.048	+0.41	0.17
163	CG = 39.869 - 0.611 CACA - 0.149 POP.ba	0.004	-0.64	0.41
ROME DOUBLE DISKING TREATMENT (n = 61)				
164	CG = 21.663 + 0.256 Tb	0.007	+0.34	0.12
DISK TRENCHING FOLLOWED BY BRUSHSAWING TREATMENT (n = 50 to 58)				
165	CG = 32.542 - 0.017 STEM.cm/m^2	0.004	-0.39	0.15
166	CG = 40.393 - 0.091 TPOP.ht	0.001	-0.41	0.17
167	CG = 66.048 - 0.067 TPOP.ht - 0.271 (STEM.cm/m^2 ÷ STEM.n/m^2)	0.001	-0.59	0.35
CHEMICAL DOSAGE SERIES (n = 35 to 94)				
168	CG = 22.512 - 13.277 $\log_{10}$POP.n/m^2	0.010	-0.30	0.09
169	CG = 44.225 - 16.852 $\log_{10}$ Tc	0.049	-0.33	0.11
170	CG = 27.443 - 0.333 Tb - 2.661 STEM.n/m^2	0.001	-0.40	0.16
171	CG = 4.287 - 9.353 $\log_{10}$ CI-3a	0.003	-0.48	0.23
ALL TREATMENTS COMBINED (n = 186)				
172	CG = 27.468 + 0.188 Tb - 0.063 EPD - 0.012 STEM.cm/m^2	0.001	+0.33	0.11

Table 26. Regression models for predicting *Pinus contorta* stem volume in Conifer Release experimental treatment blocks.

Regression Equation Components		Regression Equation Components	
ba	basal area (cm^2/m^2)	POP	aspen
bd	basal diameter (mm)	SHB	nearest shrub
CACA	percent cover *Calamagrostis canadensis*	STEM	all woody stems >50 cm tall
cm/m^2	stem length per square metre	Ta	percent cover of A-stratum
dis	distance (cm)	Tb	percent cover of B-stratum
ht	height (cm)	Tc	percent cover of C-stratum
n/m^2	number of stems per square metre	TPOP	tallest aspen
NPOP	nearest aspen	VOL	seedling stem volume (cm^3)

Eq.	Regression Equation	P	r or R	r^2 or R^2
CONTROL PLOTS (n = 23 to 25)				
173	VOL = -5.887 + 0.243 ([TPOP.dis + NPOP.dis + SHB.dis]/3)	0.049	+0.39	0.15
174	VOL = 93.262 - 30.364 POP.n/m^2	0.042	-0.42	0.18
175	VOL = 322.916 - 115.214 $\log_{10}$ NPOP.ht	0.010	-0.50	0.25
176	VOL = 158.381 - 22.145 √NPOP.bd	0.002	-0.57	0.32
177	VOL = 544.791 - 1.513 CACA - 182.463 $\log_{10}$ POP.cm/m^2	0.001	-0.72	0.52
ROME DOUBLE DISKING TREATMENT		No significant equations		
DISK TRENCHING FOLLOWED BY BRUSHSAWING TREATMENT (n = 50 to 58)				
178	VOL = 167.187 - 0.108 STEM.cm/m^2	0.043	-0.28	0.08
179	VOL = 218.518 - 0.611 TPOP.ht	0.015	-0.32	0.10
180	VOL = 367.109 - 2.406 (STEM.cm/m^2 ÷ STEM.n/m^2)	0.002	-0.43	0.18
181	VOL = 276.928 + 15.176 SHB.bd - 2.613 (STEM.cm/m^2 ÷ STEM.n/m^2)	0.001	+0.52	0.27
CHEMICAL DOSAGE SERIES (n = 71 to 95)				
182	VOL = 671.527 - 316.073 $\log_{10}$ POP.ba	0.001	-0.43	0.18
183	VOL = 649.275 - 79.534 √(POP.Ta + POP.Tb + POP.Tc)	0.001	-0.45	0.20
184	VOL = 543.302 - 14.292 TPOP.bd + 10.999 ([Ta + Tb + Tc] ÷ STEM.n/m^2)	0.001	-0.52	0.27
185	VOL = 989.032 - 35.767 √STEM.cm/m^2	0.001	-0.53	0.28
186	VOL = 1362.627 - 0.714 TPOP.ht - 77.39 √Ta - 330.285 √STEM.n/m^2	0.001	-0.70	0.49
ALL TREATMENTS COMBINED (n = 186 to 208)				
187	VOL = 416.652 - 46.024 √(POP.Ta + POP.Tb + POP.Tc)	0.001	-0.32	0.10
188	VOL = 504.081 - 71.089 √Ta	0.001	-0.34	0.12
189	VOL = 280.256 - 57.227 √CACA + 7.59 ([Ta + Tb + Tc] ÷ STEM.n/m^2)	0.001	-0.42	0.18
190	VOL = 1232.577 - 402.9 $\log_{10}$ STEM.cm/m^2	0.001	-0.43	0.18
191	VOL = 922.261 - 44.379 √CACA - 215.777 $\log_{10}$ SHB.cm/m^2 - 27.812 √(POP.Ta + POP.Tb + POP.Tc)	0.001	-0.46	0.21
192	VOL = 434.425 - 44.566 √CACA - 8.433 TPOP.bd + 9.865 ([Ta + Tb + Tc] ÷ STEM.n/m^2)	0.001	-0.50	0.25
193	VOL = 586.744 - 0.357 TPOP.ht + 2.479 Tb - 459.565 $\log_{10}$ STEM.n/m^2 - 35.566 √CACA	0.001	-0.57	0.32

Table 27. Regression models for predicting *Picea glauca* seedling height in Conifer Release experimental treatment blocks.

Regression Equation Components		Regression Equation Components	
CACA	percent cover *Calamagrostis canadensis*	NPOP	nearest aspen
cm/m^2	stem length per square metre	POP	aspen
dis	distance (cm)	SHB	nearest shrub
EPD	effective aspen density (n/m^2)	STEM	all woody stems >50 cm tall
ht	height (cm)	Tb	percent cover B-stratum
HT	seedling height (cm)	Tc	percent cover C-stratum
n/m^2	number of stems per square metre	TPOP	tallest aspen

Eq.	Regression Equation	P	r or R	r^2 or R^2
CONTROL PLOTS		No significant equations		
ROME DOUBLE DISKING TREATMENT		No significant equations		
DISK TRENCHING FOLLOWED BY BRUSHSAWING TREATMENT (n = 40)				
194	HT = 70.531 + 0.147 EPD	0.032	+0.33	0.11
195	HT = 65.410 + 1.952 (NPOP.ht ÷ NPOP.dis)	0.028	+0.34	0.12
CHEMICAL DOSAGE SERIES (n = 101 to 128)				
196	HT = 109.420 - 0.062 TPOP.ht	0.001	-0.34	0.12
197	HT = 227.302 - 59.997 $\log_{10}$ (POP.cm/m^2 ÷ POP.n/m^2)	0.001	-0.40	0.16
198	HT = 99.653 - 4.721 $\sqrt{CACA}$ - 0.179 Tc	0.001	-0.41	0.17
199	HT = 108.297 - 48.152 $\log_{10}$ STEM.n/m^2	0.001	-0.44	0.19
200	HT = 179.476 - 36.4 $\log_{10}$ STEM.cm/m^2	0.001	-0.48	0.23
ALL TREATMENTS COMBINED (n = 71 to 120)				
201	HT = 110.175 - 21.123 $\log_{10}$ Tc	0.012	-0.29	0.08
202	HT = 94.524 - 4.943 $\sqrt{CACA}$	0.001	-0.34	0.12
203	HT = 101.721 - 39.704 $\log_{10}$ STEM.n/m^2	0.001	-0.37	0.14
204	HT = 98.194 - 4.657 $\sqrt{CACA}$ - 0.13 ([Tb + Tc] ÷ POP.n/m^2)	0.001	-0.38	0.14
205	HT = 157.91 - 29.515 $\log_{10}$ STEM.cm/m^2	0.001	-0.39	0.15
206	HT = 137.735 - 4.01 $\sqrt{CACA}$ - 19.962 $\log_{10}$ SHB.cm/m^2	0.001	-0.44	0.19
207	HT = 150.857 - 3.608 $\sqrt{CACA}$ - 23.053 $\log_{10}$ STEM.cm/m^2	0.001	-0.46	0.21

Table 28. Regression models for predicting *Picea glauca* seedling basal diameter in Conifer Release experimental treatment blocks.

Regression Equation Components		Regression Equation Components	
ba	basal area (cm^2/m^2)	n/m^2	number of stems per square metre
bd	basal diameter (mm)	POP	aspen
BD	seedling basal diameter (mm)	STEM	all woody stems >50 cm tall
CACA	percent cover *Calamagrostis canadensis*	Ta	percent cover A-stratum
CI-3a	competition index 3a	Tb	percent cover B-stratum
cm/m^2	stem length per square metre	Tc	percent cover C-stratum
dis	distance (cm)	TPOP	tallest aspen
ht	height (cm)		

Eq.	Regression Equation	P	r or R	r^2 or R^2
CONTROL PLOTS (n = 48)				
208	BD = 11.341 - 13.261 CI-3a	0.032	-0.31	0.10
ROME DOUBLE DISKING TREATMENT (n = 30)				
209	BD = 22.124 - 6.725 $\log_{10}$ TPOP.bd	0.010	-0.46	0.21
210	BD = 11.190 + 0.03 NPOP.dis	0.004	+0.50	0.25
211	BD = 30.441 - 7.499 $\log_{10}$ TPOP.ht	0.001	-0.59	0.35
DISK TRENCHING FOLLOWED BY BRUSHSAWING TREATMENT		No significant equations		
CHEMICAL DOSAGE SERIES (n = 101 to 122)				
212	BD = 33.733 - 8.162 $\log_{10}$ POP.cm/m^2	0.001	-0.53	0.28
213	BD = 21.707 - 13.722 $\log_{10}$ STEM.n/m^2	0.001	-0.54	0.29
214	BD = 44.963 - 0.042 (Ta + Tb + Tc) - 11.591 $\log_{10}$ (POP.cm/m^2 ÷ POP.n/m^2)	0.001	-0.55	0.30
215	BD = 24.996 - 6.721 $\log_{10}$ POP.ba	0.001	-0.55	0.30
216	BD = 42.999 - 10.76 $\log_{10}$ STEM.cm/m^2	0.001	-0.61	0.37
217	BD = 27.116 - 0.014 TPOP.ht - 0.827 √CACA - 2.527 √STEM.n/m^2	0.001	-0.63	0.40
ALL TREATMENTS COMBINED (n = 169 to 181)				
218	BD = 17.457 - 0.058 (Ta + Tb + Tc)	0.001	-0.36	0.13
219	BD = 17.875 - 0.629 √POP.ba	0.001	-0.41	0.17
220	BD = 18.459 - 0.298 √POP.cm/m^2	0.001	-0.41	0.17
221	BD = 19.917 - 10.806 $\log_{10}$ STEM.n/m^2	0.001	-0.46	0.21
222	BD = 21.094 - 0.008 TPOP.ht - 0.952 √CACA - 0.003 STEM.cm/m^2	0.001	-0.55	0.30

Table 29. Regression models for predicting *Picea glauca* current growth increment in Conifer Release experimental treatment blocks.

Regression Equation Components	
CACA	percent cover *Calamagrostis canadensis*
CG	current seedling growth (cm)
cm/m^2	stem length per square metre
dis	distance (cm)
ht	height (cm)
n/m^2	number of stems per square metre
NPOP	nearest aspen (cm)
POP	aspen
SHB	nearest shrub
STEM	all woody stems >50 cm tall
Tb	percent cover B-stratum
Tc	percent cover C-stratum
TPOP	tallest aspen

Eq.	Regression Equation	P	r or R	r^2 or R^2
CONTROL PLOTS (n = 48)				
223	CG = 13.72 - 0.008 SHB.cm/m^2	0.006	-0.38	0.14
ROME DOUBLE DISKING TREATMENT (n = 30)				
224	CG = 2.909 + 0.115 SHB.ht	0.031	+0.39	0.15
DISK TRENCHING FOLLOWED BY BRUSHSAWING TREATMENT (n = 32 to 40)				
225	CG = 9.633 + 0.539 (NPOP.ht ÷ NPOP.dis)	0.005	+0.43	0.18
226	CG = 11.871 + 0.711 (NPOP.ht ÷ NPOP.dis) -1.277 (TPOP.ht ÷ TPOP.dis)	0.001	+0.55	0.30
227	CG = 10.761 + 0.685 (NPOP.ht ÷ NPOP.dis) - 1.177 (TPOP.ht ÷ TPOP.dis) + 0.101 (Ta ÷ SHB.n/m^2)	0.002	+0.63	0.40
CHEMICAL DOSAGE SERIES (n = 116 to 145)				
228	CG = 28.141 - 5.069 $\log_{10}$ SHB.cm/m^2 - 0.563 $\sqrt{}$(POP.Ta + POP.Tb + POP.Tc)	0.001	-0.40	0.16
229	CG = 28.221 - 8.124 $\log_{10}$ (Ta + Tb + Tc)	0.001	-0.40	0.16
230	CG = 18.503 - 1.698 $\sqrt{\text{CACA}}$	0.001	-0.41	0.17
231	CG = 21.401 - 13.028 $\log_{10}$ STEM.n/m^2	0.001	-0.45	0.20
232	CG = 27.567 - 1.251 $\sqrt{\text{CACA}}$ - 6.08 $\log_{10}$ (Ta + Tb + Tc)	0.001	-0.49	0.24
233	CG = 40.807 - 9.905 $\log_{10}$ STEM.cm/m^2	0.001	-0.50	0.25
ALL TREATMENTS COMBINED (n = 178 to 181)				
234	CG = 18.957 - 9.928 $\log_{10}$ STEM.n/m^2	0.001	-0.36	0.13
235	CG = 33.218 - 7.462 $\log_{10}$ STEM.cm/m^2	0.001	-0.38	0.14
236	CG = 17.749 - 1.451 $\sqrt{\text{CACA}}$	0.001	-0.39	0.15
237	CG = 27.976 - 1.221 $\sqrt{\text{CACA}}$ - 4.738 $\log_{10}$ SHB.cm/m^2	0.001	-0.46	0.21
238	CG = 31.011 - 5.439 $\log_{10}$ STEM.cm/m^2 - 1.129 $\sqrt{\text{CACA}}$	0.001	-0.47	0.22

Table 30. Regression models for predicting *Picea glauca* stem volume in Conifer Release experimental treatment blocks.

Regression Equation Components		Regression Equation Components	
ba	basal area (cm^2/m^2)	POP	aspen
bd	basal diameter (mm)	SHB	nearest shrub
CACA	percent cover *Calamagrostis canadensis*	STEM	all woody stems >50 cm tall
cm/m^2	stem length per square metre	Ta	percent cover of A-stratum
dis	distance (cm)	Tb	percent cover of B-stratum
ht	height (cm)	Tc	percent cover of C-stratum
n/m^2	number of stems per square metre	TPOP	tallest aspen
NPOP	nearest aspen	VOL	seedling stem volume (cm^3)

Eq.	Regression Equation	P	r or R	r^2 or R^2
	CONTROL PLOTS	No significant equations		
	ROME DOUBLE DISKING TREATMENT (n = 24 to 30)			
239	VOL = 110.479 - 53.698 $\log_{10}$ TPOP.bd	0.039	-0.37	0.14
240	VOL = 60.933 - 28.314 $\sqrt{}$POP.n/m^2	0.032	-0.43	0.18
241	VOL = 172.699 - 58.089 $\log_{10}$ TPOP.ht	0.009	-0.46	0.21
242	VOL = 20.898 + 0.285 NPOP.dis	0.006	+0.48	0.23
	DISK TRENCHING FOLLOWED BY BRUSHSAWING TREATMENT (n = 32 to 40)			
243	VOL = 112.824 - 41.679 $\log_{10}$ NPOP.dis	0.033	-0.33	0.11
244	VOL = 80.816 - 6.589 STEM.n/m^2	0.045	-0.35	0.12
245	VOL = 30.152 + 3.538 (NPOP.ht ÷ NPOP.dis)	0.019	+0.37	0.14
246	VOL = 19.418 + 3.508 (NPOP.ht ÷ NPOP.dis) +0.719 (Ta ÷ SHB.n/m^2)	0.005	+0.55	0.30
	CHEMICAL DOSAGE SERIES (n = 111 to 128)			
247	VOL = 151.796 - 1.098 (Ta + Tb + Tc)	0.001	-0.36	0.13
248	VOL = 155.073 - 10.981 $\sqrt{}$POP.ba	0.001	-0.38	0.14
249	VOL = 176.771 - 0.245 TPOP.ht	0.001	-0.39	0.15
250	VOL = 211.639 - 0.237 TPOP.ht - 9.609 STEM.n/m^2	0.001	-0.45	0.20
251	VOL = 508.358 - 162.916 $\log_{10}$ STEM.cm/m^2	0.001	-0.51	0.26
	ALL TREATMENTS COMBINED (n = 180 to 181)			
252	VOL = 111.920 - 7.547 $\sqrt{}$POP.ba	0.001	-0.28	0.08
253	VOL = 121.886 - 19.3 $\sqrt{}$CACA	0.001	-0.35	0.12
254	VOL = 159.172 - 174.244 $\log_{10}$ STEM.n/m^2	0.001	-0.42	0.18
255	VOL = 401.950 - 128.066 $\log_{10}$ STEM.cm/m^2	0.001	-0.44	0.19
256	VOL = 377.049 - 12.737 $\sqrt{}$CACA - 105.248 $\log_{10}$ STEM.cm/m^2	0.001	-0.49	0.24

Within the All Treatments Combined group for both the Site Preparation and Conifer Release experiments, 27 regression equations had correlation values of at least 0.45 (r^2 = >20 percent explained variance). Six (Eq. 207, 221, 222, 237, 238, and 256) of these equations were for white spruce, while the remaining were for lodgepole pine. Table 31 identifies the variables that occurred in the best lodgepole pine equations. There were too few equations to assess white spruce. No obvious associations occurred between the degree of correlation and the dependent variables in this data. However, height of the tallest aspen within 180 cm of the seedling occurred in three of the four best basal diameter equations as well as in the best volume equation, and percent cover of *Calamagrostis canadensis* occurred in all three volume equations.

Table 31. A comparison of independent variables for the best regression models in the All Treatments Combined group from the Site Preparation and Conifer Release experiment plots. Cells marked with a "P" represent the primary or the most important variables in each regression equation, according to lodgepole pine seedling growth characteristics (BD - basal diameter, HT - height, VOL - stem volume).

Equation Number	155	156	157	158	159	39	40	41	160	42	43	44
Dependent Variable	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD	BD
Correlation Coefficient	0.45	0.46	0.47	0.51	0.52	0.52	0.54	0.56	0.56	0.57	0.61	0.64
POP.ba	P			X								
POP.cm/m^2		P						P				
TPOP.bd			X			P						
Ta+Tb+Tc ÷ STEM.n/m^2			P									
NPOP.ht ÷ NPOP.dis			X									
CACA				P								
POP.Ta+POP.Tb+POP.Tc				X								
STEM.cm/m^2					P		P					X
STEM.n/m^2									X			
TPOP.ht									P	P		P
POP.cm/m^2 ÷ POP.n/m^2											P	

Equation Number	15	16	17	18	19	20	64	192	193
Dependent Variable	HT	HT	HT	HT	HT	HT	VOL	VOL	VOL
Correlation Coefficient	0.47	0.49	0.54	0.57	0.58	0.58	0.50	0.50	0.57
TPOP.bd	P					X	X	X	
TPOP.ht		P							X
POP.cm/m^2			P			P			
POP.cm/m^2 ÷ POP.n/m^2				P			P		
POP.ba					P				
Ta+Tb+Tc ÷ STEM.n/m^2								P	
STEM.n/m^2									P
Tb									X
CACA							X	X	X

From a practical perspective, it is often necessary to use models or indices that can be quickly and reliably applied in the field. Four equations within Table 31 generally fit these conditions: Equations 44, 43, 42, and 160. Each of these equations was based on lodgepole pine basal diameter, contains one or two variables, and explained a large amount of variance in the crop seedlings relative to the other equations. The first three equations were developed for data from the Site Preparation experiments, while Equation 160 is for lodgepole pine in the Conifer Release plots.

Figure 2 is a comparison of measured lodgepole pine seedling basal diameter values with those predicted by Equations 44, 43, 42, and 160 (See Tables 18 and 24 for formulae). A strong statistical correlation occurred between the predicted and observed values for Equations 44 and 42, but only a moderately strong relationship occurred for Equations 160 and 43. While the correlations between observed and predicted values were significant ($P < 0.0001$) for all four equations, they had a standard error of ± 6.0 to 9.5 mm. Among the Site Preparation equations, 44 and 42 had smaller standard errors (e.g., 8.3 mm) and similar predictive capabilities. Equation 160 for the Conifer Release experiments had a standard error of 8.9 mm and a 0.48 simple correlation coefficient between observed and predicted basal diameter values.

Equations 44 and 42 were not equally applicable to all treatments within the Site Preparation experiments for which they were developed as indicated in the following matrix.

Eq.	Control	2 kg/ha Hexazinone	4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching	Chemical Series	All Treatments Combined
44	-	+0.72	+0.37	+0.27	+0.27	+0.60	+0.59
42	-	+0.70	+0.36	+0.29	-	+0.60	+0.57

The strongest correlations between observed and predicted lodgepole pine basal diameter values occurred in the 2 kg/ha hexazinone treatment. Weaker but similar levels of correlation occurred in the Chemical Series and the All Treatments Combined group. Figure 3 illustrates the relationship between observed and predicted values for the 2 kg/ha hexazinone treatment. The slope and y-intercept of the regression lines are very similar to those developed for the All Treatments Combined group (Figure 2). No significant correlations occurred in the Control plots.

3.3 Assessment of Selected Competition Indices for Site Preparation Plots

Competition indices were often more strongly correlated with crop seedling height and basal diameter than individual vegetation variables, particularly CI-6 and RelHT2 (e.g., Tables 3, 4, and 5). Such indices involved the calculation of proportions between comparable dimensional characteristics such as basal diameter or height for the crop seedling and a competing tree. These indices are closely related, since height and basal diameter are strongly correlated, but they do not necessarily produce the same results (e.g., Tables 5 and 7). Figure 4 illustrates the relationship between the variables used in calculating competition index CI-6 and RelHT2 based on data from the Site Preparation experiment plots. The relationship between both pairs of variables is basically linear and relatively strong with approximately 25 percent of the variance

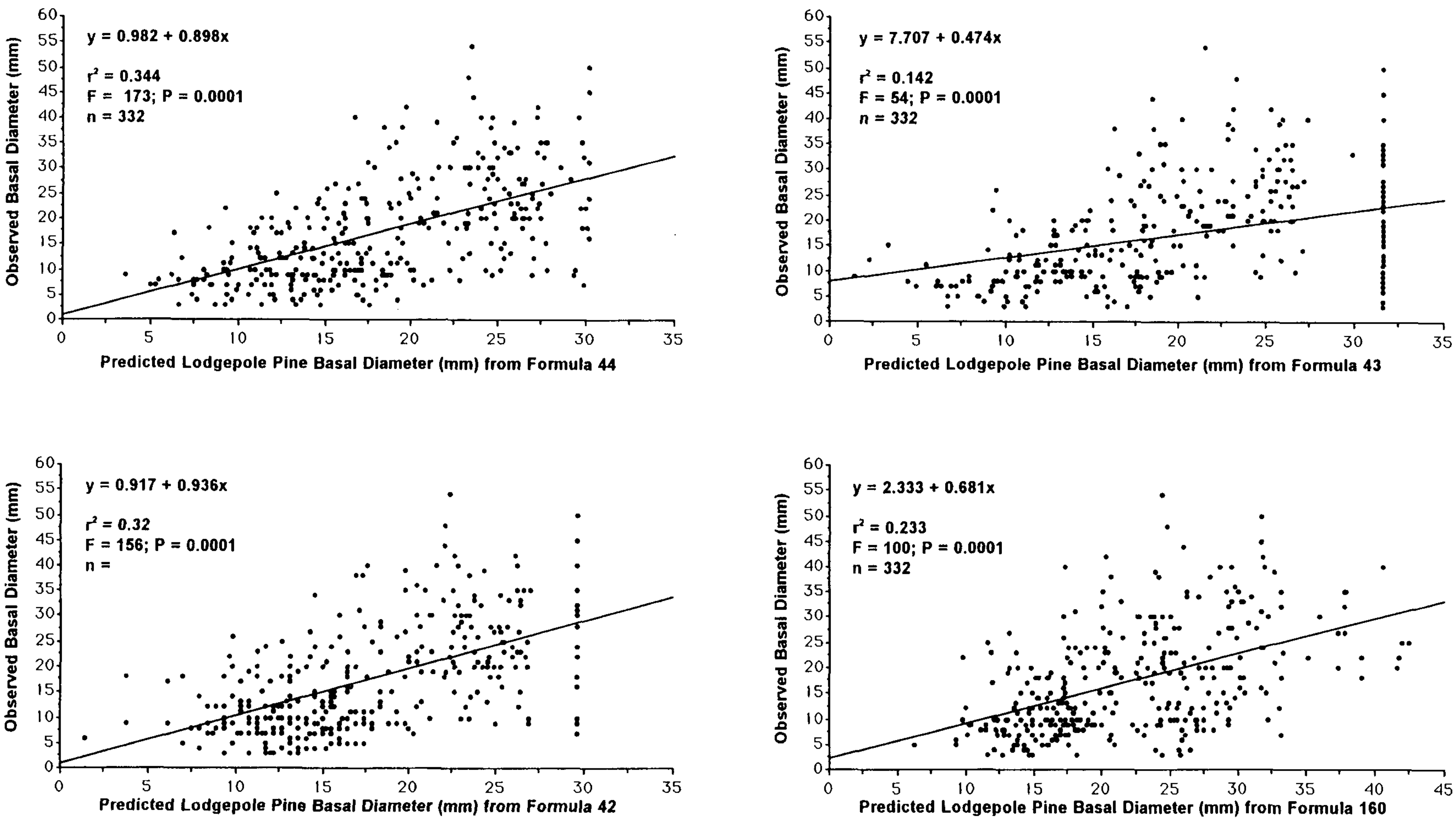
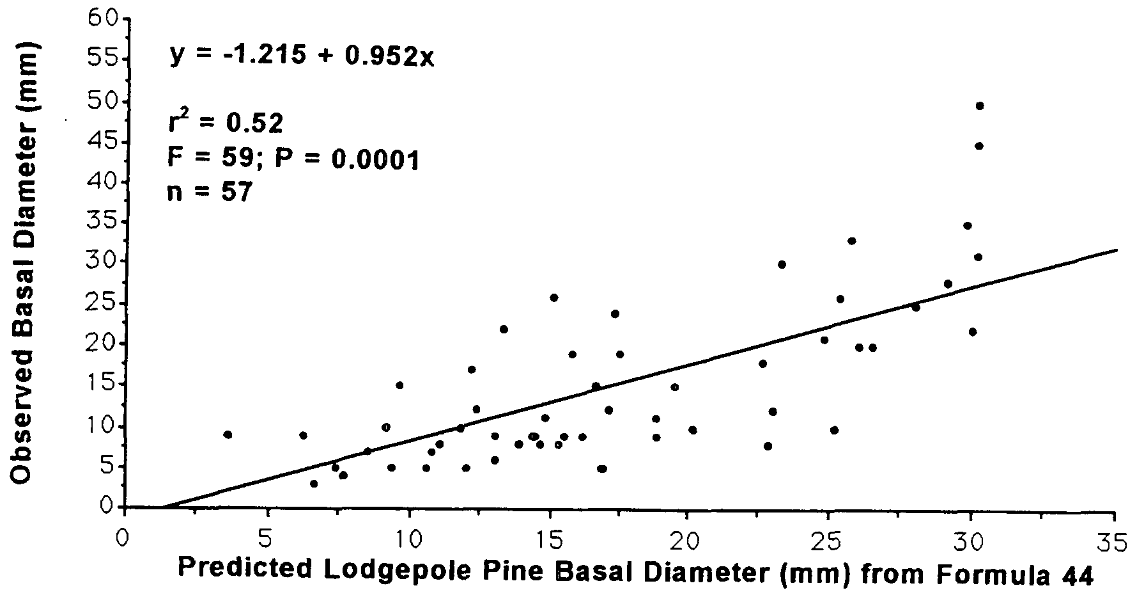


Figure 2. A comparison of predicted (x-variable) and measured (y-variable) lodgepole pine seedling basal diameter. Predicted basal diameter based on Equations 44, 43, 42, and 160.



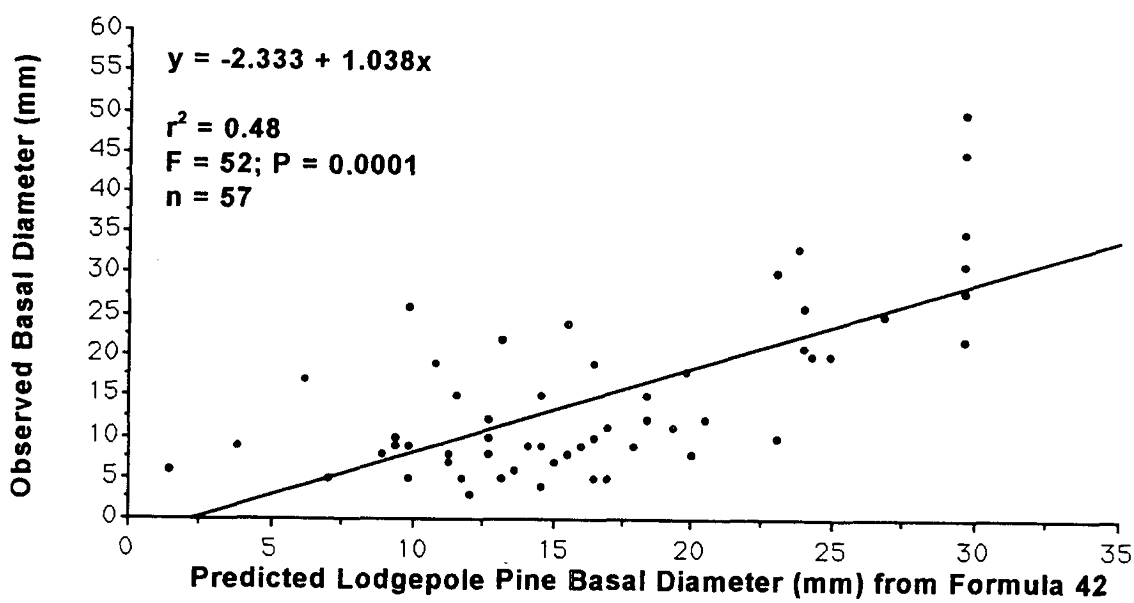
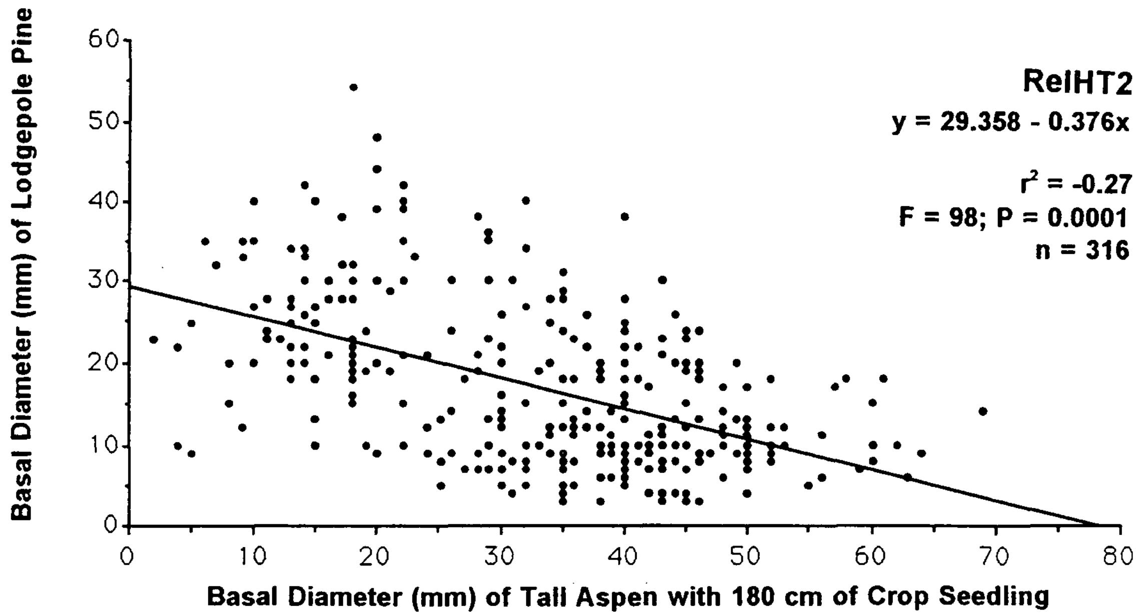


Figure 3. A comparison of predicted (x-variable) and measured (y-variable) lodgepole pine seedling basal diameters from the 2 kg/ha hexazinone treatment plots. Predicted basal diameter values were based on Equations 44 and 42.



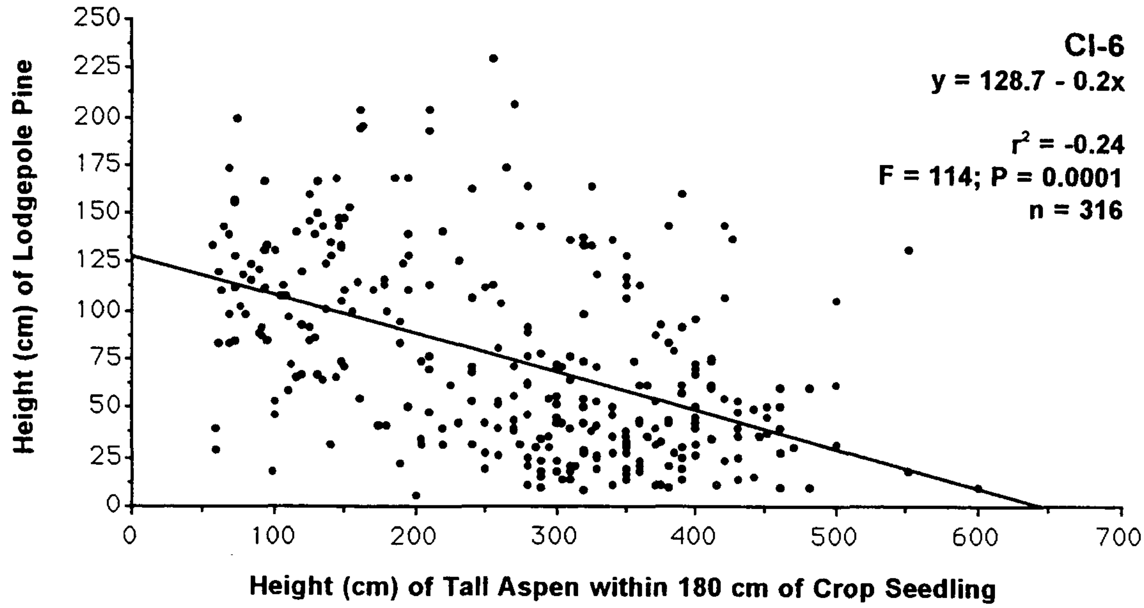


Figure 4. A comparison of variables used in competition indices CI-6 and RelHT2.

in lodgepole pine basal diameter or height associated with variation in the basal diameter or height of the tallest aspen within 180 cm of the crop seedling, respectively. From these data, it is apparent that smaller lodgepole pine seedlings tend to occur in proximity of larger aspen saplings, although there is a large amount of variability. When these variables were used in combination as competition indices and correlated with a seedling growth characteristic, the amount of explained variance in the dependent variable was more than doubled (62 to 75 percent) relative to using only height or basal diameter of the tallest aspen within 180 cm of the crop seedling (Figure 5). In addition, the standard error was also reduced by 30 to 40 percent. Therefore, crop seedling size and presumably the level of competition between the lodgepole pine and tallest aspen can be more reliably estimated from CI-6 and RelHT2 than their individual variables, particularly when estimating crop seedling basal diameter. The dispersal of samples in Figure 5 was greatest when the tallest aspen and lodgepole pine were of a similar size; therefore, the reliability of the predicted seedling value would be less.

When aspen basal diameter exceeded that of lodgepole pine by four (i.e., index 2^2) or more times, the range of dispersement around the regression line was relatively narrow (Figure 5b). After the competition index value exceeded nine (i.e., 3^2), the basal diameter of lodgepole pine remained relatively constant despite a continuous increase in aspen basal diameter and the level of competition. The sample distribution pattern for RelHT2 was reversed relative to CI-6 (Figure 5) due to the inverted structure of the formula (Table 2). When lodgepole pine was less than half the height of the tallest aspen (Figures 5a and b; Index value >0.5), a less predictable relationship occurred between the competition index and the crop seedling, particularly if lodgepole pine height was the predicted variable. In addition, the regression curve fitted to the scatter diagram based on seedling height (Figure 5d) was more complex than for basal diameter (Figure 5c).

Attempts to improve competition indices CI-6 and RelHT2 through the addition of individual vegetation variables by step-wise regression was not successful. However, combining the components of these two indices did increase the total amount of explained variance in the dependent variable and reduced the relative amount of associated standard error:

CI-7 = (TPOP.bd/P.bd) * 2 + TPOP.ht/P.ht

CI-7	Competition Index number 7
TPOP	tallest aspen within 180 cm of lodgepole pine seedling
P	lodgepole pine
bd	basal diameter (mm)
ht	height (cm)

To balance the proportions between the two halves of this index, it was necessary to invert the RelHT2 and weight the CI-6 components of the formula. Figure 6 illustrates the relationship between CI-7 and lodgepole pine seedling height (HT), basal diameter (BD), and volume (VOL). CI-7 worked about equally well (R^2 = 0.80 to 0.86) for all three dependent variables, but it was necessary to transform ($\log_{10}$) these values and to use a quadratic polynomial equation to optimize the fit of the regression. CI-7 also worked well among the various treatments in the Site Preparation experiment blocks based on simple correlations of predicted and observed values, as indicated in the following matrix:

Lodgepole Pine Variable	Control	2 kg/ha Hexazinone	4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching	Chemical Series	All Treatments Combined
Height	-0.87	-0.88	-0.88	-0.63	-0.91	-0.85	-0.86
Basal Diameter	-0.80	-0.81	-0.84	-0.60	0.89	-0.81	-0.83
Volume	-0.89	-0.86	-0.89	-0.64	-0.92	-0.87	-0.87
No. samples	58	51	63	80	63	172	315

While all of these correlation coefficients were significant and explained approximately two-thirds of the variability in the lodgepole pine growth variable, CI-7 values were substantially lower in the Rome double disking treatment. Competition index CI-7 also produced correlation values which were stronger than the separate use of either CI-6 or RelHT2.

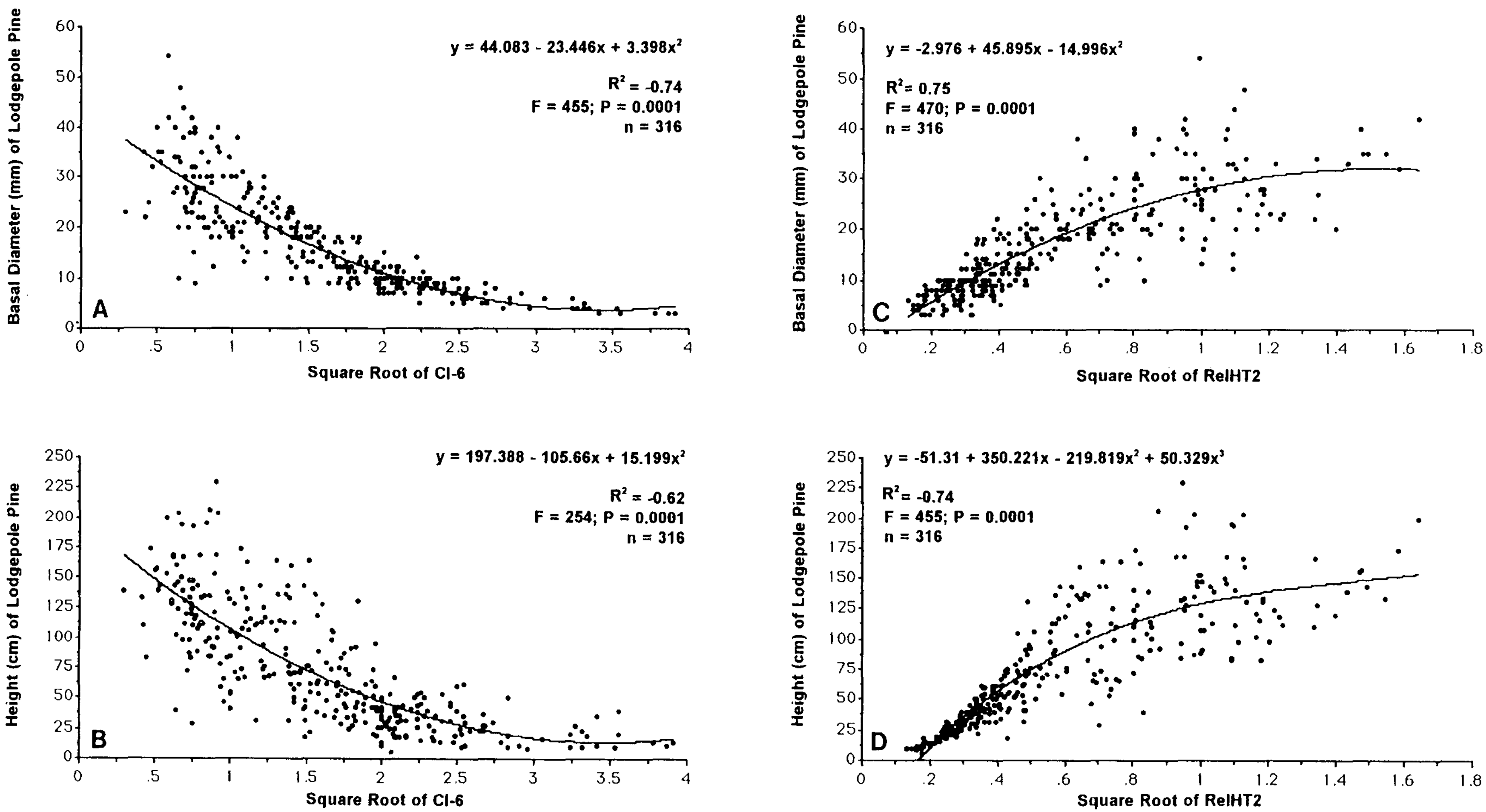


Figure 5. The relationship between lodgepole pine seedling basal diameter and height, and competition index CI-6 and RelHT2.

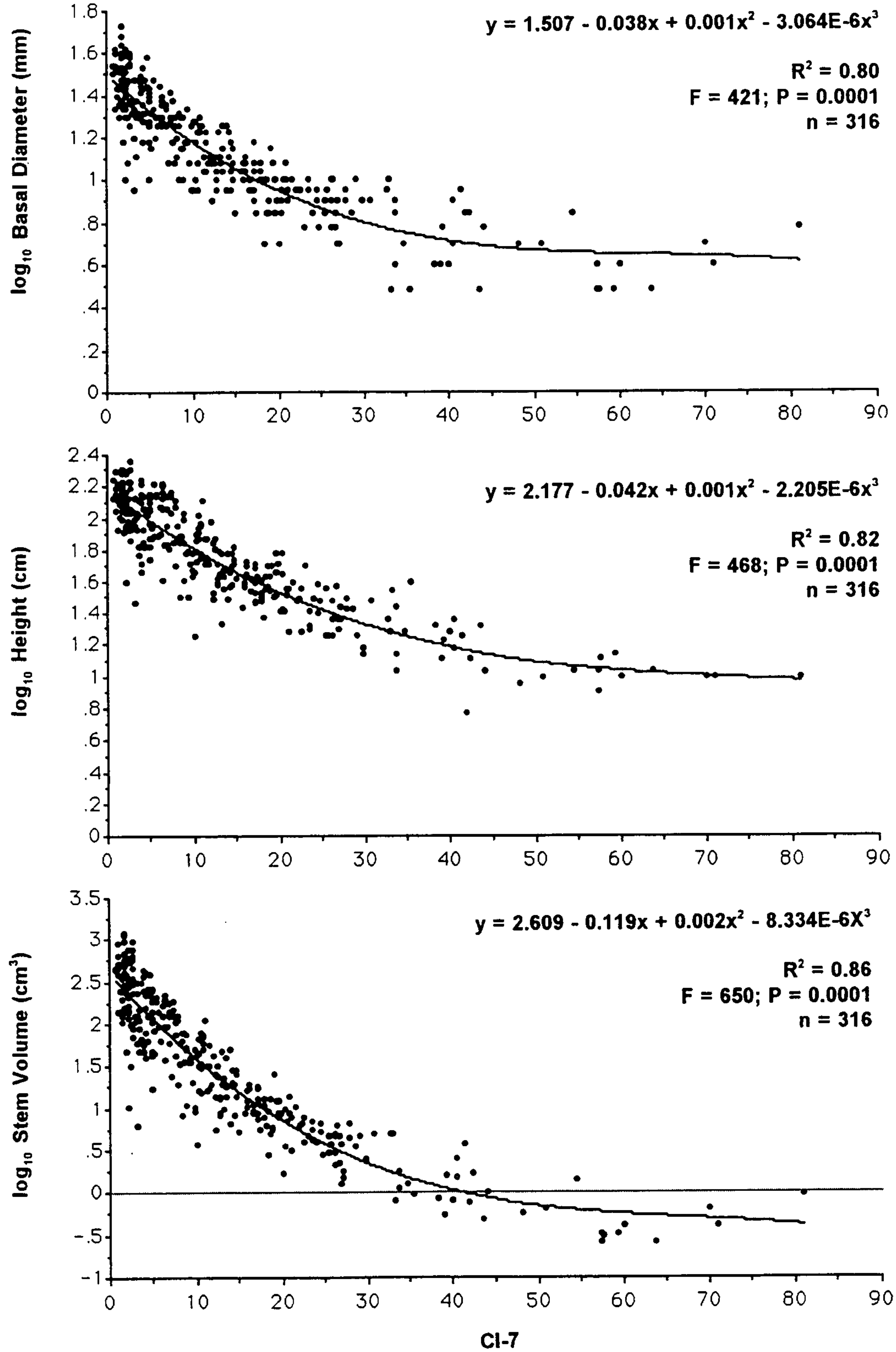


Figure 6. The relationship between lodgepole pine seedling height, basal diameter, and stem volume; and competition index CI-7.

4.0 SUMMARY AND CONCLUSIONS

The objective of this study was to analyze selected vegetation and tree characteristics to determine which variables best predicted six to eight year old lodgepole pine and white spruce height, basal diameter, stem volume, and current height growth increment based on data collected in site preparation and conifer release experimental treatment plots from the Grande Prairie area. The following interpretations and conclusions were drawn from these analyses.

1. Lodgepole pine seedling basal diameter and height were more strongly correlated with tested vegetation attributes than current height increment or stem volume. Table 32 indicates the relative potential value of each vegetation variable for predicting seedling growth characteristics. These index values were developed by squaring and summing all significant ($P < 0.05$) correlation coefficients across all treatments by vegetation variable. From this table, it appears that seedling basal diameter may be a slightly better variable for correlation and regression modelling, since it has larger and more frequency index values than height. In support of this conclusion, more than half (57 percent) of the lodgepole pine regression models with explained variance levels of 35 percent or more had basal diameter as their dependent or y-variable. Other researchers (e.g., Bormann 1965; MacDonald et al. 1990; Simard 1990b) working in widely different ecosystems have also concluded that basal diameter was easier to predict than height. White spruce was poorly correlated with all of the tested seedling growth variables relative to lodgepole pine.

   Use of seedling basal diameter in regression modelling and competition indices may be prone to a disproportionally large amount of error compared to the use of seedling height. For example, rounding error or a small amount of basal diameter measurement error could more significantly impact predicted values than the equivalent error when using seedling height (e.g., one mm error for a ten mm basal diameter verses one mm error for a 300 mm height).

2. Lodgepole pine growth characteristics were more predictable than those of white spruce, probably due to basic differences in their ecophysiology and growth strategies. Because lodgepole pine is a shade-intolerant seral species, it may be sensitive to differences in the structure and density of the surrounding vegetation. In contrast, white spruce is a shade-tolerant species that can withstand conditions that might kill lodgepole pine seedlings, but it can also take advantage of favorable conditions when they occur. Therefore, lodgepole pine growth may be better synchronized and more responsive to changes in the surrounding vegetation than white spruce, and the relative quality of these conditions would have a strong influence on growth and the degree of statistical correlation with vegetation variables such as stem densities or cover.

3. Stronger vegetation-seedling growth relationships generally occurred in the Site Preparation than the Conifer Release experimental plots for lodgepole pine based on larger r^2 values and a greater frequency of significant correlations. For example, the index values for aspen basal area and crop seedling basal diameter in Table 32 were 30 to 50 percent smaller in the Conifer Release relative to the Site Preparation plots. The reason for this difference is not clear. Some of the difference may be due to the disturbance of the regenerating

Table 32. Relative value of various vegetation variables for predicting selected growth characteristics (HT - height, BD - basal diameter, VOL - stem volume, CG - current growth increment) of six to eight year old lodgepole pine and white spruce seedlings. These correlation "index values" were determined by squaring and summing significant (P>0.05) correlation coefficients (See Tables 3 through 16). Shaded cells indicate values are equal to or greater than half of the calculated maximum for independent variables and competition indices (i.e., 70 and 227, respectively). A plus symbol indicates a minimum value due to no data for a given variable.

	SITE PREPARATION						CONIFER RELEASE							
	Lodgepole Pine			White Spruce			Lodgepole Pine				White Spruce			
Dependent Variables	HT	BD	VOL	HT	BD	VOL	HT	BD	CG	VOL	HT	BD	CG	VOL
Nearest Aspen - Distance	25	44	22	31	9	3	5	10	0	2	0	25	6	23
Nearest Aspen - Height	13	31	13	0	0	3	0	12	0	23	8	18	5	30
Nearest Aspen - Basal Diameter	6	7	4	7	0	0	0	0	0	24	0	0	0	3
Tallest Aspen - Distance	0	9	0	7	0	0	0	0	0	0	0	25	13	8
Tallest Aspen - Height	66	98	60	10	22	18	61	81	39	35	15	97	9	53
Tallest Aspen - Basal Diameter	56	74	60	7	25	13	6	34	0	12	4	26	0	6
Aspen Stem Density	118	119	63	26	0	0	25	63	6	34	14	32	17	18
Aspen Stem Length	127	140	86	52	32	29	40	76	18	48	14	59	15	18
Effective Aspen Density	10	2	0	0	0	0	0	0	0	0	11	0	22	37
Aspen Basal Area	116	135	83	57	31	27	52	93	22	46	15	63	17	17
Shrub >50 cm tall - Distance	4	35	24	2	11	15	10	17	16	32	0	0	0	0
Shrub >50 cm tall - Height	0	6	17	0	0	0	0	0	0	0	0	0	39	0
Shrub >50 cm tall - Basal Diameter	25	52	89	23	10	12	26	10	0	0	17	0	29	0
Shrub Stem Density	15	30	12	0	0	7	23	37	0	20	13	29	12	41
Shrub Stem Length	2	31	3	13	0	7	13	24	0	19	32	31	30	28
Density of Woody Stems	46	90	35	13	3	4	44	73	16	39	21	44	20	48
Total Woody Stem Length	91	140	79	23	14	13	32	98	24	65	54	81	38	44
% Cover Aspen - C stratum	+38	+48	+13	+8	+5	+5	41	52	6	13	+13	+30	+11	+14
% Cover Aspen - B stratum	16	25	25	35	12	20	10	8	32	6	0	0	0	0
% Cover Aspen - A stratum	8	13	0	7	2	4	4	10	0	3	0	9	0	0
% Cover - Total C stratum	+38	+47	+12	+9	+5	+5	53	54	10	14	+13	+41	+11	+16
% Cover - Total B stratum	21	33	20	22	13	11	35	20	45	25	0	0	0	0
% Cover - Total A stratum	0	19	13	0	0	12	12	15	4	19	0	0	0	20
% Cover - *Calamagrostis canadensis*	36	34	38	0	0	0	4	13	0	10	15	42	19	14
CI-3a (Aspen - C stratum)	+22	+29	+2	+17	+4	+1	39	10	10	0	0	+10	+0	+0
CI-3b (Aspen - B stratum)	13	6	12	19	0	10	8	7	8	0	0	0	0	0
CI-1 (Tallest Aspen)	139	136	105	45	14	13	97	124	76	93	46	102	30	67
CI-2 (Nearest Aspen)	179	165	122	55	0	21	145	150	131	112	62	91	19	59
CI-4	151	208	89	54	66	37	126	147	49	47	36	100	27	35
CI-5	180	265	126	138	176	106	207	277	73	144	174	213	105	136
CI-6	278	388	186	209	244	134	265	339	103	169	229	345	95	186
RelHT2	455	380	376	343	117	119	348	355	189	306	328	374	176	324
Shrub Basal Diameter/Conifer Basal Diameter	200	241	98	114	170	97	210	248	70	125	139	190	109	101

vegetation with herbicides and brushsawing two years after the crop seedlings were planted, which could have created an ecological imbalance in the vegetation with respect to seedling growth. However, this would not explain why correlation coefficients were also low in the control plots of the Conifer Release relative to those in the Site Preparation plots.

Vegetation and seedling growth relationships were generally weak for white spruce. However, stronger relationships tended to occur in the Conifer Release than the Site Preparation plots, particularly when basal diameter was the dependent analysis variable. Most of the stronger correlation coefficients were associated with hexazinone plots (Table 14). The reason for these stronger correlations may be due to greater vegetation diversity and associated seedling growth responses as a result of post-planting chemical treatment. Treatment of the vegetation with hexazinone increased both white spruce growth and its range of variability (Strong et al. 1995, p. 84). If vegetation conditions are relatively uniform then relatively uniform growth responses would be expected and therefore poor correlation would result.

4. Among the 26 tested vegetation variables, total woody stem length (STEM.cm/m^2), aspen stem length (POP.cm/m^2), aspen density (POP.n/m^2) and aspen basal area (POP.ba); and height and basal diameter of the tallest aspen within 180 cm of the crop seedling were most strongly correlated with lodgepole pine growth characteristics, particularly basal diameter. And, these variables were common components in the more successful regression models (see Results Section 3.2) as well as some of the tested competition indices. These variables were neither consistently nor strongly associated with white spruce growth characteristics.

   Ecologically, these variables probably represent a combination of factors to lodgepole pine seedlings. Stands with a high density of woody stems create intensive competition for physical space and light as well as for nutrients and moisture. Height and basal diameter of aspen are correlated (Appendix I), so basal diameter alone may not have a direct impact on lodgepole pine growth. However, height of the tallest aspens could represent a phytometer of relative competitive stress between aspen and the lodgepole pine seedlings. Larger trees intercept more light and consume more resources than smaller trees. As a result, a large pool of potential resources would be available when the tallest aspen as well as other competing trees are smaller and more equivalent in size to the seedling. Competition index CI-6 and RelHT2 basically represent this general concept.

5. The general lack of consistency among the developed regression equations in terms of their component variables (Appendix VII) suggests that it may be very difficult to develop a few simple universally applicable equations to predict lodgepole pine crop seedling growth characteristics or to fully assess interspecific competition. It is anticipated that the task of developing predictive models will be more difficult for white spruce. Alemdag (1978, p. 33) also reported similar modelling inconsistencies and problems.

   It may also be necessary to incorporate basic site parameters (e.g., moisture regime, soil texture, thickness of litter layer) into predictive models and competition indices, unless they are developed from a set of highly standardized soil conditions which could limit their general use. The importance of site conditions in determining growth and probably competition was demonstrated by Corns and Pluth (1984) who compared growth predicting regression equations (site index at 70 years and mean annual increment) based only on soil parameters with those that included both soil and vegetation variables. They concluded that equations which included both soil and vegetation parameters were superior to those conventionally based on only edaphic and topographic conditions. Presumably, the reverse is also true. Differences in edaphic conditions may partially explain the large differences in correlation coefficients between the Site Preparation and Conifer Release experimental blocks (Table 32, c.f. lodgepole pine). Recently, Burton (1993) drew similar conclusions from his review of selected competition indices.

This lack of consistency between seedling growth and vegetation characteristics is probably because seedlings respond to a wide variety of elements within their immediate environment which may vary from one type of vegetation to another. An example of such a multivariate response to vegetation differences may occur in Tables 3 and 4. The control, 2 kg/ha and 4 kg/ha hexazinone plots represent a chemical dosage series and a gradient pattern of response to the chemical would be expected in terms of vegetation competition. However, the strongest and most frequent correlations occurred in the 2 kg/ha rather than the 4 kg/ha hexazinone treatment plots, although the best seedling growth occurred in the 4 kg/ha treatment plots (64 cm verses 35 cm of height growth; Strong et al. 1995, p. 53). This suggests that correlated responses occur only when similar levels of competition occurs between the seedling and the competing vegetation. If one or the other is clearly superior, the less successful competitor is suppressed and only a weak correlation of variables would be possible. Weak correlations could also be possible when different species occur in proximity but are not necessarily in competition. These mixed responses make the development of growth oriented regression models and competition indices very difficult.

6. In general, competition indices were superior to vegetation characteristics as variables when correlated with seedling growth characteristics. The reason for this higher than normal degree of numerical association is because competition indices often include either basal diameter or height of the crop seedling parameters in their formulae. This potentially makes their use in correlation or regression analysis as a dependent variable questionable due to a potential lack of independence with the independent variable. However, Brand (1986, p. 27), based on work by Jolliffe and Courtney (1984), suggested that the use of relative growth values (e.g., aspen basal diameter divided by lodgepole pine basal diameter) "removes some of the problems inherent . . . with absolute growth values". Therefore, the use of crop seedling parameters within competition indices (independent variables) and as dependent variables in correlation and regression analysis would not violate the assumption of independence between dependent and independent variables. A similar approach to assessing competition indices has also been recently used by Comeau et al. (1993).

   If the previous competition index analyses are statistically valid, CI-6 and RelHT2 showed the greatest potential for estimating competition stress between crop seedlings and aspen. Competition index RelHT2 tended to have a stronger association with more crop seedling growth parameters than CI-6 (r^2 = 60 to 75 percent). However, use of the parameters that form these two indices in combination (CI-7) explained approximately 80 to 85 percent of variance associated with lodgepole pine seedling height, basal diameter, and stem volume. Similar analyses based on CI-7 for white spruce also produced much higher levels (r^2 = 48 to 59 percent) of explained variance than either CI-6 or RelHT2.

7. Due to the ecological and statistical problems associated with the development of reliable seedling growth and competition models, it might be appropriate to consider an alternative approach to assessing the types of vegetation conditions needed to promote better seedling growth. If it is assumed that crop seedlings are subject to all the ecological conditions within their immediate vicinity, then the integration of these conditions is ultimately demonstrated in terms of a growth response. Based on this assumption, it may be possible to take a more direct approach to the assessment of factors that affect crop seedling growth. This proposed approach would first require the separation of crop seedlings on the basis of growth. The basis for partitioning could vary according to the objectives of the study. As an example, lodgepole pine seedlings from the Site Preparation experimental blocks were separated into two groups: <75 cm and ≥100 cm. These class boundaries represent the minimum heights necessary to consider a lodgepole pine seedling as conditionally acceptable (i.e., ≥75 cm tall) or acceptable (≥100 cm tall) in a mixedwood forest stocking survey, according to Alberta forest regeneration standards (Anonymous 1993, p. 12-13). These heights are expected four to eight years after harvesting which usually corresponds to the amount of time since crop seedling planting. Planting of the experimental blocks was delayed for approximately four years, but the current seedling data still fits within the eight year period and criteria for growth (1987 to 1992/3).

   Table 33 summarizes the vegetation characteristics associated with the two lodgepole pine height classes. Mann-Whitney tests were used to determine if a significant difference occurred between the two seedling height classes because the data were not always normally distributed. These data indicate that sites with more than about three woody stems/m^2, half of which were aspen, and a combined length of more than 300 to 350 cm/m^2 were poor for lodgepole pine growth. In addition, growth was inhibited when the tallest aspen was greater than 270 cm tall, and the nearest aspen was more than 109 to 145 cm tall and closer than about 45 to 60 cm. Several of the variables included in Table 33 were also key components in best regression equations (See Section 3.2) and tested competition indices.

   Whether regression analysis or competition indices are used to assess crop seedling growth limiting factors, it will eventually be necessary to define what parameters and threshold values are critical for meeting management objectives. The proposed analysis approach is more direct and less encumbering than regression modelling (e.g., no constraints from sample distributions, transformation of variables, variable independence), although the approach may require refinement. As part of this analysis approach, discriminate function analysis may be a useful tool for identifying critical parameters.

In summary, modelling of vegetation variables as a means of assessing competitive influences on crop seedlings and as a means of developing management criteria is a complex problem. The results of this analysis also suggest that solutions may not necessarily be directly transferable between sites (Table 32). Therefore, it may be more cost effective to proceed directly to identifying what general threshold values (e.g., number of woody stems/m^2) are critical to crop seedling growth based on recognized management objectives.

Table 33. Differences in selected vegetation variables stratified according to lodgepole pine height classes. NPOP - Nearest aspen, POP - aspen, SHB - nearest woody plant >50 cm tall, STEM - all woody stems, TPOP - tallest aspen, ba - basal area, bd - basal diameter, dis - distance, ht - height, cm/m^2 - centimeters per square meter, and n/m^2 - number per square metre.

Variable	Lodgepole Pine (n = 154) <75 cm tall (≥75% of cases)	Lodgepole Pine (n = 98) ≥100 cm tall (≥75% of cases)	Z-value from Mann-Whitney test	P
NPOP.bd	>12 mm	<19 mm	4.59	<0.01
NPOP.dis	<61 cm	>44 cm	5.06	<0.01
NPOP.ht	>109 cm	<145 cm	6.05	<0.01
POP.ba	>24 cm^2/m^2	<13.5 cm^2/m^2	9.93	<0.01
POP.cm/m^2	>187 cm/m^2	<141 cm/m^2	9.47	<0.01
POP.n/m^2	>1.1 $stems/m^2$	<1.1 $stems/m^2$	9.28	<0.01
SHB.bd	>5 mm	<10 mm	2.29	<0.05
SHB.dis	<75 cm	>90 cm	4.01	<0.01
STEM.n/m^2	>2.7 $stems/m^2$	<3.4 $stems/m^2$	7.00	<0.01
STEM.cm/m^2	>355 cm/m^2	<277 cm/m^2	8.59	<0.01
TPOP.bd	>32 mm	<34 cm	8.17	<0.01
TPOP.ht	>270 cm	<262 cm	8.45	<0.01

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APPENDIX I. Polynomial regression model for estimating aspen basal diameter from height data and associated scatter diagram.

DF:	R:	R-squared:	Adj. R-squared:	Std. Error:
1472	.877	.77	.77	6.92

Analysis of Variance Table

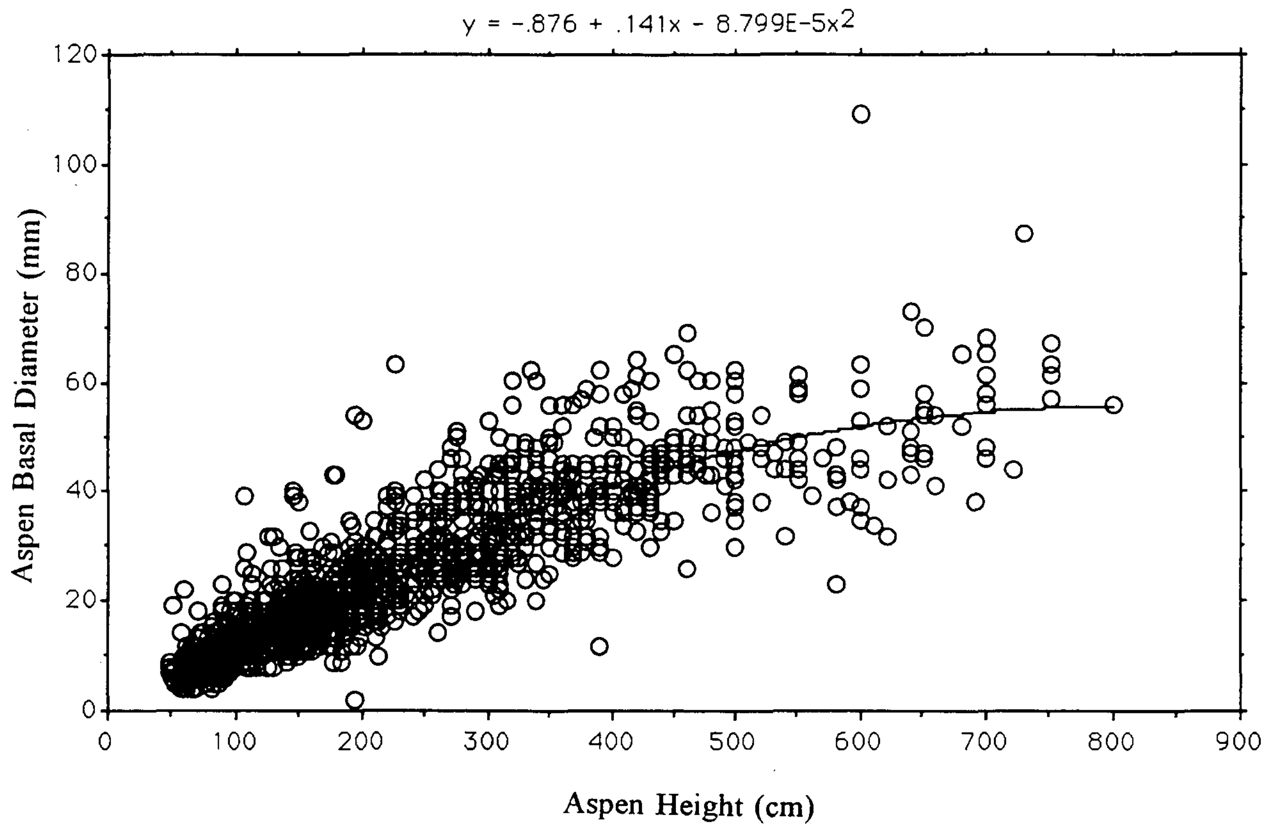
Source	DF:	Sum Squares:	Mean Square:	F-test:
REGRESSION	2	235509.105	117754.552	2459.05
RESIDUAL	1470	70392.721	47.886	p = .0001
TOTAL	1472	305901.826		

Beta Coefficient Table

Parameter:	Value:	Std. Err.:	Std. Value:	t-Value:	Probability:
INTERCEPT	-.876				
x	.141	.004	1.422	32.539	.0001
x^2	-8.799E-5	6.568E-6	-.586	13.396	.0001

Confidence Intervals and Partial F Table

Parameter:	95% Lower:	95% Upper:	90% Lower:	90% Upper:	Partial F:
INTERCEPT					
x	.132	.149	.134	.148	1058.792
x^2	-1.009E-4	-7.511E-5	-9.880E-5	-7.718E-5	179.457



y = -.876 + .141x - 8.799E-5x2
120
100
80
60
40
20
0
Aspen Basal Diameter (mm)
0
100
200
300
400
500
600
700
800
900
Aspen Height (cm)

APPENDIX II. Median (Q1, Q3) values for selected *Pinus contorta* competition variables based on 1992 and 1993 data from Site Preparation experiment blocks. H values represent Kruskal-Wallis test results ($P < 0.05 = 9.5$, $P < 0.01 = 13.3$), while letters following medians are multiple range nonparametric Scheffe' tests.

Variable	Control	2 kg/ha Hexazinone	4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching	H
Seedling Height (cm)	35(27,53)a	38(19,79)ab	55(31,92)b	112(85,140)c	58(30,92)b	108
Seedling Basal Dia. (mm)	9(7,12)a	10(8,20)ab	15(10,23)b	25(20,33)c	13(10,18)b	112
Seedling Stem Volume (cm^3)	8(2,15)a	8(3,78)b	31(8,144)b	166(85,381)c	26(7,74)b	114
SeedlingVigor Rating	2(2,3)a	2(1,4)a	3(2,4)a	4(4,5)b	3(1,4)a	87
Nearest Aspen -Distance (cm)	35(29,50)a	44(34,69)ab	49(36,71)ab	69(43,103)b	45(37,70)a	31
Nearest Aspen - Height (cm)	202(148,290)c	150(111,228)bc	155(110,190)bc	83(69,105)a	134(100,165)b	102
Nearest Aspen - Basal Diameter (mm)	22(14,28)b	19.(15,25)b	19(14,23)b	11(8,15)a	15(10,20)a	72
Tallest Aspen - Distance (cm)	114(77,145)	104(74,143)	113(87,149)	108(83,148)	118(98,148)	4
Tallest Aspen - Height (cm)	370(310,400)c	320(240,388)bc	280(196,320)b	114(83,148)a	340(300,390)c	181
Tallest Aspen - Basal Diameter (mm)	40(35,45)b	40(32,44)b	35(29,43)b	16(13,20)a	40(35,48)b	149
Aspen Stem Density (number/m^2)	2.6(1.7,3.2)c	2.1(0.6,3.0)bc	1.4(0.8,2.2)b	0.3(0.2,0.8)a	1.4(1.0,2.1)bc	96
Aspen Stem Length (m/m^2)	5.8(3.8,7.5)c	3.7(0.8,7.2)bc	2.6(1.3,4.1)b	0.3(0.1,0.6)a	2.6(1.6,4.2)b	129
Effective Aspen Density (number/m^2)	7.9(4.0,11.9)b	5.2(2.1,8.6)b	4.2(2.0,7.6)ab	2.1(0.9,5.3)a	4.8(2.0,7.3)b	31
Aspen Basal Area (cm^2)	94(60,127)c	50(10,112)b	28(13,51)b	1.8(0.5,4.0)a	41(19,62)b	145
Shrub >50 cm tall - Distance (cm)	36(20,58)a	59(28,92)ab	59(24,95)ab	70(41,101)b	43(27,68)a	27
Shrub >50 cm tall - Height (cm)	69(58,85)	64(56,81)	61(56,73)	61(55,77)	62(55,76)	6
Shrub >50 cm tall - Basal Diameter (mm)	6.0(5.0,8.0)	7.0(5.0,9.0)	7.0(6.0,9.0)	7.0(5.0,9.0)	7.0(5.0,9.0)	5
Shrub Stem Density (number/m^2)	2.7(2.0,4.0)a	1.3(0.2,2.5)c	1.6(0.6,3.8)bc	0.6(0.3,1.5)c	2.4(1.4,3.4)ab	51
Shrub Stem Length (m/m2)	2.0(1.2,3.3)a	0.8(0.1,1.6)b	1.0(0.4,2.8)ab	0.4(0.2,1.0)b	2.0(0.9,3.0)a	55
Density of Woody Stems (number/m^2)	5.4(4.2,6.8)c	3.2(1.8,5.0)b	3.4(1.8,5.6)b	1.3(0.8,2.4)a	4.2(2.7,5.8)bc	91
Total Woody Stem Length (m/m^2)	7.5(6.0,10.4)c	4.7(1.6,7.9)b	4.5(2.2,6.9)b	9.0(0.5,1.8)a	4.7(2.9,7.1)b	123
Percent Cover Aspen - C stratum	17(0,50)c	0(0,30)bc	0(0,0)ab	0(0,0)a	0(0,0)ab	72
Percent Cover Aspen - B stratum	20(0,30)b	15(0,30)b	15(0,25)b	0(0,0)a	2(0,18)b	80
Percent Cover Aspen - A stratum	3(0,8)a	0(0,7)a	3(0,20)a	0(0,4)a	0(0,8)a	12
Percent Cover - Total C stratum	17(0,50)c	0(0,30)bc	0(0,0)ab	0(0,0)a	0(0,0)ab	73
Percent Cover - Total B stratum	22.(0,35)b	15(0,30)b	16(0,30)b	0(0,0)a	5(0,20)b	64

Appendix II. Concluded.

Variable	Control	2 kg/ha Hexazinone	4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching	H
Percent Cover - Total A stratum	15(5,40)b	10(5,20)ab	19(5,35)b	5(0,15)a	15(8,30)b	26
Percent Cover - *Calamagrostis canadensis*	15(9,25)b	0(0,1)a	0(0,1)a	20(8,38)b	12(8,25)b	133
CI-1 (Tallest Aspen)	2.84(2.02,4.27)c	2.51(1.52,4.26)bc	1.64(1.07,2.44)b	-0.01(-0.29,0.30)a	2.31(1.56,2.98)bc	170
CI-2 (Nearest Aspen)	3.75(2.22,7.18)c	2.74(0.95,5.23)bc	1.66(0.43,3.34)b	-0.37(-0.87,0.06)a	1.38(0.36,2.16)b	146
CI-3a (Aspen - C stratum)	0.01(0,0.05)c	0.01(0,0.01)bc	0(0,0)ab	0(0,0)a	0(0,0)ab	72
CI-3b (Aspen - B stratum)	0.01(0,0.03)b	0.01(0,0.02)b	0.01(0,0.01)b	0(0,0)a	0(0,0.01)b	75
CI-4	0.06(0.04,0.12)c	0.04(0.02,0.10)bc	0.03(0.01,0.06)b	0.01(0,0.01)a	0.02(0.01,0.03)b	122
CI-5	2.38(1.71,3.58)d	1.87(1.01,3.09)cd	1.21(0.67,2.32)bc	0.47(0.29,0.67)a	1.10(0.64,1.65)b	144
CI-6	4.24(3.27,6.50)c	4.22(2.00,5.23)bc	2.30(1.25,4.00)b	0.57(0.45,0.83)a	3.08(2.00,4.30)bc	168
RelHT2	0.11(0.08,0.16)a	0.12(0.05,0.23)ab	0.22(0.12,0.46)b	1.01(0.73,1.32)c	0.17(0.10,0.33)ab	171
Shrub BD/Seedling Basal Diameter	0.69(0.50,1.20)c	0.78(0.39,1.13)bc	0.53(0.33,0.71)b	0.29(0.20,0.40)a	0.50(0.38,0.83)bc	82
Number of Samples	48-58	49-51	53-63	76-87	49-63	

Appendix III. Median (Q1, Q3) values for selected *Picea glauca* competition variables based on 1992 and 1993 data from Site Preparation experiment blocks. H values represent Kruskal-Wallis test results ($P < 0.05 = 9.5$, $P < 0.01 = 13.3$), while letters following medians are multiple range nonparametric Scheffe' tests.

Variable	Control	2 kg/ha Hexazinone	4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching	H
Seedling Height (cm)	55(41,63)a	57(41,78)ab	62(47,82)b	60(49,84)ab	66(39,79)ab	14
Seedling Basal Dia. (mm)	10(8,12)a	11(8,14)ab	12(10,18)b	11(9,17)ab	13(9,14)ab	13
Seedling Stem Volume (cm^3)	12(6,27)a	19(7,43)ab	22(12,81)b	17(11,65)ab	28(8,43)ab	14
Seedling Vigor Rating	3(2,3)a	3(3,4)abc	4(3,4)c	3(3,4)ab	4(3,4)bc	34
Nearest Aspen -Distance (cm)	40(27,54)a	47(36,67)ab	47(34,70)ab	69(35,101)b	55(39,77)b	24
Nearest Aspen - Height (cm)	213(135,282)b	215(149,288)b	167(125,225)b	86(70,120)a	160(110,230)b	94
Nearest Aspen - Basal Diameter (mm)	20(13,27)b	22(17,30)b	20(14,28)b	11(8,16)a	18(12,30)b	59
Tallest Aspen - Distance (cm)	121(85,143)ab	100(69,133)a	123(86,151)ab	101(63,141)ab	128(100,152)b	14
Tallest Aspen - Height (cm)	360(327,400)c	370(296,400)c	295(240,360)b	123(91,145)a	340(290,400)c	150
Tallest Aspen - Basal Diameter (mm)	39(33,45)b	38(34,45)b	39(30,45)b	15(12,22)a	40(36,48)b	120
Aspen Stem Density (number/m^2)	2.3(1.5,3.1)b	2.2(1.0,3.0)b	1.8(0.8,2.4)b	0.4(0.2,0.8)a	1.8(1.1,2.1)b	81
Aspen Stem Length (m/m^2)	5.2(3.1,7.4)c	5.5(1.4,8.4)bc	3.0(1.0,4.8)b	0.3(0.1,0.7)a	3.1(2.1,4.6)bc	104
Effective Aspen Density (number/m^2)	6.1(3.4,13.7)b	4.5(2.2,7.6)ab	4.5(2.0,8.2)ab	2.1(1.0,7.8)a	3.3(1.6,6.6)a	24
Aspen Basal Area (cm^2)	79(44,119)c	86(19,145)c	44(11,75)b	2.0(0.8,4.3)a	47(28,72)bc	117
Shrub >50 cm tall - Distance (cm)	37(23,61)a	43(29,69)ab	61(26,99)b	55(30,87)ab	31(26,61)a	17
Shrub >50 cm tall - Height (cm)	63(54,92)b	68(56,78)b	65(56,76)b	56(53,63)a	63(55,77)b	18
Shrub >50 cm tall - Basal Diameter (mm)	7(4,9)	7(6,9)	7(5,9)	6(5,8)	7(5,8)	1
Shrub Stem Density (number/m^2)	2.6(1.6,4.6)a	2.2(0.6,3.4)ab	1.0(0.2,2.9)bc	0.8(0.3,1.7)c	2.4(1.4,4.0)a	42
Shrub Stem Length (m/m^2)	1.9(1.0,3.6)a	1.4(0.3,2.5)ab	0.5(0.1,2.4)bc	0.4(0.2,1.0)c	1.8(1.1,2.9)a	46
Density of Woody Stems (number/m^2)	5.4(3.9,6.9)c	4.6(2.5,6.2)bc	3.0(1.8,6.0)b	1.4(0.6,2.5)a	4.3(3.1,5.5)bc	79
Total Woody Stem Length (m/m^2)	8.0(5.7,9.8)c	7.4(3.2,10.2)bc	5.1(2.5,7.9)b	0.9(0.4,1.8)a	5.4(3.9,6.8)bc	108
Percent Cover Aspen - C stratum	10(0,37)b	20(0,40)b	0(0,0)a	0(0,0)a	0(0,0)a	80
Percent Cover Aspen - B stratum	20(10,40)b	10(0,30)b	15(0,40)b	0(0,0)a	9(0,20)b	77
Percent Cover Aspen - A stratum	3(0,8)a	0(0,5)a	3(0,15)a	0(0,4)a	2(0,7)a	14
Percent Cover - Total C stratum	12(0,32)b	20(0,40)b	0(0,0)a	0(0,0)a	0(0,0)a	79
Percent Cover - Total B stratum	20(10,40)b	15(0,30)b	20(0,40)b	0(0,0)a	10(0,25)b	79

Appendix III. Concluded.

Variable	Control	2 kg/ha Hexazinone	4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching	H
Percent Cover - Total A stratum	15(8,35)b	17(8,35)b	15(3,45)b	4(0,15)a	18(10,25)b	27
Percent Cover - *Calamagrostis canadensis*	15(7,25)b	0(0,0)a	0(0,0)a	20(10,30)b	8(4,19)b	169
CI-1 (Tallest Aspen)	2.53(1.98,3.93)c	2.90(1.97,4.26)c	1.94(1.08,3.03)b	0.49(0.21,0.88)a	2.39(1.67,3.09)bc	117
CI-2 (Nearest Aspen)	3.63(1.95,6.51)c	3.59(1.85,5.65)c	2.10(0.84,3.98)b	0.35(-0.05,0.99)a	1.51(0.79,3.13)b	96
CI-3a (Aspen - C stratum)	0.01(0,0.02)b	0.01(0,0.03)b	0(0,0)a	0(0,0)a	0(0,0)a	79
CI-3b (Aspen - B stratum)	0.01(0,0.02)c	0.01(0,0.02)bc	0(0,0.02)bc	0(0,0)a	0(0,0.01)b	78
CI-4	0.05(0.03,0.08)c	0.04(0.03,0.08)bc	0.03(0.02,0.06)b	0.01(0.01,0.03)a	0.03(0.02,0.05)b	55
CI-5	2.12(1.32,3.11)b	2.18(1.45,3.00)b	1.71(1.00,2.47)b	1.00(0.58,1.65)a	1.53(1.01,2.58)b	45
CI-6	3.83(2.95,5.66)c	3.64(2.69,4.36)bc	3.00(1.81,4.27)b	1.36(0.86,2.00)a	3.31(2.61,5.07)bc	87
RelHT2	0.15(0.11,0.18)a	0.16(0.12,0.23)ab	0.22(0.15,0.33)b	0.60(0.38,0.75)c	0.18(0.13,0.25)ab	126
Shrub BD/Seedling Basal Diameter	0.67(0.44,1.00)	0.64(0.46,1.00)	0.54(0.35,0.80)	0.61(0.33,0.83)	0.54(0.37,0.80)	9
Number of samples	72-84	67-80	71-81	49-57	52-63	

APPENDIX IV. Median (Q1, Q3) values for selected *Pinus contorta* competition variables based on 1993 and 1994 data from Conifer Release experiment blocks. H values represent Kruskal-Wallis test results ($P < 0.05 = 9.5$, $P < 0.01 = 13.3$), while letters following medians are multiple range nonparametric Scheffe' tests.

Variable	Control	Disk Trenching and 2 kg/ha Hexazinone	Disk Trenching and 4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching followed by Brushsawing	H
Seedling Height (cm)	68(42,101)a	76(49,128)a	131(100,168)b	127(83,160)ab	78(53,108)a	55
Seedling Basal Dia. (mm)	11(8,14)a	16(11,26)ab	38(25,47)c	22(14,28)b	14(12,21)ab	77
Seedling Stem Volume (cm^3)	32(6,50)a	48(16,205)ab	563(192,906)c	169(51,311)b	45(19,111)a	70
Seedling Current Growth Increment (cm)	21(7,29)a	21(12,34)a	25(16,43)a	29(12,41)a	22(9,32)a	9
Seedling Vigor Rating	3(1,3)a	3(2,4)a	3(3,4)ab	4(3,4)b	3(2,4)a	16
Nearest Aspen -Distance (cm)	42(29,57)a	47(28,81)a	86(67,123)b	42(25,63)a	52(28,73)ab	19
Nearest Aspen - Height (cm)	310(220,370)b	136(77,220)a	144(112,194)a	153(86,214)a	110(89,157)a	46
Nearest Aspen - Basal Diameter (mm)	28(23,38)c	13(9,23)a	20(13,29)b	13(9,21)a	12(9,14)a	45
Tallest Aspen - Distance (cm)	82(52,124)a	122(93,138)a	114(90,147)a	85(56,136)a	124(79,143)a	17
Tallest Aspen - Height (cm)	505(430,550)c	300(204,406)b	201(146,263)ab	275(198,340)b	202(171,237)a	79
Tallest Aspen - Basal Diameter (mm)	43(35,48)c	31(24,39)b	29(20,34)ab	28(22,32)ab	24(18,27)a	48
Aspen Stem Density (number/m^2)	1.6(1.4,2.3)c	0.8(0.3,1.3)b	0(0,0.3)a	0.9(0.5,1.8)b	1.0(0.6,1.6)bc	70
Aspen Stem Length (m/m^2)	4.5(3.6,6.5)c	1.2(0.3,2.5)b	0(0,0.4)a	0.9(0.4,2.6)b	1.3(0.8,2.3)b	77
Effective Aspen Density (number/m^2)	5.7(3.1,11.9)b	4.5(1.5,12.5)b	1.3(0.6,2.2)a	5.7(2.5,16.0)b	3.7(1.9,12.7)ab	19
Aspen Basal Area (cm^2)	84(62,112)c	16(2,39)b	0(0,4)a	11(3,35)b	14(9,28)b	76
Shrub >50 cm tall - Distance (cm)	38(33,48)a	39(25,53)a	56(41,98)b	57(34,78)ab	42(27,58)a	21
Shrub >50 cm tall - Height (cm)	66(59,95)	62(53,74)	64(55,76)	66(56,83)	64(55,82)	5
Shrub >50 cm tall - Basal Diameter (mm)	8.0(8.0,10.0)	8.0(6.0,9.0)	6.0(5.0,8.2)	7.0(6.0,8.0)	8.0(6.0,9.0)	5
Shrub Stem Density (number/m^2)	3.0(2.2,4.0)a	2.6(1.4,3.5)ab	0.6(0.3,1.3)c	1.2(0.6,2.6)bc	4.2(1.5,6.2)a	61
Shrub Stem Length (m/m^2)	2.9(1.7,3.8)a	2.0(0.9,3.3)ab	0.5(0.2,0.8)c	1.0(0.5,2.1)bc	3.4(1.2,6.9)a	60
Density of Woody Stems (number/m^2)	5.0(4.0,6.0)c	3.3(2.2,4.2)b	1.0(0.3,1.7)a	2.4(1.6,3.8)b	5.1(3.1,7.0)c	83
Total Woody Stem Length (m/m^2)	7.8(6.4,9.3)c	3.4(2.5,4.7)b	0.7(3.5,1.5)a	2.6(1.4,4.3)b	5.9(3.3,8.2)bc	87

Appendix IV. Concluded.

Variable	Control	Disk Trenching and 2 kg/ha Hexazinone	Disk Trenching and 4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching followed by Brushsawing	H
Percent Cover Aspen - C stratum	27(17,50)b	0(0,20)a	0(0,0)a	0(0,0)a	0(0,0)a	74
Percent Cover Aspen - B stratum	12(0,16)a	0(0,15)a	0(0,0)a	0(0,12)a	0(0,20)a	14
Percent Cover Aspen - A stratum	0(0,3)ab	0(0,10)ab	0(0,0)a	0(0,10)ab	4(0,14)b	23
Percent Cover - Total C stratum	30(22,55)b	0(0,25)a	0(0,0)a	0(0,0)a	0(0,0)a	77
Percent Cover - Total B stratum	15(0,25)	10(0,25)	1(0,20)	0(10,40)	12(0,25)	4
Percent Cover - Total A stratum	12(8,22)bc	20(10,30)bc	3(0,10)a	11(4,20)ab	22(10,35)c	42
Percent Cover *Calamagrostis canadensis*	12(5,22)b	1(0,6)a	0(0,0)a	12(6,20)b	14(8,20)b	91
CI-1 (Tallest Aspen)	4.92(3.67,7.97)c	1.82(1.07,2.58)b	0.15(-0.39,0.82)ab	1.57(0.74,2.75)b	0.96(0.50,1.70)a	71
CI-2 (Nearest Aspen)	6.15(2.95,9.14)c	1.62(0.15,2.82)b	-0.19(-0.87,0.77)a	0.70(-0.96,2.51)a	0.57(-0.13,1.37)a	48
CI-3a (Aspen - C stratum)	0.01(0,0.04)b	0(0,0.01)ab	0(0,0)a	0(0,0)a	0(0,0)a	57
CI-3b (Aspen - B stratum)	0(0,0.01)	0(0,0.01)	0(0,0)	0(0,0.01)	0(0,0.01)	6
CI-4	0.08(0.03,0.13)c	0.02(0.01,0.03)b	0.01(0,0.01)a	0.02(0.01,0.03)b	0.02(0.01,0.03)ab	44
CI-5	3.27(2.00,4.31)b	0.81(0.51,1.38)a	0.61(0.29,0.87)a	0.78(0.43,1.24)a	0.78(0.54,1.06)a	45
CI-6	3.52(2.61,5.25)c	1.90(1.22,3.09)b	0.71(0.51,1.31)a	1.39(0.96,2.19)ab	1.46(0.97,2.30)ab	55
RelHT2	0.16(0.08,0.23)a	0.24(0.13,0.44)ab	0.88(0.55,1.30)c	0.45(0.30,0.68)c	0.44(0.25,0.58)bc	62
Shrub BD/ Seedling Basal Diameter	0.69(0.56,1.10)c	0.44(0.26,0.65)bc	0.19(0.12,0.27)a	0.32(0.25,0.50)b	0.46(0.32,0.61)bc	58
Number of Samples	24-26	34-48	21-34	58-65	51-59	

Appendix V. Median (Q1, Q3) values for selected *Picea glauca* competition variables based on 1993 and 1994 data from Conifer Release experiment blocks. H values represent Kruskal-Wallis test results ($P < 0.05 = 9.5$, $P < 0.01 = 13.3$), while letters following medians are multiple range nonparametric Scheffe' tests.

Variable	Control	Disk Trenching and 2 kg/ha Hexazinone	Disk Trenching and 4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching followed by Brushsawing	H
Seedling Height (cm)	68(58,80)a	92(67,112)b	68(41,106)ab	69(58,86)ab	68(57,95)ab	15
Seedling Basal Dia. (mm)	10(8,13)a	16(11,20)b	18(12,25)b	12(11,13)ab	13(10,16)ab	37
Seedling Stem Volume (cm^3)	18(9,35)a	69(23,114)b	58(15,201)b	24(19,40)ab	34(15,56)ab	27
Seedling Current Growth Increment (cm)	11(8,13)a	16(10,19)ab	20(11,29)b	11(6,15)a	10(9,15)a	28
Seedling Vigor Rating	3(3,4)a	4(4,5)b	3(2,4)a	3(3,4)a	3(3,4)ab	32
Nearest Aspen -Distance (cm)	38(26,52)a	53(33,81)ab	88(36,135)b	37(17,84)ab	46(18,71)a	18
Nearest Aspen - Height (cm)	365(220,520)b	146(100,210)a	179(140,263)a	127(82,205)a	123(104,148)a	68
Nearest Aspen - Basal Diameter (mm)	29(18,38)c	14(10,21)ab	20(18,28)bc	14(8,17)a	13(10,15)a	56
Tallest Aspen - Distance (cm)	60(50,102)a	110(83,148)b	120(93,151)b	130(102,157)b	103(77,130)b	39
Tallest Aspen - Height (cm)	550(470,660)c	325(222,462)b	272(195,430)ab	240(158,340)ab	182(150,226)a	105
Tallest Aspen - Basal Diameter (mm)	46(41,53)b	37(25,49)b	40(23,54)b	24(18,32)a	20(17,25)a	84
Aspen Stem Density (number/m^2)	1.6(1.1,2.1)c	0.6(0.3,1.3)ab	0.2(0,0.6)a	0.8(0.5,1.4)b	1.0(0.6,1.3)b	59
Aspen Stem Length (m/m^2)	5.6(3.6,8.1)b	1.2(0.4,3.5)a	0.3(0,0.8)a	1.0(0.4,2.1)a	1.0(0.4,1.6)a	90
Effective Aspen Density (number/m^2)	6.7(3.7,14.8)b	3.6(1.5,8.8)ab	1.3(0.5,7.7)a	7.3(1.4,36.2)ab	4.7(2.0,30.5)b	18
Aspen Basal Area (cm^2)	114(73,181)b	16(2,63)a	2(0,9)a	10(3,23)a	8(3,14)a	96
Shrub >50 cm tall - Distance (cm)	33(24,52)	38(28,64)	40(31,69)	43(24,69)	42(25,57)	3
Shrub >50 cm tall - Height (cm)	72(61,89)a	60(53,79)a	64(58,84)a	64(58,78)a	66(59,83)a	9
Shrub >50 cm tall - Basal Diameter (mm)	7(6,8)	7(4,9)	6(4,11)	7(6,9)	8(6,10)	6
Shrub Stem Density (number/m^2)	3.0(2.1,3.7)ab	1.9(1.3,3.4)bc	1.4(0.8,3.4)c	1.6(1.1,2.0)c	3.4(2.4,6.4)a	36
Shrub Stem Length (m/m^2)	2.7(1.7,4.3)a	1.3(0.8,2.6)b	1.0(0.5,3.0)b	1.1(0.6,1.7)b	2.7(1.8,7.9)a	35
Density of Woody Stems (number/m^2)	4.6(3.5,5.8)b	3.0(1.7,3.8)a	2.1(1.0,3.8)a	2.4(1.6,3.2)a	4.3(3.7,7.4)b	52
Total Woody Stem Length (m/m^2)	8.6(7.3,11.5)c	3.2(1.3,5.7)ab	1.7(0.7,3.7)a	2.2(1.5,3.7)ab	4.3(2.9,9.5)b	77

Appendix V. Concluded

Variable	Control	Disk Trenching and 2 kg/ha Hexazinone	Disk Trenching and 4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching followed by Brushsawing	H
Percent Cover Aspen - C stratum	60(20,80)b	0(0,20)a	0(0,0)a	0(0,0)a	0(0,0)a	106
Percent Cover Aspen - B stratum	0(0,15)a	8(0,20)a	0(0,2)a	0(0,2)a	0(0,1)a	16
Percent Cover Aspen - A stratum	0(0,12)a	0(0,3)a	0(0,0)a	1(0,10)ab	8(0,15)b	27
Percent Cover - Total C stratum	60(25,86)b	0(0,30.0)a	0(0,0)a	0(0,0)a	0(0,0)a	108
Percent Cover - Total B stratum	8(0,26)a	10(0,25)a	0(0,0)a	0(0,11)a	0(0,15)a	14
Percent Cover - Total A stratum	20(10,30)ab	0(0,0)a	10(0,25)a	10(3,20)a	25(12,40)b	23
Percent Cover *Calamagrostis canadensis*	15(8,26)b	1(0,2)a	0(0,0)a	17(13,27)b	10(8,20)b	97
CI-1 (Tallest Aspen)	7.77(4.75,11.45)b	2.24(0.99,3.50)a	2.16(0.65,3.31)a	1.21(0.65,2.48)a	1.23(.072,1.91)a	93
CI-2 (Nearest Aspen)	6.44(3.88,12.34)b	1.00(0.21,2.40)a	1.01(0.30,2.56)a	1.05(0.28,6.41)a	0.85(0.42,2.05)a	63
CI-3a (Aspen - C stratum)	0.04(0.01,0.09)b	0(0,0.01)a	0(0,0)a	0(0,0)a	0(0,0)a	79
CI-3b (Aspen - B stratum)	0(0,0.01)a	0(0,0.01)a	0(0,0)a	0(0,0)a	0(0,0)a	10
CI-4	0.07(0.05,0.12)b	0.02(0.01,0.04)a	0.02(0.01,0.03)a	0.02(0.01,0.09)a	0.03(0.01,0.06)a	51
CI-5	2.50(1.86,4.00)b	1.17(0.65,1.60)a	1.47(0.71,2.50)a	1.07(0.67,1.64)a	1.08(0.77,1.41)a	65
CI-6	4.56(3.50,5.87)b	2.61(1.46,3.51)a	2.43(1.37,4.00)a	2.00(1.37,2.72)a	1.54(1.18,1.92)a	70
RelHT2	0.12(0.10,0.16)a	0.29(0.18,0.41)b	0.33(0.16,0.58)b	0.32(0.18,0.48)b	0.38(0.28,0.55)b	71
Shrub BD / Seedling Basal Diameter	0.67(0.47,1.00)b	0.50(0.28,0.66)a	0.37(0.19,0.71)a	0.32(0.18,0.48)ab	0.59(0.44,0.80)ab	20
Number of Samples	49-54	43-53	26-37	25-31	33-42	

APPENDIX VI. Median (1st and 3rd quartile) values for selected *Pinus contorta* and *Picea glauca* seedling characteristics within the Site Preparation and Conifer Release experimental treatment plots at the time of measurement (1992-1994). H values represent the results of Kruskal-Wallis tests ($P < 0.05 = 9.5$, $P < 0.01 = 13.8$). Values followed by the same letter do not differ ($P < 0.05$) among the different treatments according to nonparametric Scheffe' tests.

Site Preparation Treatments

Pinus contorta	Control	2 kg/ha Hexazinone	4 kg/ha Hexazinone	Rome Double Disking	Disk Trenching	H
Height (cm)	40 (30-53)a	40 (19-80)ab	60 (32-102)ab	116 (89-144)c	62 (35-111)b	102
Basal Diameter (mm)	9 (7-12)a	10 (8-20)ab	15 (10-23)b	25 (20-33)c	13 (10-18)b	112
Stem Volume (cm^3)	8 (4-18)a	9 (4-86)ab	34 (9-168)b	221 (92-394)c	33 (9-101)b	112
Number of Seedlings	58	57	64	90	63	-
Picea glauca						
Height (cm)	56 (41-64)a	57 (42-82)ab	63 (47-85)b	63 (52-86)ab	70 (43-93)b	16
Basal Diameter (mm)	10 (8-12)a	11 (8-14)ab	12 (10-18)b	11 (9-17)ab	13 (9-14)ab	13
Stem Volume (cm^3)	13 (7-29)a	21 (8-48)ab	23 (12-81)b	17 (11-66)ab	32 (9-47)ab	15
Number of Seedlings	84	80	84	61	63	-

Conifer Release Treatments

Pinus contorta	Control	DiskTrenching and 2 kg/ha Hexazinone	DiskTrenching and 4 kg/ha Hexazinone	Rome Double Disking	DiskTrenching followed by Brushsawing	H
Height (cm)	68 (42-101)a	76 (49-128)a	163 (129-203)b	127 (83-160)b	78 (53-108)a	55
Basal Diameter (mm)	11 (8-14)a	16 (11-26)ab	38 (25-47)c	22 (14-28)b	14 (12-21)ab	77
Stem Volume (cm^3)	32 (6-50)a	48 (16-205)ab	616(232-1115)c	169 (51-311)b	45 (19-111)a	70
Current Growth Increment (cm)	21 (7-29)a	21 (12-34)a	25 (16-43)a	29 (12-41)a	22 (9-32)a	9
Number of Seedling	26	48	45	70	59	-
Picea glauca						
Height (cm)	68 (58-80)a	92 (68-112)b	89 (51-138)ab	69 (58-87)ab	68 (57-95)ab	17
Basal Diameter (mm)	10 (8-13)a	16 (11-20)b	18 (12-25)b	12 (11-13)ab	13 (10-16)ab	40
Stem Volume (cm^3)	18 (9-35)a	69 (23-114)b	76 (22-246)b	24 (19-40)ab	34 (15-56)ab	31
Current Growth Increment (cm)	11 (8-13)a	16 (10-19)b	20 (11-29)b	11 (6-15)a	10 (9-15)ab	28
Number of Seedlings	54	53	38	31	42	-

APPENDIX VII. Summation of comparable regression equations from Tables 17 through 30.

Equation Form	Equation Number
CACA	1,3,51,202,230,236,253
CACA + Ta	2
CACA + Tb	28
CACA - Tc	198
CACA - Ta+Tb+Tc	232
CACA - POP.cm/m^2	177
CACA +POP.Ta - POP.cm/m^2	118,207
CACA - POP.ba - POP.Ta+POP.Tb+POP.Tc	158
CACA - SHB.cm/m^2 - POP.Ta+POP.Tb+POP.Tc	191
CACA + Ta+Tb+Tc/Stem.n/m^2	189
CACA - Tb+tC/POP.n/m^2	204
CACA - TPOP.bd + [Ta+Tb+Tc] ÷ STEM.n/m^2	192
CI-3a	82,137,171,208
EPD	194
EPD + POP.ba	124
NPOP.bd	176
NPOP.dis	21,65,76,210,242,243
NPOP.dis + SHB.bd	69
NPOP.dis + Ta + CACA - Tc	25
NPOP.ht	108,175
NPOP.ht ÷ NPOP.dis	195,225,245
NPOP.ht ÷ NPOP.dis - TPOP.ht ÷ TPOP.dis	226
NPOP.ht ÷ NPOP.dis - TPOP.ht ÷TPOP.dis + Ta/SHB.n/m^2	227,246
NPOP.ht ÷ NPOP.dis - [TPOP.dis+NPOP.dis+SHB.dis]/3	70,91
NPOP.ht ÷ NPOP.dis - [TPOP.dis + NPOP.dis +SHB.d]/3 ÷ POP.ba/POP.n/m^2	72
POP.ba	8,19,32,38,46,53,61,67,75,79,85,93, 101,103,111,115,122,126,139,143,145,150, 155,182,215,219,248,252
POP.ba - CACA	105,163
POP.ba ÷ POP.n/m^2	30
POP.ba ÷ POP.n/m^2 + [Tb+Tc]/POP.n/m^2	133
POP.ba ÷ POP/n.m^2 - [NPOP.dis+TPOP.dis+SHB.dis]/3	71
POP.cm/m^2	6,14,17,22,31,36,41,52,73,78,84,94,104, 110,116,121,144,156,212,220
POP.cm/m^2 + NPOP.bd	95,134,149
POP.cm/m^2 - TPOP.bd	20
POP.cm/m^2 ÷ POP.n/m^2	18,43,56,62,98,120,197
POP.cm/m^2 ÷ POP.n/m^2 - TPOP.bd - CACA	64
POP.n/m^2	5,13,35,57,100,151,168,174,240
POP.n/m^2 + NPOP.bd - POP.cm/m^2	96
POP.n/m^2 + [TPOP.dis+NPOP.dis+SHB.dis]/3	102
POP.Ta + POP.Tb + POP.Tc	80,86,183,187
POP.Ta + SHB.dis - POP.cm/m^2	117
POP.Tb	68,162
POP.Tb + POP.Tc	81,83
SHB.bd	50,66,125
SHB.bd - STEM.cm/m^2 ÷ STEM.n/m^2	181
SHB.bd - STEM.cm/m^2 ÷ STEM.n/m^2 - CI-3b + Ta+Tb+Tc	129

APPENDIX VII. Concluded.

Equation Form	Equation Number
SHB.cm/m^2	29,88,107,185,223
SHB.cm/m^2 - POP.Tc+POP.Tb+POP.Tc	87,228
SHB.dis	161
SHB.ht	224
SHB.n/m^2	106,132,142,203
SHB.n/m^2 + CACA - SHB.cm/m^2	49
STEM.cm/m^2	7,33,37,40,48,135,140,146,153,159, 165,178,190,200,205,216,233,235,251,255
STEM.cm/m^2 - CACA	206,237,238,256
STEM.cm/m^2 - TPOP.bd	54
STEM.cm/m^2 - TPOP.ht	44
STEM.cm/m^2 ÷ STEM.n/m^2	12,47,74,128,147,180
STEM.n/m^2	199,213,231,234,244,250,254
Ta	24,45,112,188
Ta ÷ SHB.n/m^2	23
Ta+Tb+Tc	34,218,229,247
Ta+Tb+Tc ÷ stem.n/m^2	10,89,138
Ta+Tb+Tc - POP.cm/m^2 ÷ POP.n/m^2	214
Ta+Tb, CACA, [TPOP.dis+NPOP.dis+SHB.dis]/3 + POP.ba	4
Ta - POP.ba + NPOP.ht ÷ NPOP.dis	113
Tb	123,164
Tb - EPD - STEM.cm/m^2	172
Tb+Tc	77
Tb+Tc ÷ POP.n/m^2	130
Tb - POP.n/m^2 + SHB.dis	136
Tb - STEM.n/m^2	141,170
Tb+Ta ÷ POP.m/m^2 - CACA	27
Tb+Tc ÷ POP.n/m^2 - CACA - TPOP.bd	63
Tc	119,169,201
TPOP.bd	15,39,59,92,209,239
TPOP.bd + [Ta+Tb+Tc] ÷ STEM.n/m^2	148,184
TPOP.bd + [Ta+Tb+Tc] ÷ STEM.n/m^2 - NPOP.ht ÷ NPOP.dis	152,157
TPOP.dis	90
[TPOP.dis+NPOP.dis+SHB.dis]/3	26,97,114,173
[TPOP.dis+NPOP.dis+SHB.dis]/3 - NPOP.ht ÷ NPOP.dis	109
[TPOP.dis+NPOP.dis+SHB.dis]/3 + Ta+Tb+Tc	9
TPOP.ht	11,16,42,55,60,99,127,131,166,179, 196,211,241,249
TPOP.ht - CACA - STEM.n/m^2	217,160
TPOP.ht - CACA - STEM.cm/m^2	222
TPOP.ht - POP.n/m^2	58
TPOP.ht - POP.ta - STEM.n/m^2	154
TPOP.ht - STEM.cm/m^2 ÷ STEM.n/m^2	167
TPOP.ht - Ta - STEM.n/m^2	186
TPOP.ht + Tb - STEM.n/m^2 - CACA	193