

**MANAGEMENT OF ASPEN
REGENERATION DENSITY
ON BOREAL MIXEDWOOD SITES**

1996

**S. Navratil, R. Hayward & L. Brace
Northern Forestry Centre
Edmonton, Alberta
T6H 3S5**

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Forest Industry Development Branch
13th Floor, Commerce Place
10155 - 102 Street
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T5J 4L6
Telephone: (403) 422 - 7011

ABSTRACT

The efficacy of a variety of vegetation control methods for managing initial aspen density is presented using the results from five research trials in Alberta. Methods included pre-harvest chemical applications, post-harvest mechanical and chemical site preparation and mechanical site preparation followed by manual and chemical release treatments.

A range of aspen densities from low to high levels of control can be achieved by appropriate techniques. The ranking of treatment efficacies is summarized for four levels of control. The highest efficacy rates in controlling aspen regeneration were produced by pre-harvest single tree injection of glyphosate (Vision) that reduced aspen density to 10% of untreated control densities.

Concepts and silvicultural benefits of initial aspen density control and of pre-harvest treatments are discussed.

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1.0 INTRODUCTION

1.1 Project Background

The vegetation management research trials described in this report were established with funding from the 1985-90 Canada-Alberta Resource Development Agreement, Sub-Program B.3. Subsequent measurement, analysis, and reporting was funded by the 1991-96 Canada-Alberta Partnership Agreement in Forestry (PAIF).

Projects include the Major Grande Prairie Trial (Grande Prairie Forest) and three satellites; A at Calling Lake (Lac La Biche Forest), B at Weberville (Peace River Forest), and C at Hines Creek (Prairie River Forest). The fifth is the Weyerhaeuser-Drayton Valley project (Rocky-Clearwater Forest).

This report covers the establishment, ingress and growth of aspen regeneration following silvicultural treatments aimed at managing initial aspen density on *mixedwood sites designated for conifer or mixedwood production*, as opposed to competition control at the juvenile stand stage. The Grande Prairie and Satellite A trials focus on the effects of chemical, mechanical and manual site preparation and release treatments on aspen regeneration. Satellite trial B focuses on aspen suckering effects of pre-harvest single-tree and ground-spot chemical treatments and post-harvest mechanical site preparation treatments. Satellite C and the Weyerhaeuser-Drayton Valley trials are confined to pre-harvest, single-tree, chemical treatments. Table 1 summarizes the treatment and assessment schedules for each trial.

The projects cover a range of Ecosites for which aspen control strategies are of potential value in future forest ecosystem management. The Grande Prairie and Satellite A (Calling Lake) trials are in the Central Mixedwood Subregion, and Satellite B (Weberville) is in the Dry Mixedwood Sub-Region of the Boreal Forest Natural Region. The Satellite C (Hines Creek) and Weyerhaeuser-Drayton Valley trials are in the Lower Foothills Subregion of the Foothills Natural Region (Figure 1) (Beckingham 1994).

1.2 Why Control Aspen on Mixedwood Sites

Boreal mixedwoods in Western Canada occupy about one-third of regional productive forest land and over one-half of the productive forest land of Alberta, representing some of the best sites for timber production (Corns and Annas 1986, Kabzems et al. 1986). Aspen (*Populus tremuloides* Michx.) is the most common deciduous associate of conifers in the boreal mixedwood.

The regional application of sustained yield policies within forest management agreements has resulted in formalized stocking and performance standards for coniferous regeneration. Recent reviews of boreal mixedwood management challenges identified interspecific competition, particularly between conifers, aspen and grass following clearcut harvesting, as the dominant mixedwood management problem in the region (Samoil 1988, Peterson et al. 1989).

Table 1
Summary of Treatments and Assessments for Each Trial

Year	Grand Prairie Method I	Method II	Satellite A (Calling Lake)	Satellite B (Weberville) ¹	Satellite C (Hines Creek)	Drayton Valley
1986	* baseline measurements	* baseline measurements * chem. site-prep (fall)	* established * baseline measurements * treatments applied	* established * baseline measurements (cruise of parent stand)	* established	
1987	* mech. treatments (spring) * crop trees planted * 1st yr. assessment aspen target trees and density	* mech. treatments (spring) * crop trees planted * 1st yr. assessment aspen target trees and density	* crop trees planted * 1st yr. assessment aspen target trees and density	* chemical treatments (June) * parent tree mortality (Sept.)	* chemical treatments (June) * parent tree mortality (Sept.)	
1988	* 2nd yr. assessment aspen target trees and density	* 2nd yr. assessment aspen target trees and density	* 2nd yr. assessment aspen target trees and density	* stand harvested (Jan.) * mechanical treatment * crop trees planted	* parent tree mortality (Aug.) * stand harvested (Nov.)	
1989	* release treatments (spring) * 1st yr. post-release assess. aspen target trees and density	* 3rd yr. assessment aspen target trees and density	* 3rd yr. assessment aspen target trees and density	* 1st yr. assessment aspen target trees and density		* established * herbicide application
1990	* 2nd yr. post release assessment aspen target trees and density			* 2nd yr. assessment aspen target trees and density		* 1st cut area harvested * 2nd herbicide application * 1st yr. assess. 1st cut * crown mort. 2nd cut * sampling for residue analysis * sampling for OSB testing
1991		* 5th yr. assessment aspen target trees and density	* 5th yr. assessment aspen target trees and density	* 3rd yr. assessment aspen target trees and density	* aspen density assessment	* 2nd cut area harvested * 2nd yr. assess. aspen target trees and density 1st cut * 1st yr. assess. aspen target trees and density 2nd cut * sampling for residue analysis * sampling for OBS testing
1992	* 4th yr. post release aspen target trees and density			* 5th yr. assess. aspen target trees and density		* 3rd yr. assess. aspen target trees and density. 1st cut
1993	* assessment of vegetation, competition and conifer seedling growth					* 3rd yr. assess. aspen target trees and density 2nd cut.

1. 1st, 2nd and 3rd year assessments done in spring as if year before for Satellite B (Weberville).



Figure 1 Location of Project Trials Within Natural Regions and Subregions of Alberta
Trials: GP = Grande Prairie; A, B and C = Satellites; DV = Drayton Valley

In Alberta, surveys of regenerating juvenile stands on 11 to 20-year-old cutovers throughout the province have shown that 64% of cutblocks have changed from predominantly conifers to predominantly mixedwoods or hardwoods since harvest (Henderson 1988), confirming aspen competition as a major limiting factor to coniferous regeneration success. In west-central Alberta aspen competition was identified as a major obstacle to lodgepole pine juvenile growth (Navratil and MacIsaac 1993).

Rapid increases in the utilization of deciduous species associated with conifers on mixedwood sites (Navratil et al. 1994), especially aspen, have accelerated the rate of harvesting on mixedwood sites, and the subsequent conversion of mixedwoods to hardwoods, which began during the exploitation of the coniferous component of mixedwoods before deciduous species were in demand (Samoil 1988, Brace 1992).

The addition of aspen as a valuable tree species rather than a "weed tree" in mixedwood management has done little to reduce concerns about the impact of aspen competition in areas designated for conifer production (Peterson et al. 1989). In fact, the need for a vegetation management strategy, which includes an adaptive approach to density management of aspen regeneration in order to ensure adequate conifer regeneration and growth, as well as productive aspen and aspen-conifer mixed stands is even greater now than in the past in Alberta. This need has been accelerated by new forest management initiatives, including Ecosystem Management, Forest Conservation, Caribou Management, Biodiversity and Old Growth Strategies, and Special Places 2000. Localized coniferous shortages already exist and the committed coniferous AAC reached 92.3% in 1995.¹

1.3 Aspen Control Using an Adaptive Vegetation Management Concept

Vegetation management is the principal means by which foresters divert part of the limited resources of a given ecosystem from undesirable woody and nonwoody competitors to further the objectives of forest management (Sutton 1985).

Vegetation management of aspen regeneration and competition must be adaptable with many options to accommodate a variety of silvicultural strategies including:

- 1) Promotion of hardwood production.
- 2) Control of aspen to promote conifer growth and production.
- 3) Adaptive control of aspen to achieve simultaneous hardwood and softwood production in species mixtures.

Approaches to aspen regeneration and competition control vary with the stage of the renewal cycle, degree of aspen interference and objectives of the silviculture system (Figure 2). Tools and methods that might be used to control aspen are multiple and may include a variety of approaches and treatments, such as chemical, manual, mechanical, prescribed burning, systems-based methods which minimize aspen density through the design and application of appropriate

¹Rocky Mountain Section CIF position paper on "Allocation of Timber," adopted in June 1994.

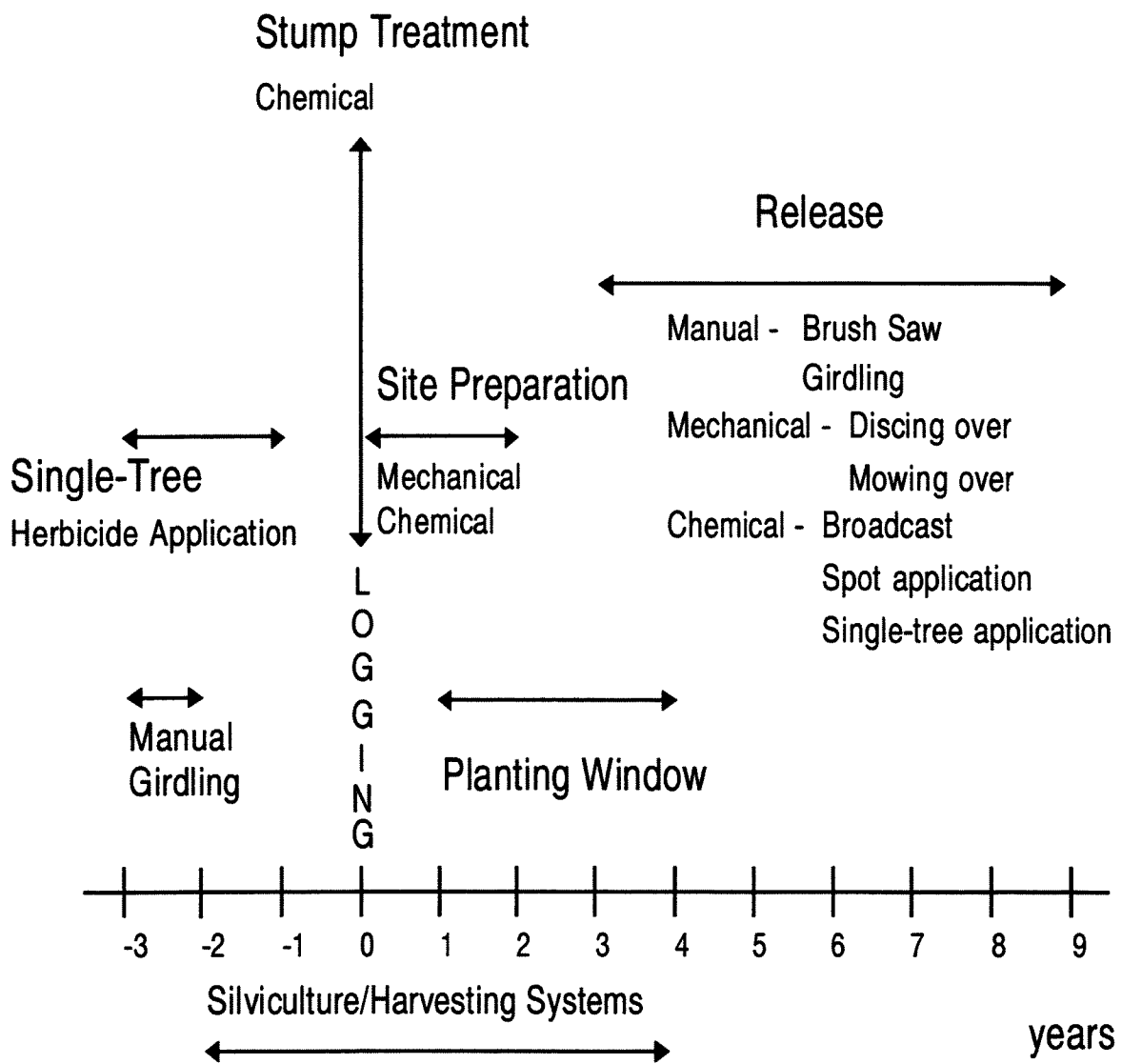


Figure 2 Approaches to Control of Aspen Competition on Mixedwood Sites

silvicultural systems (Sutton 1985) and combinations of the above.

The concepts emphasized in this report centre on managing initial aspen density. This may be achieved by treatments applied prior to harvest or shortly after harvest. The pre-harvest treatments used in this study were single-tree chemical treatments that employed a variety of techniques and registered herbicides. Post-harvest treatments included chemical and mechanical site preparation.

The management of initial aspen density, as opposed to competition control when the juvenile stand is formed, offers the possibility of avoiding severe competition before it becomes a problem. It also offers the opportunity to produce species mixtures suited to management objectives and stand and site conditions and to use systems-based methods.

2.0 PROJECT DESCRIPTION

2.1 Grande Prairie - Major Trial

The trial site, design, treatments and progress are described in detail by Todd and Brace (1987) and Brace et al. (1988). Navratil and Lane (1987) reported progress in the aspen development component of the trial, and Strong et al. (1995a) reported six-year vegetation composition, plant community structure, biodiversity and conifer growth by treatment. Strong et al. (1995b) also reported response of white spruce and lodgepole pine seedlings to competition on the Grande Prairie trial site. The trial site is located in the Grande Prairie Forest, on the Proctor and Gamble FMA, about 23 km south of the town of Grande Prairie.

Aspen dominated the overstory canopy of both study sites prior to harvesting, although the Method II stand was denser than the Method I stand and had a 20% cover of lodgepole pine. Overall canopy cover in Method II occurred within the 71% to 100% closure class with a height of 19 m to 25 m. Canopy closure was up to 50% in Method I. Forest stands at both sites originated about 1918, so they were about 65 years old when they were harvested in 1983.

Soils were predominantly Gleyed Solonetzic Grey and Gleyed Dark Grey Luvisols with moderately well to imperfect drainage.

2.1.1 Objectives

The objectives of this component of the trial are:

- a) To test the efficacy of mechanical, chemical (Pronone) and combined site preparation treatments for controlling aspen sucker density.
- b) To test the efficacy of mechanical, chemical (Pronone) and manual release treatments for controlling aspen sucker density.

2.1.2 Design and Methods

Initial fieldwork began in the summer of 1985, with the layout of a systematic, complete block design with three replicates per block in each method. All were completed in the autumn of 1985 (Figure 3). There were five treatments in Method I and originally six treatments in Method II. In 1988, a seventh treatment was added in Method II. Within each treatment, 20-20 m² circular plots were established to assess aspen regeneration density.

Spruce and pine crop trees were planted in 1987 (Todd and Brace 1987), and competition between aspen and spruce and pine are reported separately (Strong et al. 1995b). Planting was done in controls and chemical only treatments using hand-scalping.

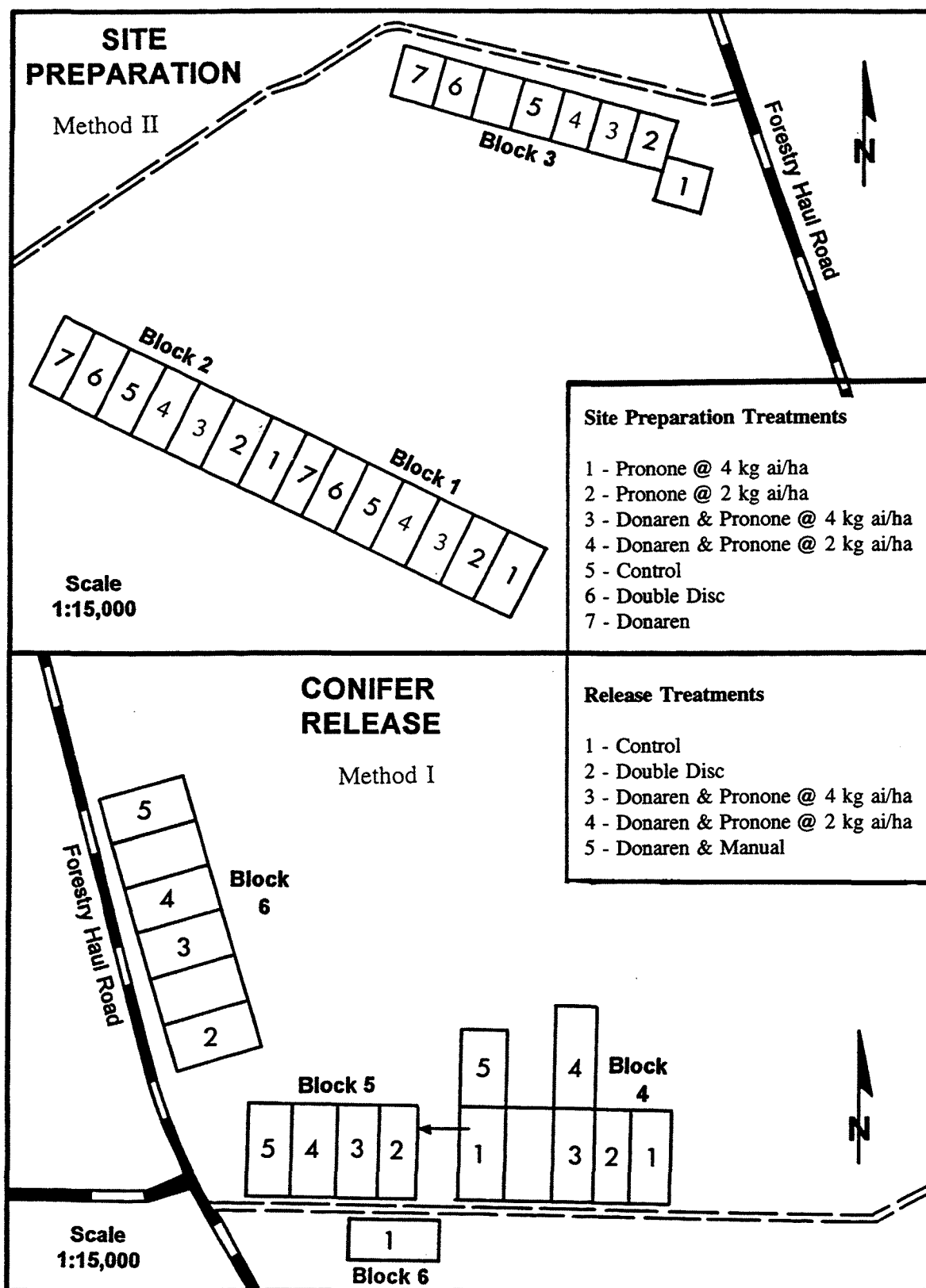


Figure 3 Grande Prairie Major Trial Layout

a) Release Treatments - Method I

1. Control - no release treatments.
2. Double-discing - A Rome Disc pulled by a D-8 Caterpillar tractor treated the entire area twice in a circular pattern.
3. Donaren Disc Trenching of the treatment area with Pronone at 2 kg ai/ha release. The Donaren trenches were approximately 2 m apart. The chemical release was applied May 1989, using a skidder-mounted ground applicator.
4. Donaren Disc Trenching with Pronone at 4 kg ai/ha release - Similar to Treatment 3 except with a higher rate of Pronone.
5. Donaren Disc Trenching of the treatment area with manual release. The area was released with brush saws in May 1989.

b) Site Preparation Treatments - Method II

1. Pronone at 4 kg ai/ha - The Pronone was applied by helicopter.
2. Pronone at 2 kg ai/ha - The Pronone was applied by helicopter.
3. Pronone at 4 kg ai/ha with Donaren Disc Trenching - Pronone applied by helicopter then Disc-Trenched.
4. Pronone at 2 kg ai/ha with Donaren Disc Trenching - Similar to Treatment 3 except with Pronone at a lower dosage.
5. Control - no site preparation treatments.
6. Double-Disc - A Rome Disc pulled by a D-8 Caterpillar tractor treated the entire area twice in a circular pattern.
7. Donaren Disc Trenching - A Donaren Disc Trencher treated the entire area. Trenching was done at the same time as the other Donaren sites, but data were not collected until 1988.

The chemical site-preparation treatments were applied in August 1986. Mechanical treatments were applied in May 1987, and all blocks were planted in June 1987. The chemical and manual releases were both done in May 1989.

c) Data Collection and Assessment Methods

Data collection and assessment methods are described in detail by Navratil and Lane (1987) and Navratil and Hayward (1990). The summary of treatments and assessments for the period of 1986 to 1992 are shown in Table 1.

2.2 Satellite A - Calling Lake

The trial site, design, treatments and progress were previously reported by Navratil and Lane (1987) and Navratil and Hayward (1990). The trial is located in the Lac La Biche Forest, Calling Lake Ranger District, about 6 km east of Highway 813 on the Chevron road.

The parent stand was predominantly mature aspen with a few scattered mature white spruce. The area was devastated by a tornado in June of 1984. Since then the spruce was salvage logged, and

the remaining unmerchantable debris was cut and piled in the winter of 1985/86.

The soils in the area are predominantly sandy loam to sandy clay Orthic Grey Luvisol. Although the soils are of a coarse nature the site appears poorly drained, suggesting a shallow or perched water table.

2.2.1 Objective

The objective of Satellite Trial A was to compare the efficacy of commonly used mechanical site preparation techniques and ground (simulated air) application of Velpar L for control of aspen competition. The focus is mainly on site preparation techniques.

2.2.2 Design and Methods

The trial was laid out in 1986 in a randomized complete block design with four replicates, with six treatments in each replicate (Figure 4). Treatments were applied in September and October of 1986. Each treatment replicate was 0.2125 ha in size. There was a 5 m buffer around the treatment, and within this there were 20 circular plots, 20 m² in size. These plots were used for pre-treatment and post-treatment assessments of density, growth and condition of aspen trees.

Spruce crop trees were planted in 1987 (Navratil and Lane 1987), and competition between aspen and spruce trees has been reported separately (Strong et al. 1995b).

a) Treatment Descriptions

1. Control - No site preparation was undertaken.
2. Straight Blade - An unmodified straight blade on a D-7 Caterpillar tractor was used to remove the organic layer and expose the mineral horizons. The entire area was scraped, leaving little or no organic soil horizons on the treatment.
3. Double Pass Rome Disc - Large stumps were first removed with the straight blade on the D-7. Care was taken to leave the organic layer as intact as possible. The Rome Disc was pulled by a Massey Ferguson 1805 farm tractor. The entire area was disced once in one direction, then disced again perpendicular to the first direction. Replicate four was too wet to be disced, so there are only three replicates of this treatment.
4. Velpar L at 3 kg ai/ha - Velpar L was applied using an R & D backpack sprayer with a four-nozzle boom. The sprayer simulates an aerial application. The equipment was calibrated for an effective spray width of 2 m and a speed of about 3.4 km/h. The spray dilution was 19:1 (water:Velpar), and the climatic conditions were ideal for application. The herbicide deposition and soil residue levels were monitored immediately, as well as 210 and 360 days after spraying (Feng and Navratil 1990).
5. Marttiini Plow - The Marttiini plow as pulled by a D-7 Caterpillar tractor. The plow penetrated to a depth of about 30 cm, and the rows were approximately 2 m apart. The plow had very little problem with the stumps. Good treatment cover and consistency were maintained.

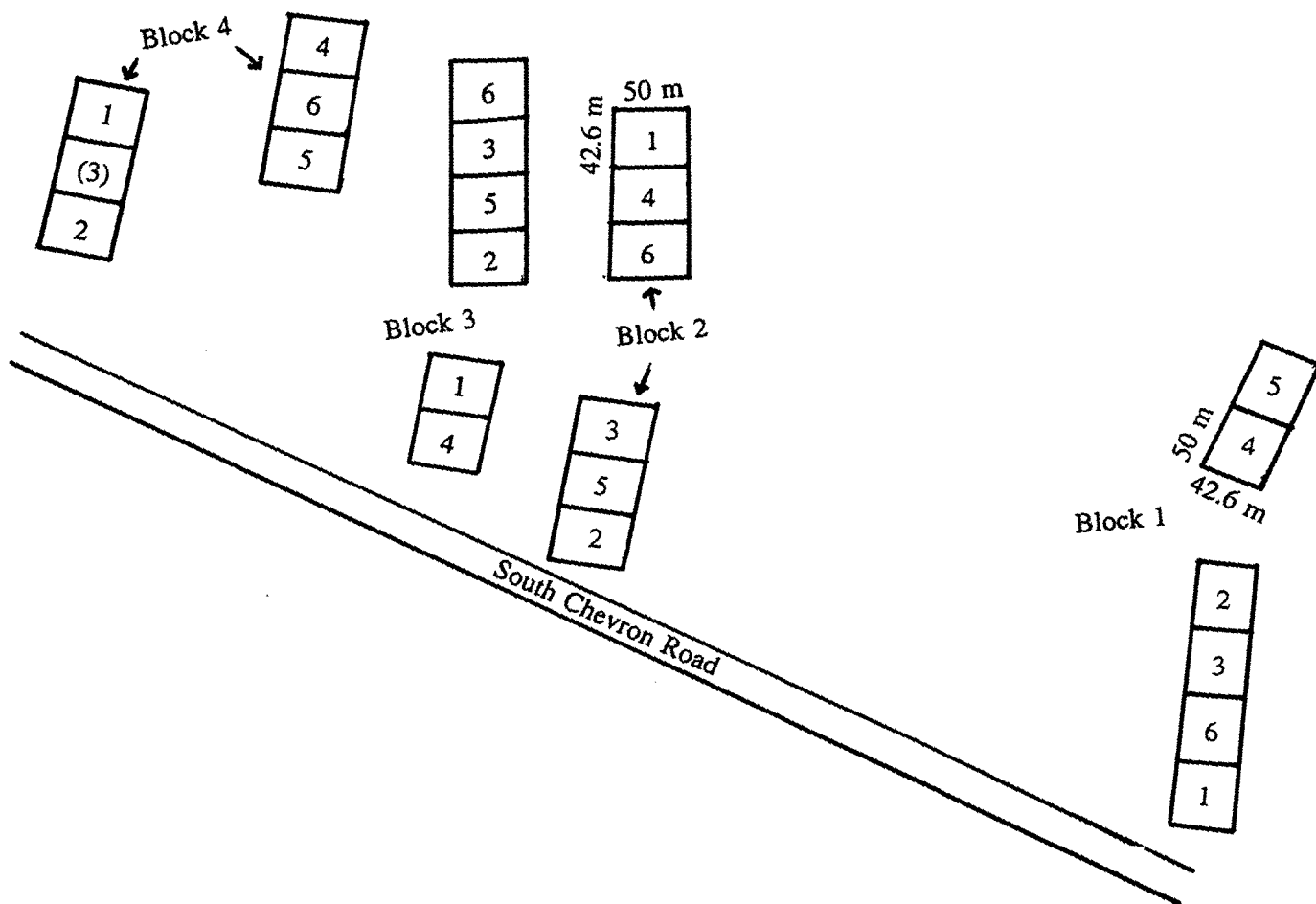


Figure 4 Satellite Trial A Layout (Scale 1:5400)

6. Marttiini Plow and Later Velpar Release - The Marttiini plow site preparation was completed as described in Treatment 5, but the Velpar release option was not required.

b) Data Collection and Assessment Methods

Data collection and assessment methods are described in detail by Navratil and Lane (1987), and Navratil and Hayward (1990). A summary of treatments and assessments for the period of 1986 to 1992 are shown in Table 1.

2.3 Satellite B - Weberville

The trial site, design, treatments and progress were reported previously by Navratil and Lane (1987) and Navratil and Hayward (1990). The trial is located in the Peace River Forest Weberville Demonstration Area about 50 km north of the town of Peace River.

In 1988 the forest in the trial site was predominantly aspen aged about 65 years with stem densities of 1000 to 3500 /ha. Soils are Orthic Grey Luvisols, well to imperfectly drained.

2.3.1 Objective

The objective of Satellite Trial B was to evaluate the efficacies of pre-harvest single-tree applications of herbicides, pre-harvest spotgun application of Velpar, and post-harvest Rome-discing of different intensities and timings, for the control of aspen suckering.

2.3.2 Design and Methods

The trial was laid out in a randomized complete block design with four blocks and 10 treatments (Figure 5). Each treatment replicate was 0.2125 ha in size with a 5 m buffer around the inside of the treatment area, and within this were 20 circular subplots 20 m² in size. The circular subplots were monitored for aspen sucker density and growth and condition.

All chemical treatments were completed in June 1987. Parent tree mortality was assessed in September 1987, and cutting and piling of the parent stand was completed in January 1988. Site preparation was done in June and July 1988. White spruce container seedlings were planted in late August 1988.

a) Treatment Descriptions

1. Punch and Fill - Vision
Supplier: Monsanto
Active Ingredient: Glyphosate
Dosage: 1 ml undiluted Vision/5 cm dbh

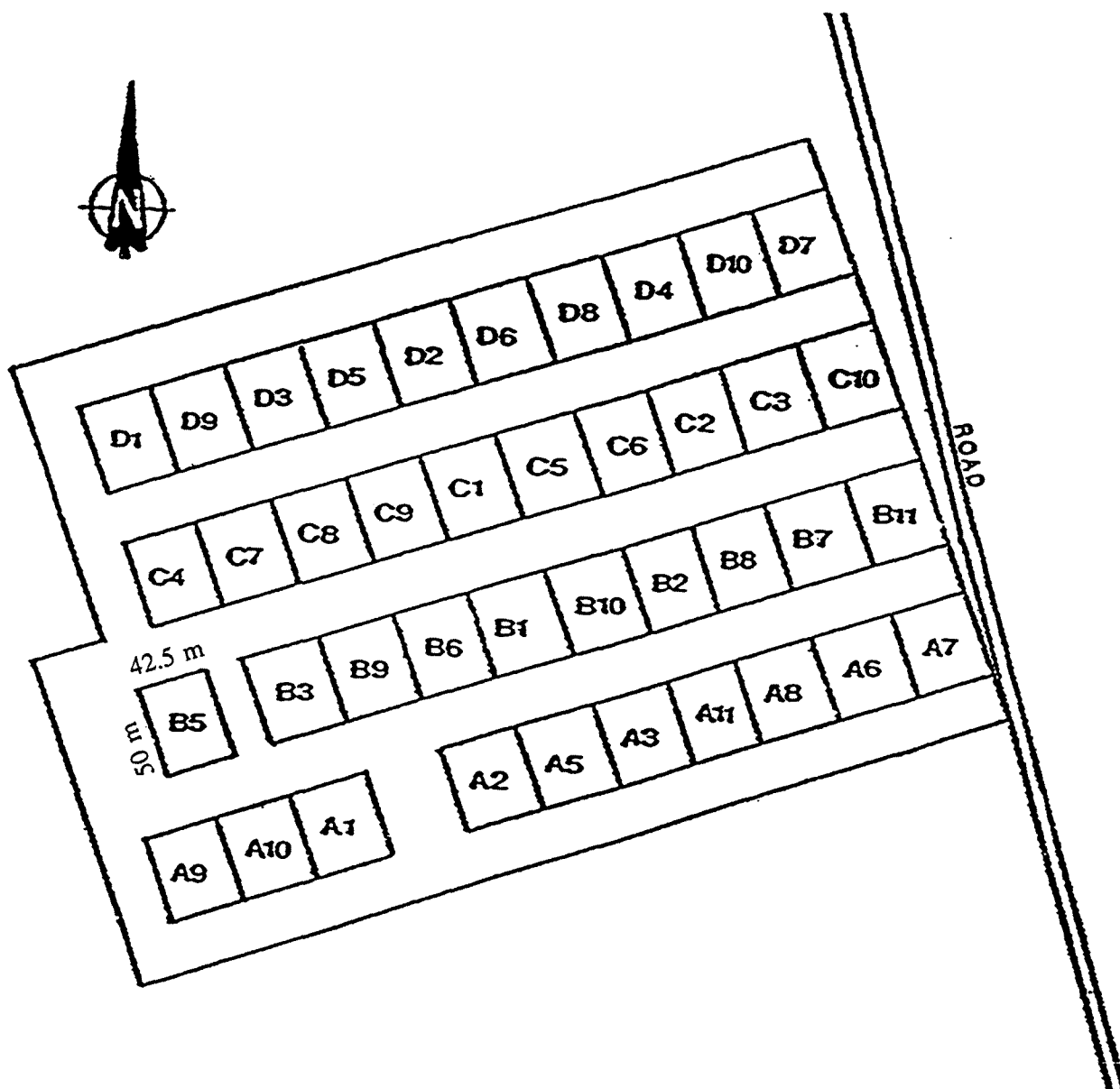


Figure 5 Satellite Trial B Layout (Scale 1:4000)

2. Gel-Cap - 1N (recommended dosage)
Supplier: Pace Chemicals
Active Ingredient: Glyphosate
Dosage: 1 capsule/10 cm dbh
3. Carbopaste
Supplier: Monsanto
Active Ingredient: Glyphosate (6%)
Dosage: 1 ml/2.5 cm dbh
4. Swedish Dry Notch Method - Tablet
Supplier: F.I.C. Sweden
Active Ingredient: Hexazinone
Dosage: 1 tablet/5 cm dbh²
(In blocks C and D only)
5. Spotgun - Velpar
Supplier: Dupont
Active Ingredient: Hexazinone
Dosage: 3 kg ai/ha, grid 2 x 2 m, 5 ml/spot
6. Punch and Fill - Velpar
Supplier: Dupont
Active Ingredient: Hexazinone
Dosage: 1 ml undiluted Velpar/5 cm dbh
7. Control - no treatment
8. Single-pass Rome Disc - June 1988
9. Double-pass Rome Disc - June 1988
10. Rome Disc - June and July 1988
Two single passes separated by time
11. Gel-Cap - 2N (double recommended dosage)
Supplier: Pace Chemicals
Active Ingredient: Glyphosate
Dosage: 2 capsules/10 cm dbh
(In blocks A and B only)

Due to the breakage of dry tablets, Treatment 4 was applied in blocks C and D only. The remaining replicates in blocks A and B were substituted with Treatment 11.

b) Data Collection and Assessment Methods

Data collection and assessment methods are described in detail by Navratil and Lane (1987) and Navratil and Hayward in (1990). The summary of treatments and assessments for the period of 1986 to 1992 are shown in Table 1.

²The manufacturer's recommended dosage is 1 tablet per 5 cm of circumference.

2.4 Satellite C - Hines Creek

The trial site, design, treatment and progress were reported previously by Navratil and Lane (1987) and Navratil and Hayward (1990). The trial is located near Stoney Lake, north of the town of Hines Creek, Alberta.

The stand was a mature (120 - 150 year-old) spruce-aspen, in which the aspen component was quite low (25%) and evenly dispersed. Soils are Orthic Grey Luvisols, well to imperfectly drained.

2.4.1 Objective

Satellite Trial C was designed to test the effectiveness of pre-harvest single-tree chemical treatments of aspen in a mature mixedwood stand for control of aspen suckering after harvest.

2.4.2 Design and Methods

The trial was laid out in a randomized complete block design with four replicates and five treatments (four treatments and one control) (Figure 6). Each treatment replicate was 0.42 ha in size. The buffer width was equivalent to the average tree height, and within the treatment area there was a minimum of 10 mature aspen trees. After harvest the assessment plots extended in cardinal directions from the base of sample trees, along a transect, as described by Herring and Pollack (1985) for single-tree vegetation control monitoring. There were no coniferous seedlings planted in this trial.

Herbicide treatments were applied in June and July of 1987 and the area was logged in the winter of 1988-89, allowing almost two full growing seasons for herbicide effect before aspen trees were harvested.

a) Treatment Descriptions

1. Swedish Dry Notch Method
Supplier: F.I.C. Sweden
Active Ingredient: Hexazinone
Dosage: 1 Tablet/5 cm dbh³
2. Punch and Fill, Formula 40 (double recommended dosage)
Supplier: Dow Chemical
Active Ingredient: 2, 4-D (33% solution)
Dosage: 1 ml/1.5 cm dbh
3. Punch and Fill, Velpar
Supplier: Dupont
Active Ingredient: Hexazinone
Dosage: 1 ml/5 cm dbh

³The dosage recommended by the supplier is 1 tablet per 5 cm of circumference.

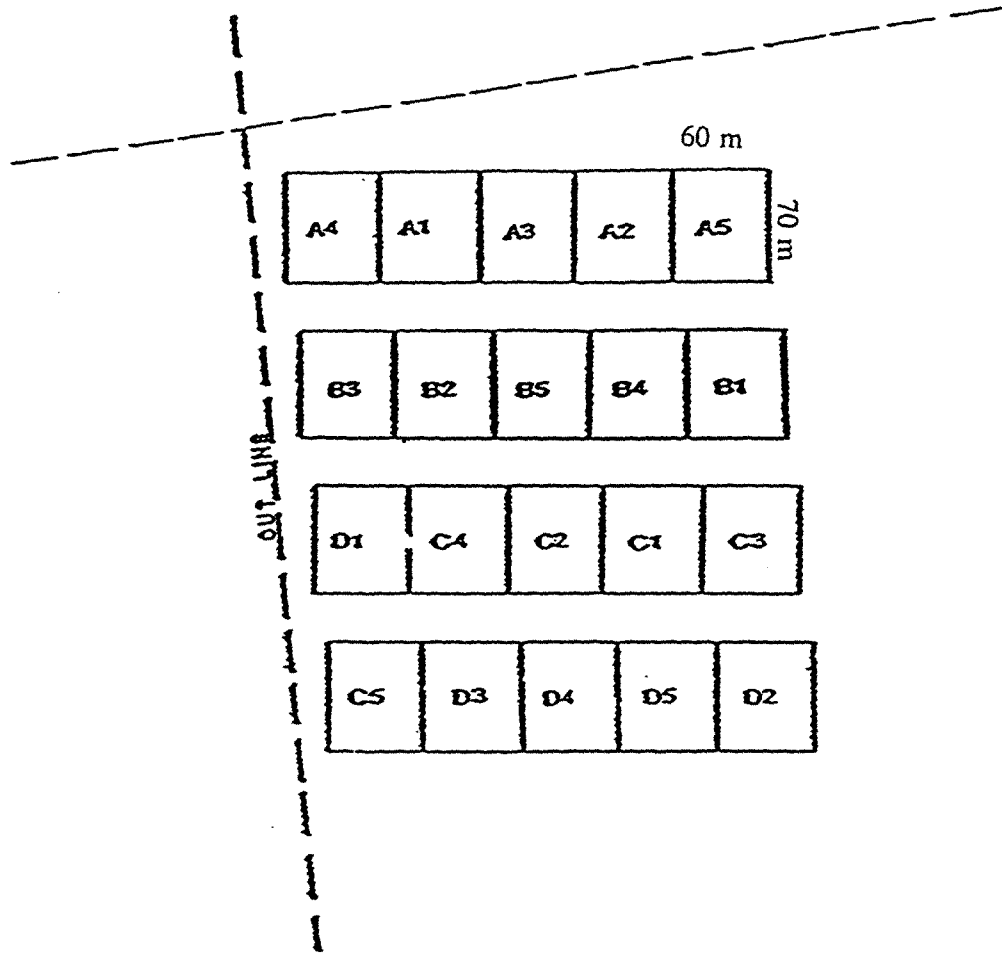


Figure 6 Satellite Trial C Layout (Scale 1:4800)

4. Punch and Fill, Formula 40 (recommended dosage)
Supplier: Dow Chemical
Active Ingredient: 2, 4-D (33% solution)
Dosage: 1 ml/ 3.0 cm dbh
5. Control - no treatment

b) Data Collection and Assessment Methods

Data collection and assessment methods are described in detail by Navratil and Lane (1987), and Navratil and Hayward (1990). The summary of treatments and assessments for the period of 1986 to 1992 are shown in Table 1.

2.5 Weyerhaeuser-Drayton Valley Trial

The trial site, design, treatments and progress were previously reported by Navratil, Hayward and Winship (1990). The trial is located in the Willesden Area, Rocky-Clearwater Forest, legal description SW 33 and SE 32-42-7-W5.

The forest stand in the trial area was a mature spruce-aspen. The average age, in 1988, was 107 years for the aspen and 116 years for the spruce. The aspen had a mean diameter of 27 cm and a mean height of 21.7 m. The mean diameter and height for the spruce were 27 cm and 19.8 m, respectively. The stand had a mean aspen volume of 78.5 m³/ha and had a mean spruce volume of 125.2 m³/ha. Soils are Orthic Grey Luvisols, well to imperfectly drained.

2.5.1 Objectives

- a) To test the efficacy of two single-tree application methods of Glyphosate (Modified Punch and Fill and commercial Ezject-Monsanto) at two times of growing season (spring flush and mid-season), with periods of 6, 8 and 18 months between treatment and harvesting, for control of aspen suckering density.
- b) To assess wood properties of glyphosate-treated trees, sequentially harvested 6, 8 and 18 months after herbicide application for oriented strandboard (OSB) production.
- c) To determine glyphosate residues in wood of treated trees 6 months after herbicide application (if detectable levels, repeat in 18-month harvest).

Only objective a) is reported here.

2.5.2 Design and Methods

The trial is laid out in a randomized complete-block design with three replicates and nine treatments (seven treatments and two controls) per replicate (Figure 7). Each replicate was divided into two sections: one section to be harvested in the winter of 1989-90, the other in the winter of 1990-91. Each treatment was 0.42 ha in size with the exception of those treatments in the first cut, replicate 1, which were 0.46 ha in size. These treatment sizes were increased to compensate for a seismic line running through the middle of the blocks.

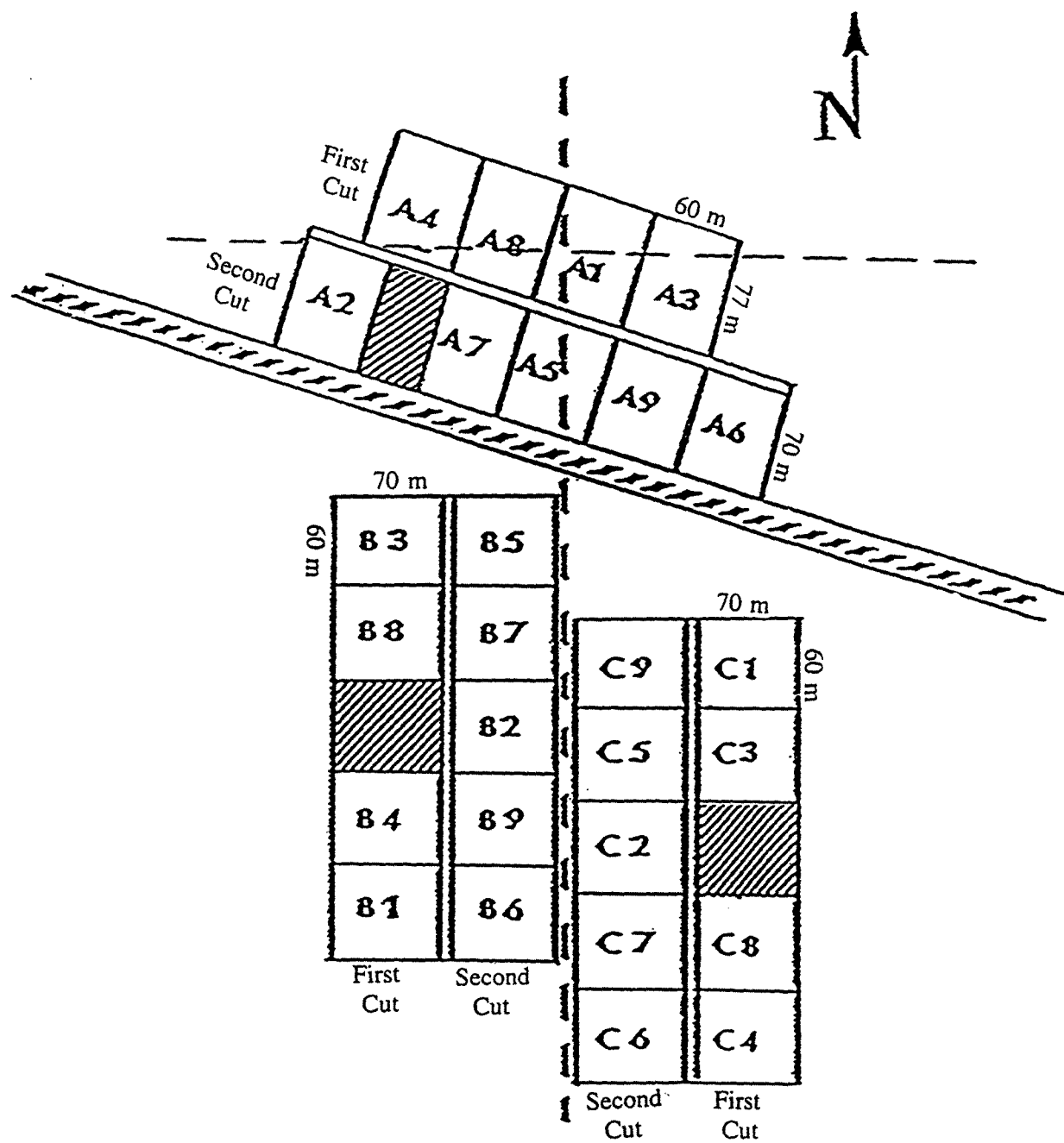


Figure 7 Weyerhaeuser - Drayton Valley Trial Layout

There were no coniferous seedlings planted in this trial for experimental purposes. There were two basic methods of application used, each method having a different time of application and/or time of harvesting.

a) Treatment Descriptions

Treatment	Time of application	Time of harvest	Time between treatment and harvest
1. Punch and Fill (1N) ^a Vision-Glyphosate Dosage: 1 ml/10 cm dbh ^b	July 1989	March 1990	6 months
2. Punch and Fill (1N) Vision-Glyphosate Dosage: 1 ml/10 cm dbh	July 1989	March 1991	18 months
3. Punch and Fill (2N) ^c Vision-Glyphosate Dosage: 1 ml/5 cm dbh	July 1989	March 1990	6 months
4. Ezject-Monsanto Glyphosate Dosage: 1 capsule/5 cm dbh	July 1989	March 1990	6 months
5. Ezject-Monsanto Glyphosate Dosage: 1 capsule/5 cm dbh	July 1989	March 1991	18 months
6. Punch and Fill (1N) Vision-Glyphosate Dosage: 1 ml/10 cm dbh	May 1990	March 1991	8 months
7. Ezject-Monsanto Glyphosate Dosage: 1 capsule/5 cm dbh	May 1990	March 1991	8 months
8. Control No treatment	----	March 1990	----
9. Control No treatment	----	March 1991	----

^a Recommended dosage

^b Diameter at breast height

^c Double recommended dosage

i) Punch and Fill

For the application at the recommended dosage (1N), 1 ml of undiluted Vision (Trademark, Monsanto Canada) was administered for every 10 cm diameter at breast height (dbh). The holes were made by a specially designed "hammer puncher" that penetrated the bark and phloem into the outer layers of wood. The correct dosage of Vision was applied with a calibrated spotgun applicator. The holes were fairly evenly spaced around the tree at breast height, and 1 ml of

herbicide was deposited in each hole (ie. six holes with 1 ml per hole for a 30 cm dbh tree). The double dosage (2N) was achieved by applying 1 ml for every 5 cm dbh, using twice as many holes per tree.

ii) Ezject Injector System

The Ezject Injector System was supplied by Monsanto Canada Inc., who describe the system as follows: "The system utilizes an empty non-charged .22 calibre cartridge. The capsule is filled with 0.14-0.18 g active ingredient of the isopropylamine salt of glyphosate. The specially designed injector implants this capsule, open end first, by driving it into the target tree to a depth of 0.5 to 1.5 cm. The cartridge must penetrate at least to the cambium tissue just inside the bark of the tree. The tree then absorbs the glyphosate through the circular incision created by the implantation." The cartridges were implanted at a rate of one capsule/5 cm dbh and were evenly spaced around the tree at breast height.

b) Data Collection and Assessment Methods

Data collection and assessment methods are described by Navratil, Hayward and Winship (1990). The summary of treatments and assessments is shown in Table 1.

3.0 RESULTS

3.1 Individual Projects

3.1.1 Grande Prairie - Major Trial

The trial has two components: Mechanical and chemical site preparation treatments (Method II) and Mechanical site preparation followed by release treatments (Method I), discussed separately.

a) Site preparation treatments

The treatment effects on aspen density 3 years after treatment ranged from no effect (Pronone 2 kg) to the reduction to 27% of control densities (Rome Discing). Statistically significant differences occurred within both mechanical and chemical treatments (Table 2).

In the mechanical treatments, Disc Trenching was less effective in reducing aspen density than Rome Discing with 2 passes.

In the chemical treatments, the aerial applications of Pronone at 2 and 4 kg/ha were relatively ineffective in controlling the density of aspen suckers. There was no difference between Control and Pronone 2 kg treatments. Pronone application at the rate of 4 kg reduced aspen density to only about 75% of Control. The addition of Disc Trenching to Pronone applications enhanced treatment effectiveness, especially for the 4 kg/ha rate, which improved from 75% of Control to 45% of Control in year 3.

The ranking of treatments in descending order of effectiveness was as follows:

	% of Control Density	
	<u>3 year</u>	<u>5 year</u>
Pronone 2 kg	105	98
Pronone 2 kg & Disc Trenching	84	82
Disc Trenching	79	78
Pronone 4 kg	75	69
Pronone 4 kg & Disc Trenching	45	46
Rome Discing 2 passes	27	24

The most effective treatments were Rome Discing - 2 passes (27% of Control) and Pronone 4 kg & Disc Trenching (45% of Control), representing 3 year aspen densities of 14,158 trees/ha and 23,842 trees/ha, respectively.

The ranking and statistical significance of differences 3 and 5 years after treatment remained about the same (Table 2). There was little relationship between aspen density at year 3 and proportionate change by year 5. There appeared to be no or little relationship between the treatments and aspen mortality (changes in density) occurring from year 3 to year 5. The range of mortality among treatments was narrow, varying from 40 to 46%. The treatments with lower 3-year density had less steep slope of mortality (Figure 8).

Table 2
Mean Aspen Density 2, 3, and 5 Years After Treatment
Grande Prairie - Major Trial - Mechanical and Chemical Site Preparation Treatments

Treatment	Pre-treatment densities	2 years after treatment	% of control	3 years after treatment			% of control	5 years after treatment		% of control
Control	68194b	56100a	100	53183	a ¹	a ²	100	31403	a ³	100
Pronone 2 kg	82875a	59350a	106	55867	a	a	105	30925	a	98
Pronone 2 kg & Disc Trenching	76745ab	55425a	99	44729	b	b	84	25861	b	82
Pronone 4 kg	86150a	41125b	73	39805	c	b	75	21762	b	69
Disc Trenching	n/a	48800ab	87	41833	n/a	b	79	24433	b	78
Pronone 4 kg & Disc Trenching	73620ab	33026bc	59	23842	d	c	45	14383	c	46
Rome Disc 2 passes	69526b	17067d	30	14158	e	c	27	7683	d	24

1. Letters designate statistical significance of differences among means using pre-treatment data as a covariate.
2. Letters designate statistical significance of differences among means without a covariate.
3. Letters designate statistical significance of differences among means without a covariate (GT 2 method).

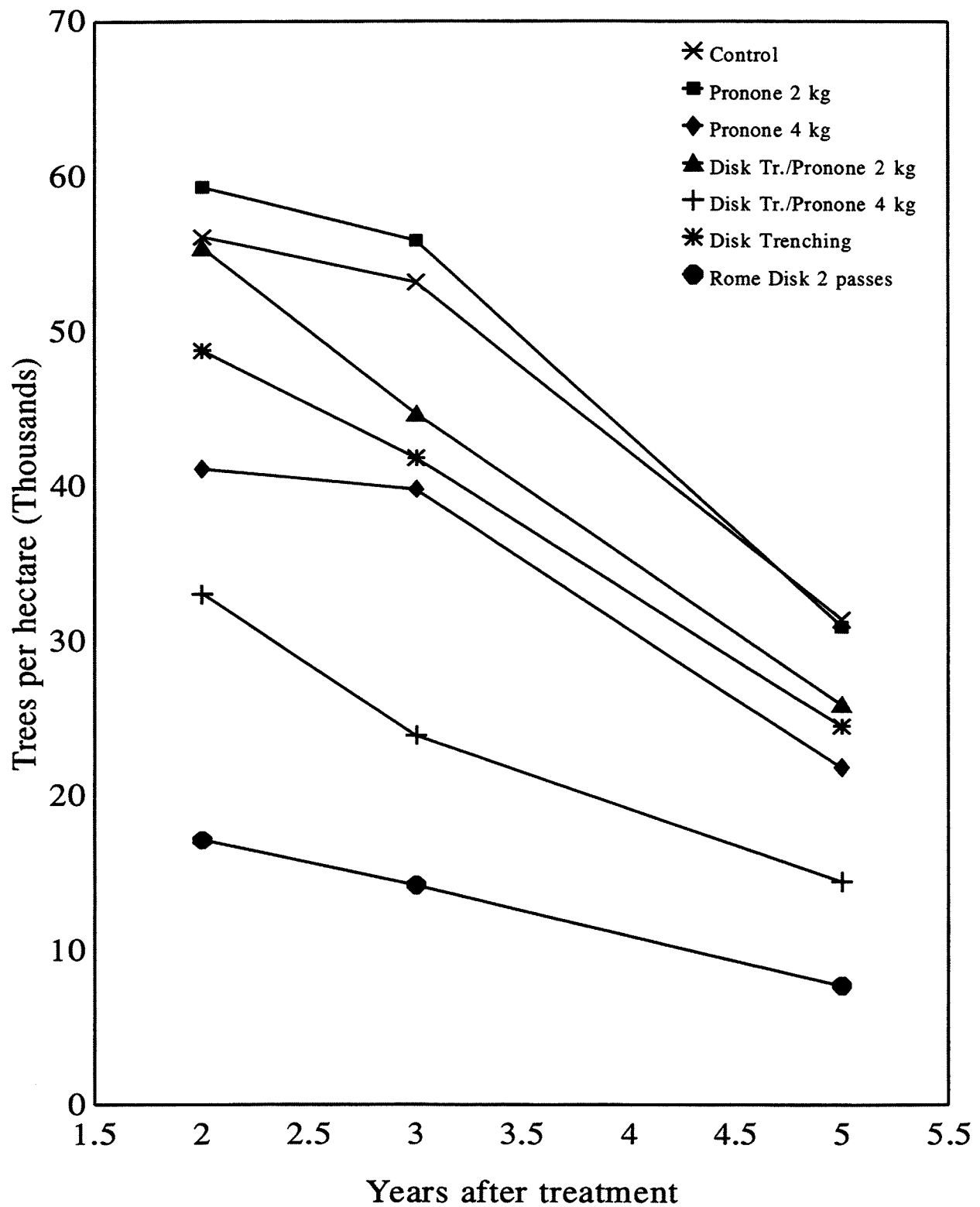


Figure 8 Changes in Aspen Density After Treatment - Grande Prairie - Major Trial Mechanical and Chemical Site Preparation Treatments

Mean height of aspen, 5 years after treatment, as compared to Control, was not affected by Pronone 2 kg/ha, slightly reduced (10-14%) by Disc Trenching and Pronone 4 kg/ha and moderately reduced (20%) by Pronone applications (2 kg and 4 kg/ha) followed by Disc Trenching (Table 3). The greatest reduction (68%) occurred in Rome Disc treatments where the majority of aspen resuckered after treatment. Height reductions were proportionate to density reductions which indicates that they resulted from mortality and subsequent resuckering after mechanical treatments. Height reductions in Pronone 2 kg and 4 kg applications without Disc Trenching were probably due to partial killing of terminals, branches and possibly roots by the applied herbicide.

b) Site Preparation with Release Treatment

Pre-treatment aspen densities in different treatments were in a narrow range of 32,898 - 40,233 trees/ha (Table 4), and were assumed to have minor or no effect on efficacy interpretations. Therefore the treatment effects are interpreted as % of Control.

Two-year aspen density reflects the effects of site preparation by Rome Discing - 2 passes and Disc Trenching prior to implementation of the release treatments. Rome Discing reduced aspen density as compared to Control by about 30% while Disc Trenching slightly increased aspen density. The Rome Discing area was not re-treated by release and the aspen density of 20541 trees/ha at year 2 gradually changed to 11 116 trees/ha at year 6, about 53% of Control densities. Over this period of four years, between 2 and 6 years after Discing treatment, the mortality in Rome Discing treatment was about double (46%) that for Control (25%) despite of the lower initial densities, 20 541 trees/ha and 28 406 trees/ha at year 2. This suggests that in Rome Discing aspen suckers formed on fragmented and wounded roots had lower viability and resistance to environmental stresses and consequently higher mortality. Differentiation of shoots formed in clusters that normally occur after sucker initiation (Navratil 1993, Shepperd 1993) probably also contributed to the observed higher mortality.

All release treatments reduced the number of live aspen one and two years after treatment (Figure 9, Table 4). Manual release and Pronone at 4 kg/ha had about the same effectiveness reducing aspen density to 26-28% of Control by 2 years after release treatment. Pronone at 2 kg/ha was less effective and reduced aspen density to 42% of Control. In the chemical release treatments (Pronone 2 kg/ha and Pronone 4 kg/ha) subsequent aspen mortality between year 2 and 4 after release was at the rate comparable to those shown in Control and Rome Discing and there was no indication of resuckering after treatments. Despite the substantial decrease in aspen densities in the first 2 years after the manual release cut, aspen density 4 years after release (6 years after mechanical treatment) was significantly higher than those observed in Pronone treatments and Rome Discing (Figure 9). After manual release cutting, young aspen regenerates by resuckering from the roots and by sprouting from the root collar of remaining stubs.

All treatments reduced height of aspen 4 years after release treatment (= 6 years after initial site preparation treatment). The most effective treatments were Disc Trencher & Pronone 4 kg, Rome Disc 2 passes and Disc Trencher & Manual Release, reducing aspen height to 28-39% of Control (Table 5).

Table 3
Height and Density of Aspen 5 Years¹ After Treatment
Grande Prairie - Major Trial - Mechanical and Site Preparation Treatments

Treatment	Height (cm)	Density (trees/ha)
Control	222a	31403a
Pronone 2 kg	221ab	30925a
Disc Trenching & Pronone 2 kg	176d	25861b
Pronone 4 kg	192cd	21762b
Disc Trenching & Pronone 4 kg	178d	14383c
Disc Trenching	201bc	24433b
Rome Disc 2 passes	71e	7683d

1. Years after treatment means the number of growing seasons after treatment.

Table 4
Mean Aspen Density 2, 3, 4, and 6 Years After Site Preparation Treatment
Grande Prairie - Major Trial - Mechanical Site Preparation Followed by Release Treatments

Treatment	Pre-Treatment	2 years ¹	% of control	3 years ¹ 1 year ²	% of control	4 years ¹ 2 years ²	% of control	6 years ¹ 4 years ²	% of control
Control	39237a	28406a	100	28583a	100	27041a	100	21133a ³	100
Rome Disc 2 passes	40233a	20541b	72	14016b	49	14216b	53	11116c	53
Disc Trenching & Pronone 2 kg	39883a	34208a	120	23467bc	82	11408bc	42	8442c	40
Disc Trenching & Pronone 4 kg	32898b	31350a	110	16958c	59	6916d	26	3283d	16
Disc Trenching & Manual Release	37008ab	29733a	105	7616a	27	7592cd	28	16833b	80

1. Years (growing seasons) after mechanical treatment (Rome Disc or Disc Trencher).
2. Years (growing seasons) after release treatment (chemical or manual).
3. Letters indicate statistical significance of difference among means using GT-2 method.

Table 5
Mean Height of Aspen 4 Years After Release Treatments
Grande Prairie - Major Trial - Mechanical Site Preparation Followed by Release Treatments

Treatment	Height (cm)	Height as % of control
Control	322 ±147 ¹	100
Disc Trenching & Pronone 2 kg	263 ±175	82
Disc Trenching & Pronone 4 kg	126 ±66	39
Rome Disc 2 passes	119 ±72	37
Disc Trenching & Manual Release	90 ±42	28

1. One standard deviation.

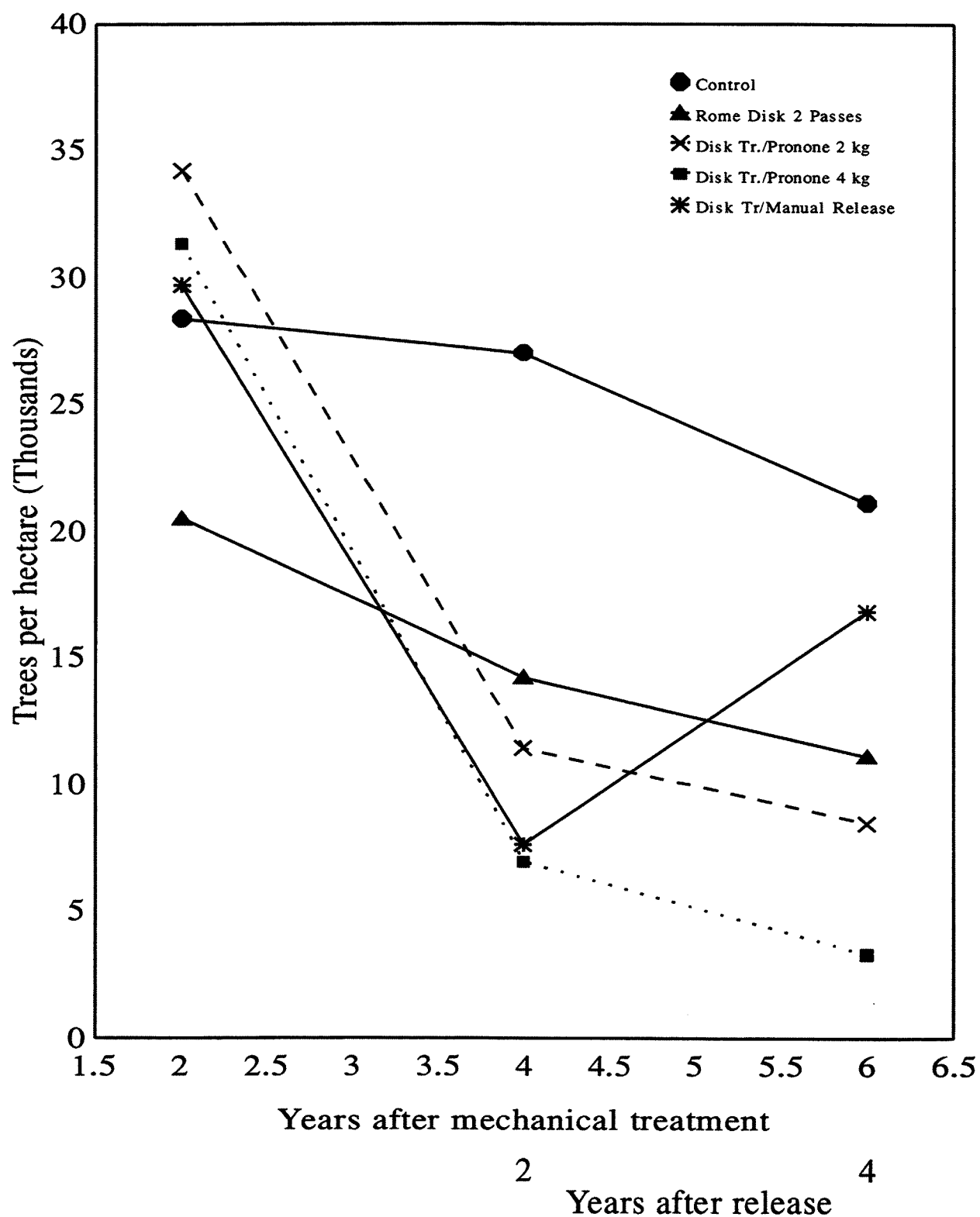


Figure 9

Changes in Aspen Density After Treatment - Grande Prairie - Major Trial
Mechanical Site Preparation Followed by Release Treatments

3.1.2 Satellite trial A - Calling Lake

Prior to implementation of site preparation treatments in Sept.- Oct. 1986, existing aspen and balsam poplar (*Populus balsamifera* L.) regeneration, presumably originating on the site since the tornado in 1984 and subsequent salvage-harvest and debris piling in 1985-86, was recorded as baseline, pre-treatment density.

Pre-treatment and one-year post-treatment densities were recorded for *Populus spp.*, combining aspen and balsam poplar. Pre-treatment densities varied in a wide range from 13 662 trees/ha to 38 869 trees/ha among the areas of treatments (Table 6). Consequently, the interpretations of treatment efficacies should consider these differences and need to be limited to the comparisons of relative changes in densities within treatments.

One year post-treatment densities (Table 7) show that Rome Discing reduced *Populus* densities most effectively, by 73%, followed by Marttiini and Blade treatments that resulted in 36-51% reductions. During the same period of one year, natural mortality in Control treatment was only 7% (Table 6).

Over the period of five years after treatment natural mortality in the Control was relatively high, about 57%. Assuming that the pre-treatment deciduous regeneration was approximately 1-2-year-old the observed mortality rate is within the upper range of density changes for aspen suckers in the cluster differentiation phase (Navratil 1991, Shepperd 1993).

In Rome Discing, blading and to a minor degree in one of the Marttiini treatments poplar (*Populus Spp.*) densities increased between one year and three years after treatments, presumably by resuckering and seeding in. This was particularly true for the Blade treatment that had the highest poplar (*Populus spp.*) (Table 6) and aspen densities (Table 7) in both year 3 and year 5 after treatment. Both aspen and balsam poplar can prolifically regenerate by seed on exposed mineral soil provided that soil moisture conditions are favourable. Root excavations of randomly selected aspen and balsam poplar stems in the Blade treatment in 1989 confirmed that over 70% of excavated trees were of seed origin.

It is important to note that (despite the low pre-treatment densities) the final poplar (*Populus spp.*) and aspen densities in the Blade treatment were higher than that of Control.

Over the five year period after treatment, treatments by Velpar, Marttiini and Rome Discing produced about the same effects, reducing pre-treatment densities in the range of 71-82%.

It appears that three growing seasons after treatment were required for Velpar to significantly reduce poplar density. There was a slight decrease (-19%) in densities in the first year after treatment, followed up by a substantial, 69% decrease in the third year after treatment. Five years after treatment poplar (*Populus spp.*) density in the Velpar treatment was the lowest among all treatments but not significantly different from Discing and one of the Marttiini treatments. In relative efficacy (% reduction from the pre-treatment densities) the Velpar treatment ranked about the same as Marttiini and Rome Discing.

In summary, despite a wide range in the pre-treatment densities, the densities in all treatments

Table 6
Pre-Treatment and Post-Treatment Densities of *Populus spp.* (Aspen and Balsam Poplar)
Calling Lake - Satellite Trial A

Treatment	Pre-treatment	Years after treatment					
		1 year	% ¹	3 years	%	5 years	%
Control	21025bc	19587	-7	16462	-22	9100b	-57
Blade	13662c	7000		30712		11588a	
Rome Disc 2 passes	27608b	7341		9900		4966d	
Velpar	22262bc	17962		6881		4325d	
Marttiini 1	17075c	11006		11687		4925d	
Marttiini 2	38869a	18987		18093		7143c	

1. Natural mortality relative to pre-treatment density.

Table 7
Aspen and Balsam Poplar Density 1, 3, and 5 Years After Treatment
Calling Lake - Satellite Trial A

Treatment	Pre-treatment	Years after treatment							
		1 year	3 years				5 years		
			% of control	Aspen	% of control	Balsam poplar	Aspen	% of control	Balsam poplar
Control	21025bc ¹	19587 ¹	100	12987bc	100	3475	6844a	100	2256
Blade	13662c	7000	36	24887a	192	5825	6844a	100	4744
Rome Disc - 2 passes	27608b	7341	38	7417cd	57	2483	3058b	45	1908
Velpar	22262bc	17962	92	5181d	40	1700	3194b	47	1131
Marttiini 1	17075c	11006	56	8806cd	68	2881	3300b	48	1625
Marttiini 2	38869a	18987	97	15675b	121	2418	5718a	84	1425

1. Includes both aspen and balsam poplar.

ended up in a relatively narrow range between 1131 and 4744 stems/ha and between 3058 and 6844 trees/ha for balsam poplar and aspen, respectively, five years after treatment (Table 7).

Post-treatment changes in aspen density showed three different trends varying with treatments (Figure 10).

	1 - 3 years after treatment	3 - 5 years
Control	light mortality	heavy mortality
Blade	significant increase	very heavy mortality
Rome Discing	medium increase	heavy mortality
Velpar	heavy mortality	light mortality
Marttiini	minor increase or no change	medium to heavy mortality

For practical application it appears that if initial deciduous regeneration (predominantly aspen) on a mixedwood cutblock is in the range of 17 000 - 27 000 trees/ha and the regeneration target for controlling competition is not more than 5 000 aspen any of the following treatments - Velpar application, Marttiini and Rome Discing site preparation - can all achieve desired results.

3.1.3 Satellite trial B - Weberville

Both pre-harvest chemical and post-harvest mechanical methods were effective in controlling aspen density and there was a range of efficacies within both chemical and mechanical methods (Figure 11, Table 8).

Pre-harvest, single-tree application of the encapsulated and paste-carried herbicides had lower efficacy than Punch and Fill methods. In the former group (encapsulated and paste-carried) carbopaste treatment had the highest efficacy (36% of Control densities) followed up by Gel-Cap treatments (62% of Control). The lowest efficacy (88% of Control) was associated with the application of Swedish dry tablets containing hexazinone.

In two pre-harvest treatments using Velpar, the spot ground application of Velpar was more effective in controlling aspen density than the Punch and Fill application of Velpar.

The most effective treatment was obtained by the Punch and Fill application of Vision which reduced aspen density to 4% of that of Control. Mean aspen density in Punch and Fill Vision treatments was 2 831 trees/ha, in contrast to Control treatments which contained, on average, 65

In mechanical methods, in post-harvest Rome Discing treatments, 3-year aspen densities ranged from 5243 to 47 285 trees/ha and were influenced by a number of disc passes and timing between the passes. The highest efficacy was achieved by two discing passes separated by 1 month which reduced aspen density to 5 243 trees/ha (8% of Control level).
881 trees/ha 3 years after harvest.

The treatment effectiveness 3 and 5 years after harvest remained about the same, but statistical differences between treatments were less distinct after 5 years. Aspen densities between 3 and

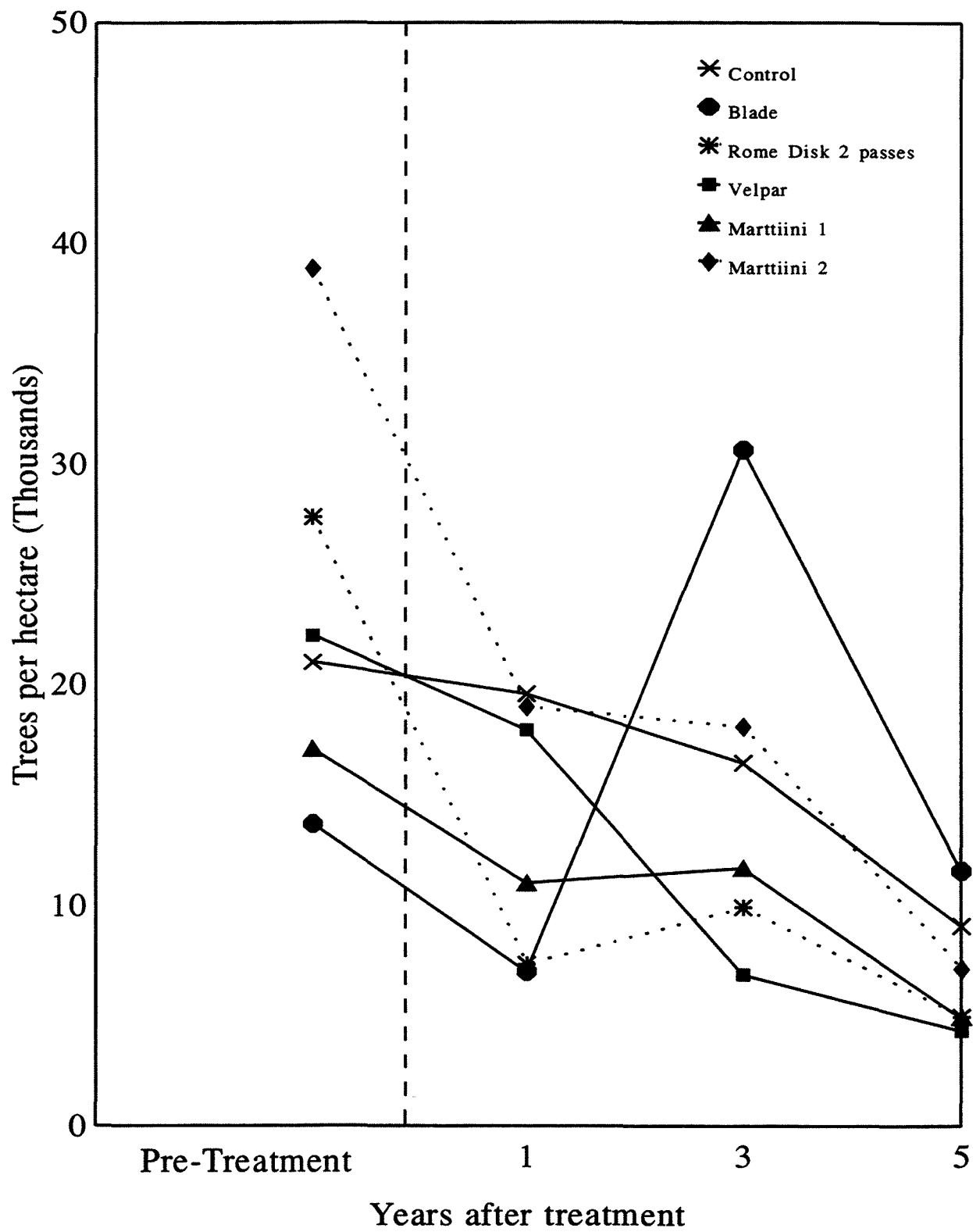


Figure 10 Changes in Aspen Density From Pre-Treatment to 5 Years After Treatment Satellite A

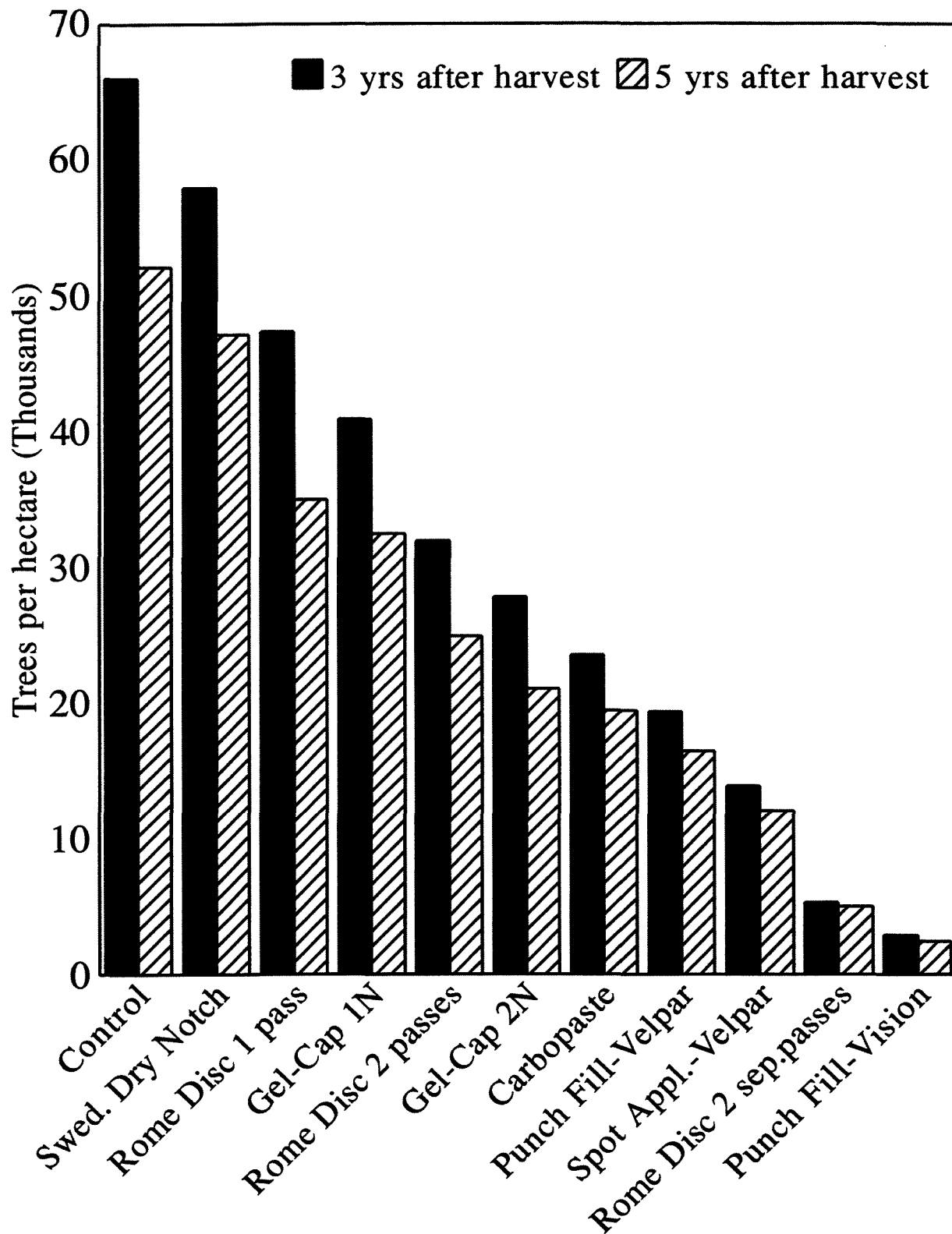


Figure 11 Aspen Density 3 and 5 Years After Treatment - Satellite Trial B, Weberville

Table 8
Aspen Density 3 and 5 Years After Treatment
Satellite Trial B - Weberville

Treatment	3 years ¹	% of control	5 years	% of control	% mortality (3 to 5 years)
Control	65881a	100	51987a	100	-21
Swed. Dry Notch	57775b	88	47075a	91	-19
Rome Disc 1 pass	47285c	72	34875b	67	-26
Gel-Cap 1N	40806d	62	32387b	62	-21
Rome Disc 2 passes	31862e	48	24862c	48	-22
Gel-Cap 2N	27750f	42	21000cd	40	-24
Carbopaste	23519fg	36	19373cd	37	-18
Punch Fill - Velpar	19269g	29	16381de	32	-15
Spot Appl. - Velpar	13781h	21	11925e	23	-13
Rome Disc 2 separate passes	5243i	8	4968f	10	-5
Punch Fill - Vision	2831j	4	2412f	5	-15

1. Rome disc treatments were done in the first summer after harvest.

5 years decreased proportionally with density. In high density treatments, mortality caused a substantial drop in densities (30% change) while in low density treatments (Rome Disc 2 separate passes and Punch and Fill-Vision) density changed only slightly (Table 8). The overall ranking of treatments tested at Satellite B shown in three classes of effectiveness is shown in Table 9.

3.1.4 Satellite trial C - Hines Creek

In accordance with the Expert Committee for Weed (Herring and Pollack 1985) protocol aspen and balsam poplar regeneration was assessed on transects in cardinal directions from stumps. Due to logistical constraints the number of cardinal transects was uneven in different treatments. Observations are based on 18 transects (90 regeneration plots) in Control, 16 transects (80 plots) in Formula 40 treatments and 4 transects (20 plots) in Velpar treatments. The Swedish Dry Notch treatment resulted in very low crown mortality (Navratil and Lane 1987) and was not assessed for post-harvest aspen regeneration.

Aspen regeneration in Control four years after harvest was only 11,970 trees/ha. This low level of aspen regeneration can be explained by the overmature stage and high component of balsam poplar in the parent stand and by heavy grassing-in after harvest.

Single tree chemical treatments by Formula 40 and Velpar had a pronounced effect on aspen regeneration four years after harvest reducing the number of aspen suckers to about 20% of Control (Table 10). There was no significant difference between Formula 40 and Velpar treatments.

3.1.5 Weyerhaeuser Canada, Drayton Valley

The results of different components of this trial are reported in detail by Navratil (1995, in preparation) and Feng and Navratil (in preparation). A summary of objectives and results of the biological efficacy of treatment effects on aspen regeneration are presented in the following.

The biological efficacy objectives were:

- a. Trial 1. Compare three types of treatments: Ezject, Punch and Fill Vision at 1 ml/10 cm dbh, and Punch and Fill Vision at 1 ml/5 cm dbh.
- b. Trial 2. Compare effects of time between application and harvest; 8 months and 18 months.

Trial 2 also allows a comparison of the treatment effects of Ezject and Punch and Fill Vision 1 ml/10 cm dbh.

Ezject treatment had a low efficacy in reducing aspen regeneration as compared to Punch and Fill Vision (Table 11). Ezject in trial 1 reduced regeneration to 91% of Control while Punch and Fill Vision treatments reduced aspen density to 6% and 12% of Control for dosages of 1 ml/10 cm dbh and 1 ml/5 cm dbh, respectively. There was no significant difference between the two dosage levels of Vision application.

In trial 2, the length of time between application and harvest of the treated trees did not significantly affect efficacy in reducing aspen density, though the 18 month delay had slightly lower aspen densities (Table 12).

Table 9
Aspen Density 3 Years After Treatment
Relative Ranking of Treatment Effectiveness at Satellite Trial B

Range %	% of control	Treatment	
	100	Control	65881 trees/ha
42-88	88	S.D.N	> 25000 trees/ha
	72	Rome Disc 1 pass	
	48	Rome Disc 2 passes	
	62	Gel-Cap 1N	
	42	Gel-Cap 2N	
21-36	36	Carbopaste	10-25 000 trees/ha
	39	Punch and Fill - Velpar	
	21	Spot Appl. - Velpar	
4-8	7.9	Rome Disc 2 separate passes	< 10000 trees/ha
	4.3	Punch and Fill - Vision	

Table 10
Aspen Density 4 Years After Treatment
Satellite Trial C - Hines Creek, Alberta

Treatment	trees/ha	% of control
Control	11970a	100
Punch & Fill Formula 40 2,4-D (33% solution) 1 ml/1.5 cm dbh (Double recommended dosage)	2400b	20
Punch & Fill - Velpar Hexazinone 1 ml/5 cm dbh	2250b	19

Table 11
Aspen Density 3 Years After Harvest of the Treated Trees
Trial 1 - Weyerhaeuser Canada, Drayton Valley

Treatment	trees/ha	% of control
Control	8942a	100
Ezject	8108a	91
P & F Vision - 1 ml/10 cm dbh	542b	6
P & F Vision - 1 ml/5 cm dbh	1033b	12

Table 12
Aspen Density 3 Years After Harvest of the Treated Trees
Trial 2 - Weyerhaeuser Canada, Drayton Valley

Treatment	trees/ha	% of control
Control	18500a	100
Ezject 8 months prior to harvest	11025b	60
Ezject 18 months prior to harvest	10317b	56
P & F Vision 8 months prior to harvest	3117c	17
P & F Vision 18 months prior to harvest	1692c	9

Table 14
Aspen Density Relative to Control of Each Trial 1-5 Years After Treatment

% of control Year after treatment					Treatment	Trial
1	2	3	4	5		
	106	105		98	Pronone 2 kg	Grande Prairie - Trial 1
	99	84		82	Pronone 2 kg & Disc Trenching	
	87	79		78	Disc Trenching	
	73	75		69	Pronone 4 kg	
	59	45		46	Pronone 4 kg & Disc Trenching	
	30	27		24	Rome Discing 2 Passes	Satellite A
36 ¹		192		100	Blade	
97 ¹		121		84	Marttiini 2	
56 ¹		68		48	Marttiini 1	
38 ¹		57		45	Rome Discing 2 passes	
92 ¹		40		47	Velpar	Satellite B
88		88		91	Swedish Dry Notch	
77		72		67	Rome Disc 1 pass	
58		62		62	Gel-Cap 1N	
53		48		48	Rome Disc 2 passes	
33		42		40	Gel-Cap 2N	Grande Prairie - Trial 2
30		36		37	Carbopaste	
26		29		32	Punch Fill - Velpar	
19		21		23	Spot Appl. - Velpar	
4		8		10	Rome Disc 2 separate passes	
3		4		5	Punch Fill - Vision	Satellite C
				53	Rome Disc 2 passes ³	
				40	Disc Trenching & Pronone 2 kg ²	
				16	Disc Trenching & Pronone 4 kg ²	
				80	Disc Trenching & Manual Release ²	
			20		Punch and Fill Formula 40	Drayton Valley - Trial 1
			19		Punch and Fill - Velpar	
		91			Ezject	
		12			P&F Vision 1 ml/5 cm dbh	
		6			P&F Vision 1 ml/10 cm dbh	
		60			Ezject 8 mo. prior to harvest	Drayton Valley - Trial 2
		56			Ezject 18 mo. prior to harvest	
		17			P&F Vision 8 mo. prior to harv.	
		9			P&F Vision 18 mo. prior to harv	

1. Includes both aspen and balsam poplar.

2. 4 years after release treatments.

3. 6 years after site preparation treatments.

Table 15
Treatment Efficacy Classes for Reducing Aspen Density 3 and 4 Years After Treatment
(Based on % reduction of aspen density compared to control)

Treatment efficacy class	Density reduction as % of control	Treatment
increase in aspen density		Pronone 2 kg - Grande Prairie - Trial 1 Blade - Satellite A Marttiini 2 - Satellite A
none to very low	0-15	Swedish Dry Notch - Satellite B Ezject - Drayton Valley - Trial 1
low	16-35	Pronone 2 kg & Disc Trenching - Grande Prairie - Trial 1 Disc Trenching - Grande Prairie Pronone 4 kg - Grande Prairie Marttiini 1 - Satellite A Rome Disc 1 pass - Satellite B
medium	36-59	Pronone 4 kg & Disc Trenching - Grande Prairie - Trial 1 Rome Discing 2 passes - Satellite A Gel-Cap 1N - Satellite B Rome Disc 2 passes - Satellite B Gel-Cap 2N - Satellite B Ezject 8 mo. prior to harvest - Drayton Valley-Trial 2 Ezject 18 mo. prior to harvest - Drayton Valley-Trial 2
high	60-79	Rome Discing 2 passes - Grande Prairie - Trial 1 Velpar - Satellite A Carbopaste - Satellite B Punch Fill - Velpar - Satellite B Spot Appl. - Velpar - Satellite B Punch and Fill Formula 40 - Satellite C
very high	80+	Rome Disc 2 separate passes - Satellite B Punch Fill - Vision - Satellite B Punch and Fill - Velpar - Satellite C P&F Vision 1 ml/5 cm dbh - Drayton Valley-Trial 1 P&F Vision 1 ml/10 cm dbh - Drayton Valley-Trial 1 P&F Vision 8 mo. prior to harv. - Drayton Valley-Trial 2 P&F Vision 18 mo. prior to harv.- Drayton Valley-Trial 2

Table 16
Treatment Efficacy of Mechanical Treatments for Reducing Aspen Density
(Based on % change in aspen density compared to control)

Treatment efficacy	Density reduction as % of control	% Reduction 3 years after treatment	% Reduction 5 years after treatment
		+92% Blade - Satellite A +21% Marttiini 2 - Sat. A	
none-very low	0-15%		0% Blade - Satellite A
low	16-35	-21% Disc Trenching-Grande Prairie -28% Rome Disc 1 pass - Satellite B -32% Marttiini 1 - Satellite A	-16% Marttiini 2 - Satellite A -12% Disc Trenching - Grande Prairie -33% Rome Disc 1 pass - Satellite B
medium	36-59	-43% Rome Disc 2 passes - Satellite A -52% Rome Disc 2 passes - Satellite B	-49% Rome Disc 2 passes - Grande Prairie - Trial 2 ¹ -52% Marttiini 1 - Satellite A -52% Rome Disc 2 passes - Satellite B -55% Rome Disc 2 passes - Satellite A
high	60-79	-73% Rome Disc 2 passes - Grande Prairie	-76% Rome Disc 2 passes - Grande Prairie - Trial 1
very high	80+	-92% Rome Disc 2 separate passes - Satellite B	-90% Rome Disc 2 separate passes - Satellite B

1. 6 years after treatment.

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