CONTROL OF ASPEN DEVELOPMENT IN AREAS DESIGNATED FOR SOFTWOOD PRODUCTION

SUMMARY OF SATELLITE TRIALS
A, B and C

Forest Research Branch, AFS [1]
1987

S. Navratil and J. Lane

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[1]215 McLeod Avenue, Spruce Grove, Alberta T7X 2Y4

DISCLAIMER

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ABSTRACT

Aspen management for the development of pure softwood stands and superior aspen stands requires suppression of undesirable trees. Satellite Trials A, B and C are designed to test the efficacy of selected techniques for control of aspen. Two major control strategies implemented are 1) site preparation and 2) pre-harvest single tree chemical application of parent aspen trees. The Satellite trials were established in 1986 and despite the delays in obtaining herbicide application permits, they have effectively progressed. This report contains the technical description of the trials, information on establishment, future workplans and some preliminary findings.

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INTRODUCTION

Aspen management will be an important area of forestry in the near future. Of Alberta's 19,723,746 hectares of productive forest land base, 10,794,115 hectares contain some deciduous component, the majority of which is aspen. (Timber Management Branch, Phase III).

Alberta has a well developed softwood industry and must aggressively support and promote softwood reforestation aimed at maintaining the coniferous annual allowable cut. Aspen is a serious competitor on productive softwood sites. There are problems in controlling and suppressing aspen in order to establish a new softwood crop and bring it through to a "free to grow" state. Such problems are evident in recent mixedwood cutovers and in aspen stands which have been converted to softwood plantations. From this perspective, the control of aspen suckering and ingress is currently seen as very urgent and deserving of immediate research.

On the other hand, aspen is an abundant and often overmature resource which is currently underutilized but has great future promise as a source of fibre. This research will provide information useful in management strategies to promote the development of aspen stands and improve their quality.

The objectives of the project are to develop aspen control strategies in areas designated for softwood production and to develop techniques for altering density of aspen suckering. In order to fulfill the above goals a body of factual information on aspen control alternatives adapted to the Alberta situation and environment needed to be developed.

The primary test site of the Vegetation Management Program in Grande Prairie is one of the sources of data and provides information on the effects of mechanical, chemical (Pronone) and combined site preparation treatments on aspen suckering, and mechanical, manual and chemical softwood release.

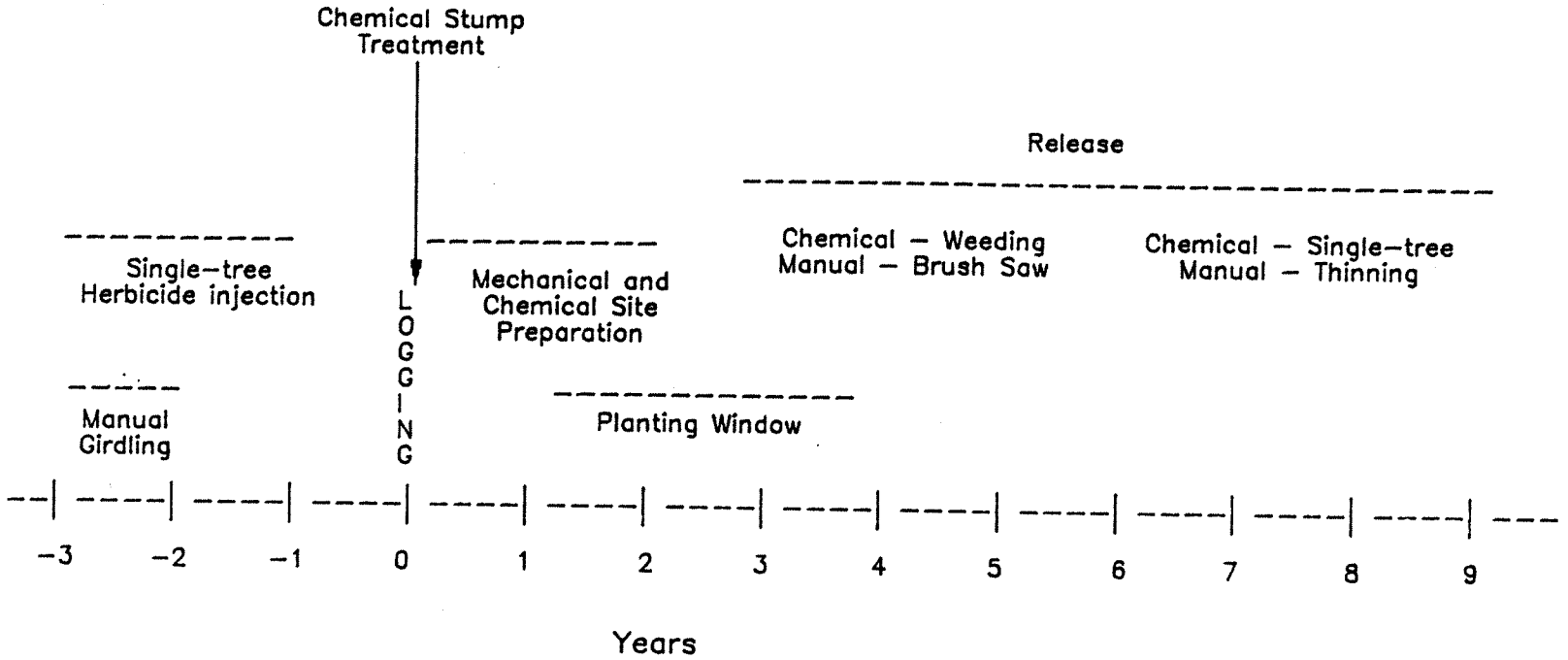
The role of the Satellite trials is to broaden options and methods for aspen control and test their effectiveness on several sites in Alberta.

Control of aspen suckering and growth offers several options (Figure 1).

PRE-HARVEST:
- chemical treatments of standing trees
- soil application of root active herbicides
- mechanical/manual girdling

AT THE TIME OF LOGGING:
- chemical treatment of stumps

Figure 1. Concept and Options for Control of Aspen Suckering



Satellite Trials:

D, E

C, part B

A, B, C

A, part B

F (Original Plan)

(Reduced Plan)

POST-HARVEST: Site preparation	- chemical treatments (soil and foliage application) broadcast and spot application
	- mechanical treatments
POST-ESTABLISHMENT: Clearing/weeding/release	- chemical treatments soil/foliage applications broadcast, spot and single tree applications
	- mechanical - manual

The original plan of Satellite trials called for six trials (A, B, C, D, E, F) with the intention to test aspen control methods in all three phases - (pre-harvest, post-harvest, post-establishment) of the harvest-renewal cycle.

Owing to the budgetary reduction the scope of Satellite trials was reduced and later, additional modifications were necessary due to the moratorium and controversy surrounding herbicide use.

The current Satellite trials A, B and C focus primarily on the pre-harvest, single-tree chemical applications and chemical/mechanical site preparation techniques.

Single-tree treatments as compared to broadcast, aerial or ground applications may be viewed as more environmentally sound and consequently more acceptable from a public relations point of view. Cost-effectiveness of both approaches will need to be compared though the labor intensity of single-tree treatments could be an acceptable trade-off in low-employment regions.

Biologically, an information basis needs to be developed pertaining to the timing of single-tree treatments, efficacies and dosages of chemicals, rate and extent of spread of toxic effects into root systems, persistency of effects and others. Though the Satellite trials B and C are designed to assess the effects on suckering density and growth, additional information related to the above questions will also be gathered.

The trials A and B were designed to supplement the methods used in the Alberta Forest Service on the Maintaining Our Forests (MOF) projects. It is expected that the generated results will be useful in developing stand conversion strategies.

Overall, the methodology of Satellite trials is designed to improve our understanding of aspen synecology and silviculture and, with a longer duration of trials, our knowledge of how to manage conifer plantations, and mixedwood and aspen stands for improved yield and quality.

SATELLITE TRIAL A: CALLING LAKE

Objective:

The objective of the Satellite Trial A is 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 on site preparation techniques.

Trial Area Description

The trial is located in the Calling Lake Ranger District, about six kilometers east on the south Chevron road. The parent stand was predominantly mature aspen with a few scattered 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 predominatly sandy loam to sandy clay, Orthic Gray Luvisol (Appendix). Although the soils are of a coarse nature the site appears poorly drained suggesting a shallow or perched water table.

Soil temperature profiles are being monitored on the control, marttiini, disc and blade treatments in block 1. These will be compared to greenhouse trial results.

The trial area has been placed under reservation to avoid disturbance.

Trial Design

The trial is laid out in a randomized complete block design with four replicates and six treatments within each replicate (Figure 2). Each treatment replicate is .2125 ha in size. There is a 5m buffer around the treatment and within this are twenty 20 m^2 circular plots. The circular plots are used for pre-treatment and post-treatment assessments of density, growth and condition of both aspen and crop trees and the competition level between these species.

Description of treatments in the Satellite trial A:

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 area.

3. Double Pass Rome Disc: Large stumps were first removed with

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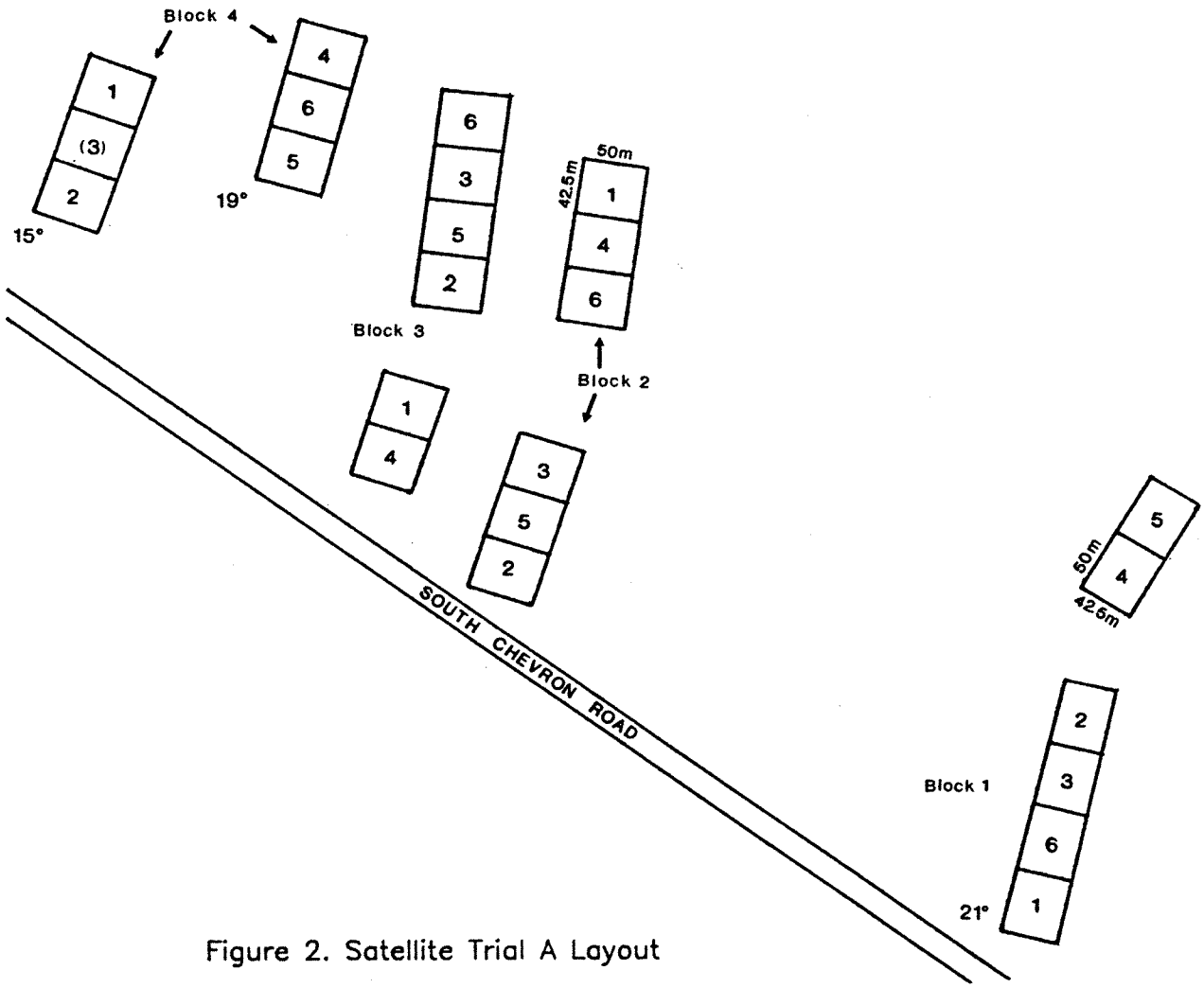

Figure 2. Satellite Trial A Layout

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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 in the opposite direction. Replicate 4 was too wet to be disced therefore there are only three replicates of this treatment.

The disc penetrated to an average depth of 15 cm. A preliminary survey of the root segmentation caused by discing revealed that 52% of roots sampled were segmented to less than 30 cm. in length. (Table 1)

Table 1 Percent of roots in each length class for the three replicates double disced in Calling Lake, Satellite Trial A

Replicate	0-10	11-20	21-30	31-40	41-50	51+
1	4	32	24	24	0	16
2	4	20	20	24	0	32
3	4	16	32	12	4	32
Total Average	4%	23%	25%	20%	1%	27%

4. Velpar L @ 3 kg ai/ha: The Velpar was applied using an R & D backpack sprayer with a 4 nozzle boom. The sprayer is designed to simulate an aerial application. The equipment was calibrated for an effective spray width of 2 meters and a speed of about 3.4 kmh. The spray dilution was 19:1 (water: velpar). The environmental conditions were ideal for application. (Table 2)

Table 2 Environmental Conditions on September 17, 18, 1986

	September, 1986	
	17	18
Max. Temperature °C	10°	13°
Relative Humidity (%)	67	42
Max. Wind speed (kmh)	7	13
Wind Direction	NW	S
Cloudiness	scattered	scattered
Rainfall (mm)	2.2	0.0

The total rainfall post-application to October 30th was

38.2 mm, a substantial amount (17.8 mm) of which fell from September 26th to 28th.

Hexazinone Residue Monitoring

The pesticide permit No. 86-GA96 issued for the Satellite Trial A (Appendix) stipulated that herbicide soil residue monitoring be conducted on the application site. The protocol for this monitoring was formulated with assistance from J. Feng, CFS, NoFC (Appendix).

The hexazinone was to have been applied at a rate of 3.0 kg ai/ha but the deposition samples show a slightly higher mean application rate (3.8 kg ai/ha).

Two deposition sampling methods were used (Figure 3). The conventional core sampling method shows a low deposition rate because the chemical tends to get caught up in the foliage and surface litter. The jar samples are expected to be a more accurate measure of deposition rate. Figure 4 shows how the amount of hexazinone present in the soil has changed over time. The residue in the upper layers of 30 cm of soil after 1 year is 9% of the initial deposition rate. After the winter approximately 26% of the total hexazinone remaining has moved below the 15 cm depth. One year later, 29% of the total has moved downward. The residue is at such a marginal level that further monitoring may not be necessary.

Figure 3. Satellite Trial A Hexazinone deposition levels monitored by two methods immediately after application and how it affects the pattern of residue persistence

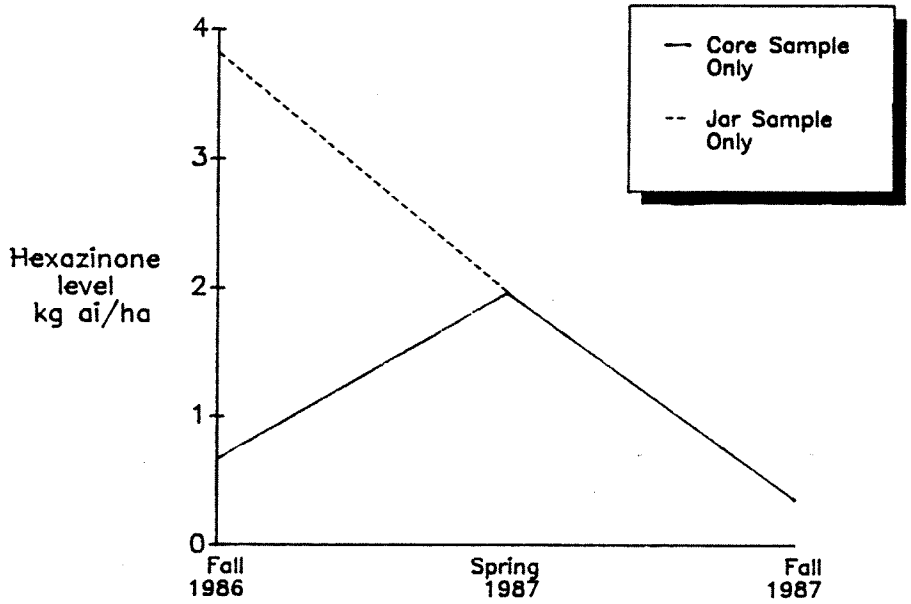
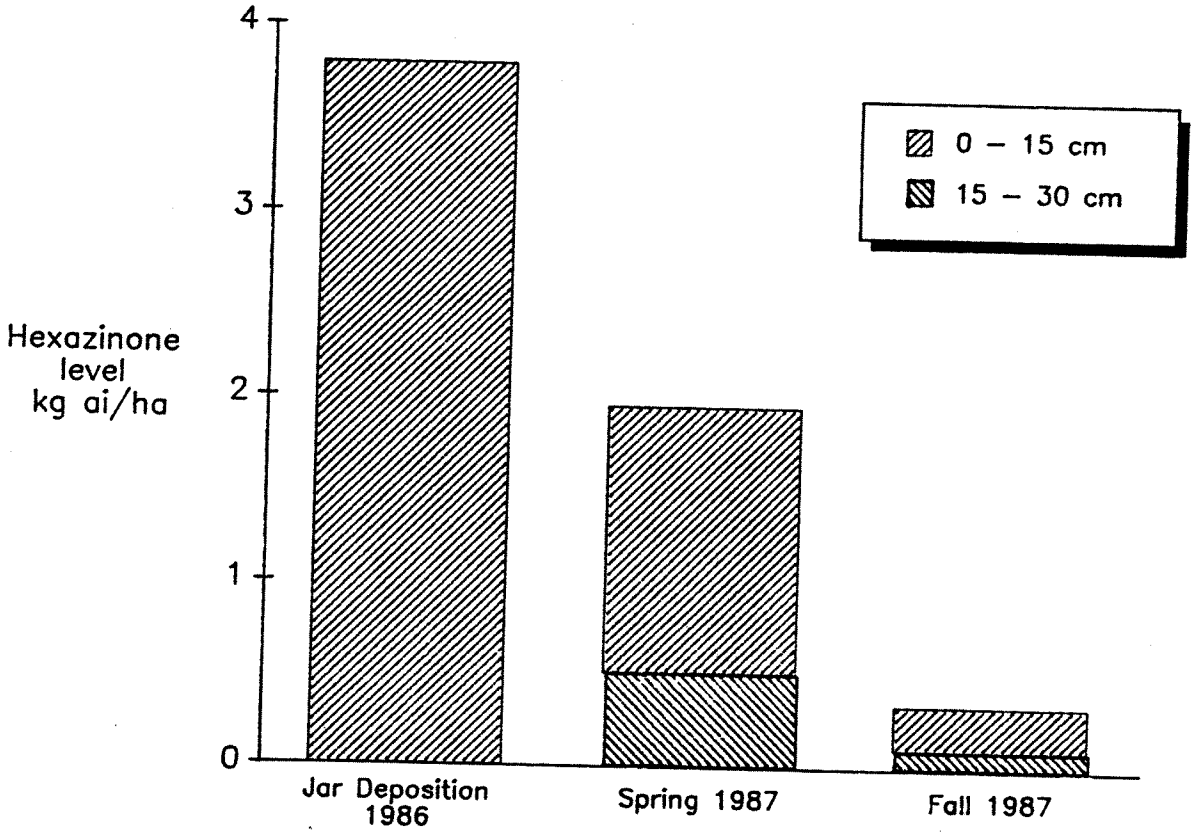


Figure 4. Hexazinone deposition and residue levels monitored at the time of application (Fall 1986), Spring 1987, and Fall 1987



5. Marttiini Plow: The marttiini plow was pulled by a D7 caterpillar tractor. The plow penetrated to a depth of about 30 cm, rows were approximately 2 meters apart. The plow had very little problem with the stumps. Good treatment cover and consistency was maintained.

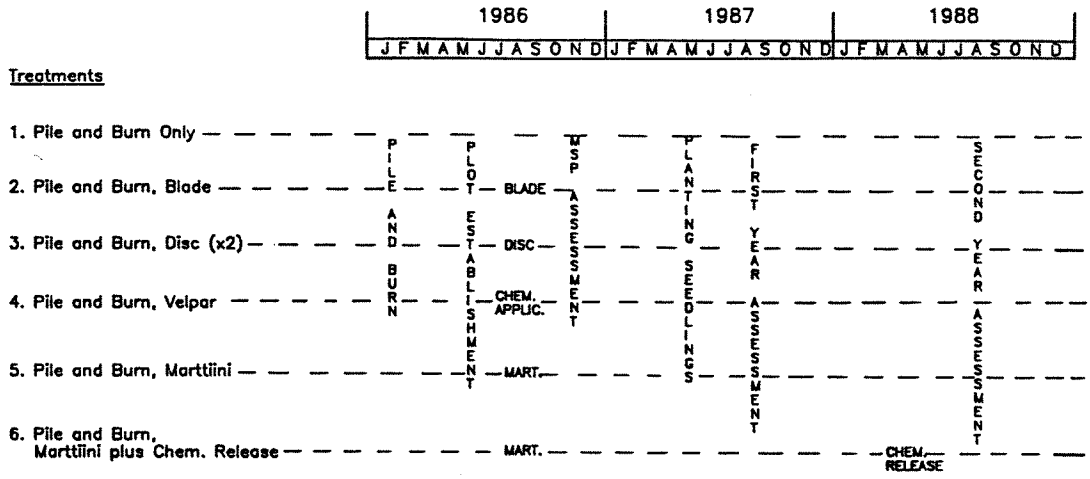
6. Marttiini Plow and later Velpar Release: The marttiini plow site preparation was completed as described above. The treatment will be chemically released with Velpar L when the need arises.

Time Schedule:

Owing to the delays in obtaining the pesticide permit the schedule of the trial was changed. The current schedule of treatment and assessment is as shown in Figure 5. The maintenance and assessments of trials will have to be extended beyond the limitation of the current FRD Agreements. A minimum

of 5 years after treatments will be required to produce meaningful and applicable results.

Figure 5. Satellite Trial A – Calling Lake Current Time Schedule



The pre-treatment assessment was completed in August 1986.

The chemical and mechanical site preparation was carried out in September-October, 1986.

The piles were burned in November of 1986.

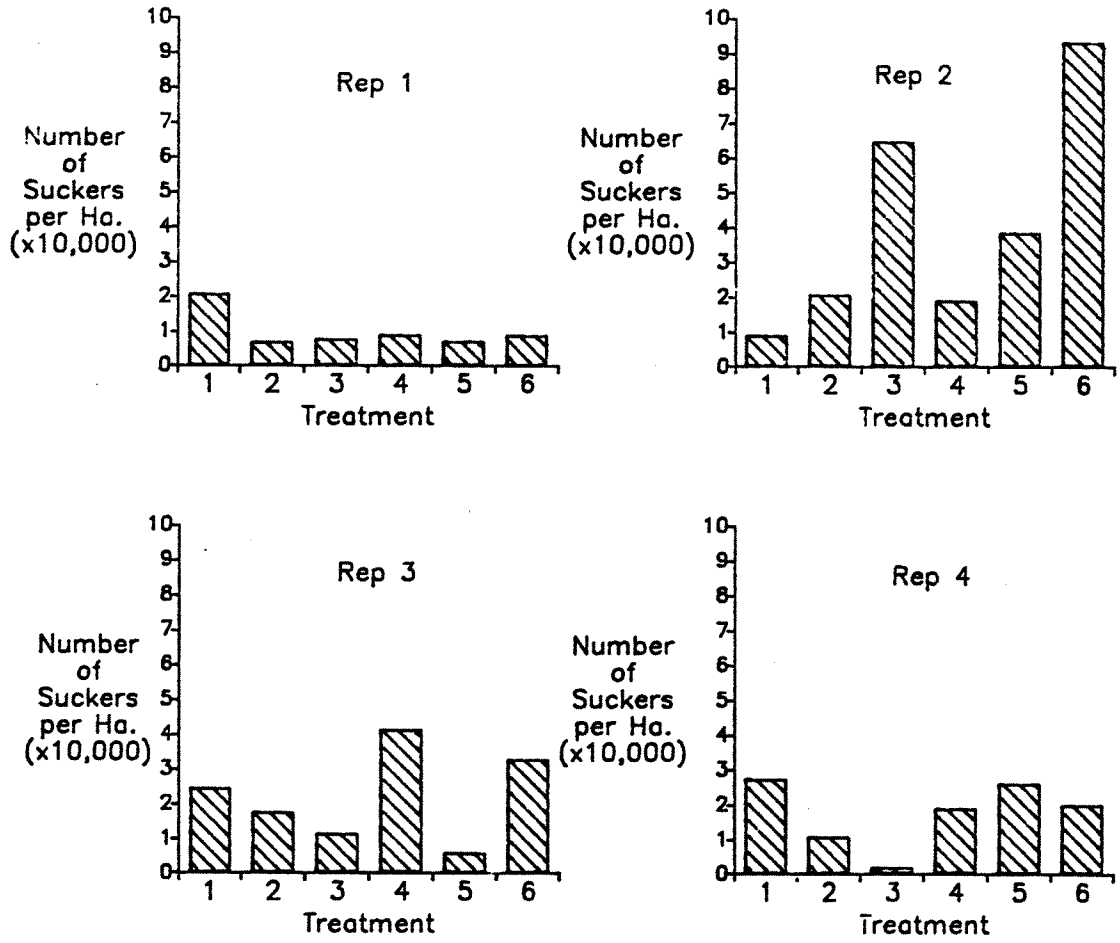
The area was planted in May, 1987 with white spruce (3+0) bareroot stock.

Findings to Date:

Pre-treatment Assessment of Aspen Suckers

The pretreatment assessment of the subplots showed that the mean aspen sucker density ranged 10,200 - 41,000 stems/ha between blocks and considerable variation occured between treatment replicates within blocks (Figure 6). These differences will have to be considered in interpretation of the treatment efficacies and treated as a covariant.

Figure 6. Satellite Trial A pretreatment aspen density

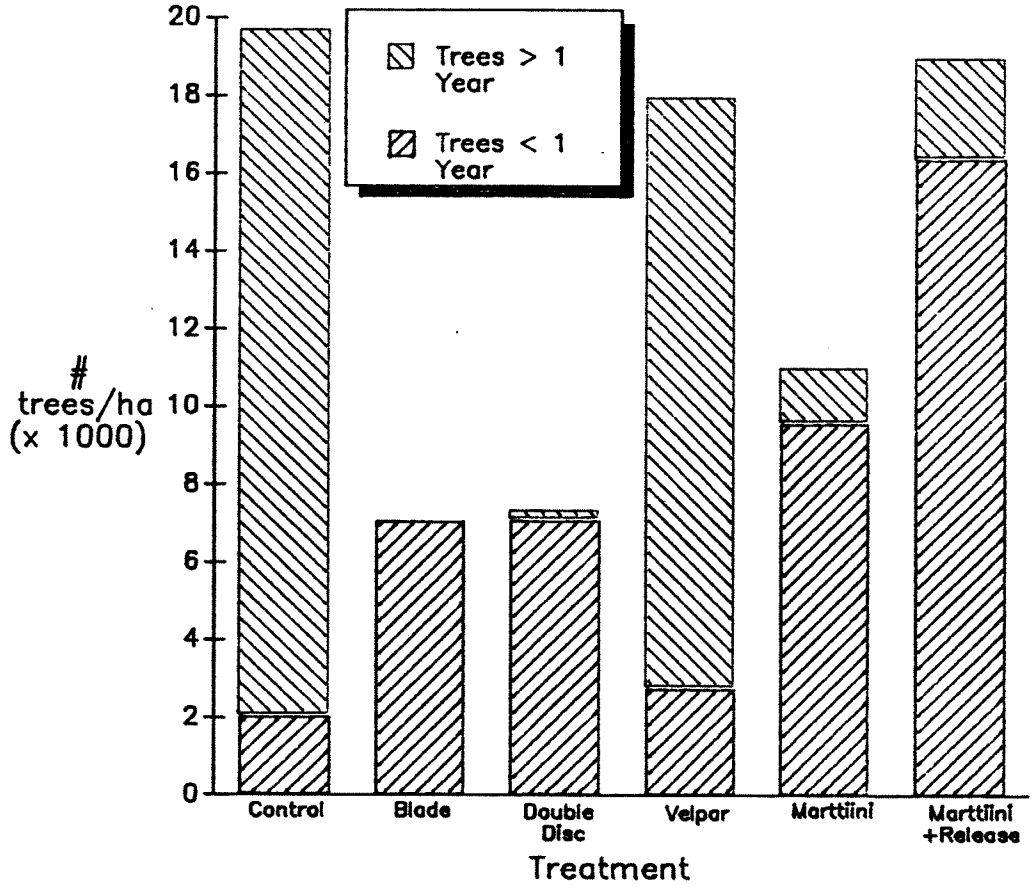


Post Treatment First Year Assessment

Aspen Density

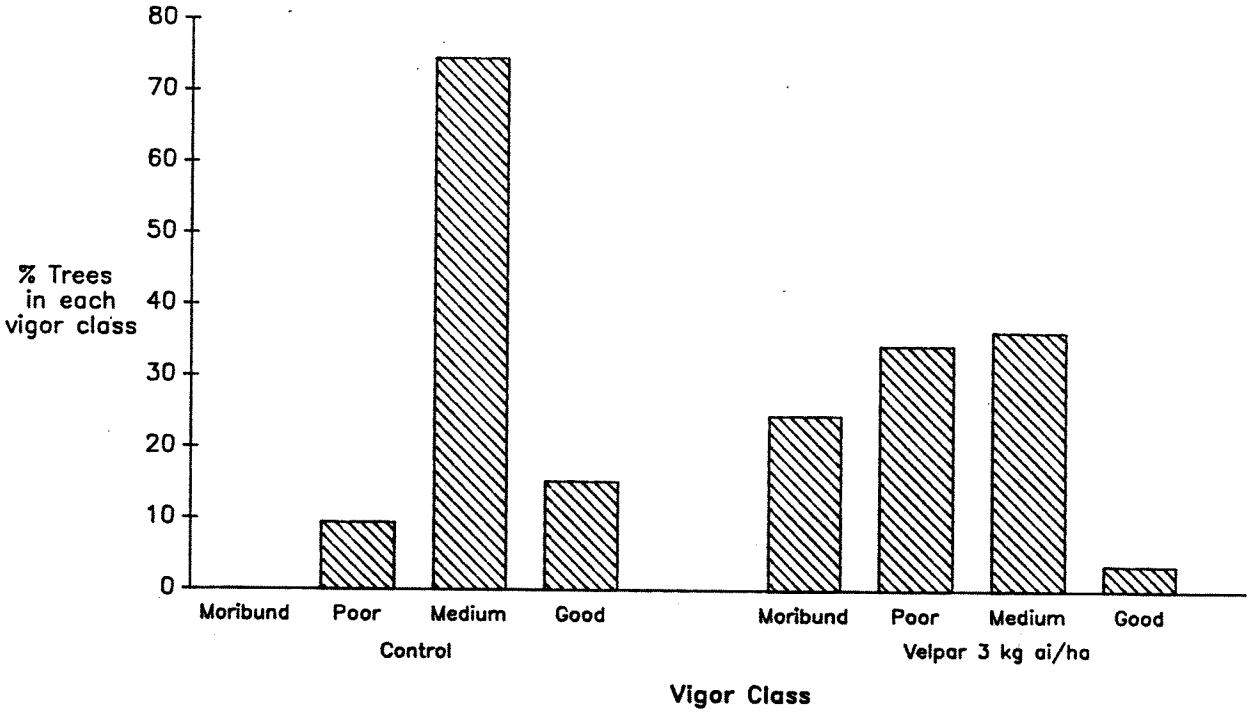
The pretreatment density analysis revealed that all treatments were not homogeneous, therefore to analyze post treatment data (1987), pretreatment density was considered a covariate and analysis of covariance was used. There is a significant difference in total sucker density, density of suckers 0-1 years in age and density of suckers 1-2 years of age between treatments (Figure 7). Anova tables have been included in the Appendix.

Figure 7. Satellite Trial A density of aspen suckers one year after treatment



As expected the control treatment has the highest total density, few suckers were younger than one year. The blade and double disc treatments have significantly reduced the total density although the newly initiated suckers have been significantly increased when compared to the control treatment. The Velpar treatment still maintains a relatively high aspen density but this could be due, in part, to the method used in tallying alive trees. Trees are considered to be alive if the bark is at all green when scraped. When the frequency of aspen in vigor classes (ECW protocol) is compared (Figure 8) it is evident that the health of aspen suckers was substantially affected by the Velpar treatment. The high incidence of suckers in the moribund class of vigor indicates that the density can be expected to drop considerably in the next assessment.

Figure 8. Satellite Trial A frequency of aspen in vigor classes for Control and Velpar treatments

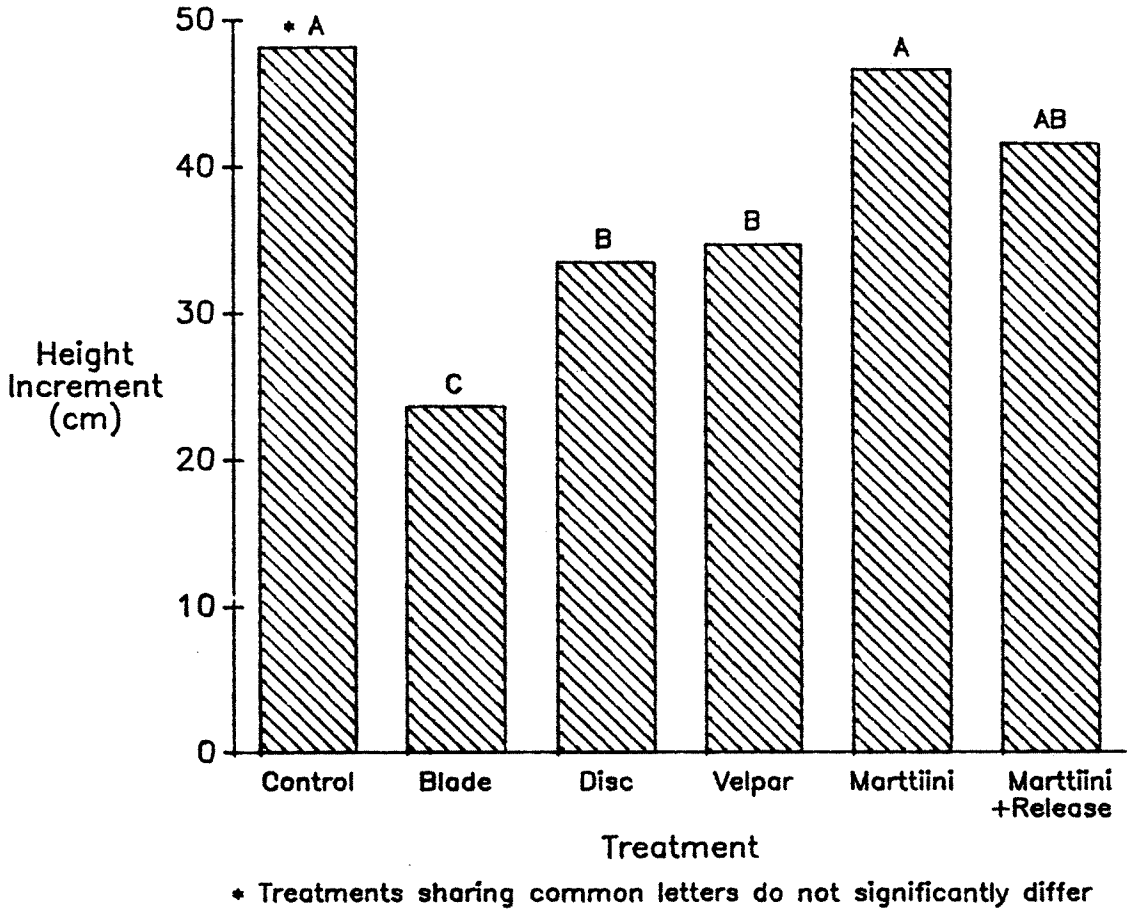


The Marttiini treatments have relatively high density, the majority of which are post-treatment initiated suckers. If severe overtopping of planted white spruce occurs in the next assessment, chemical release treatment (Velpar) may be implemented the following summer.

Height growth of aspen

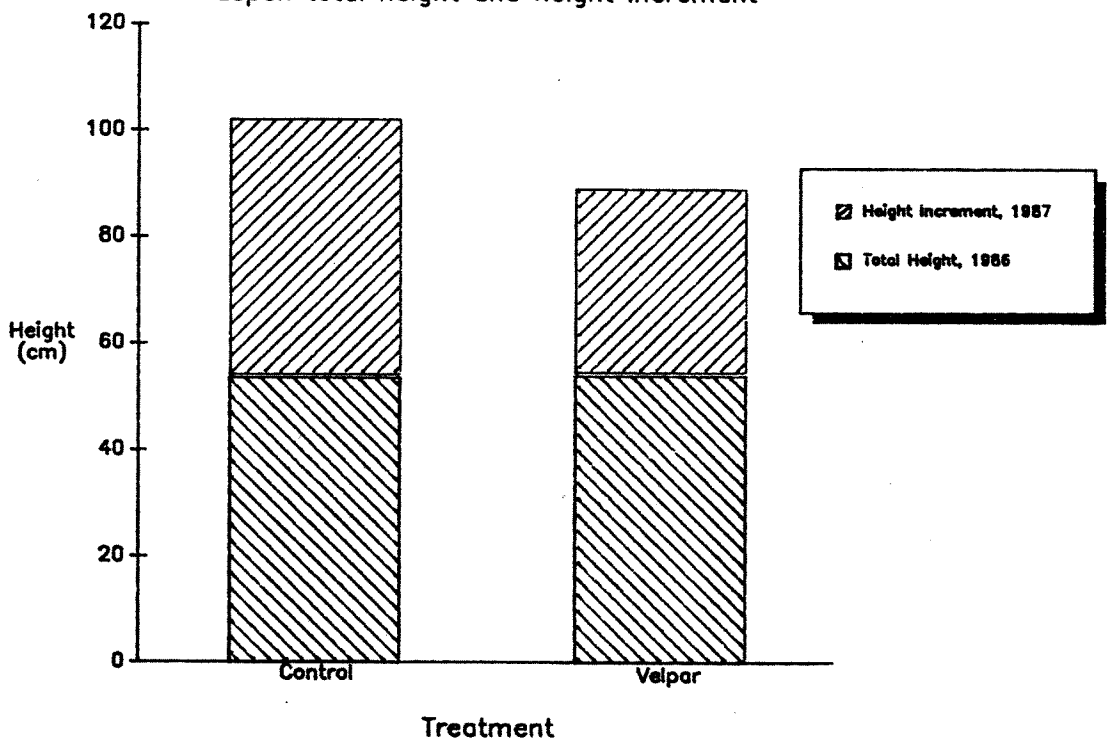
Average total tree height and height increment of aspen was significantly reduced by the severe site preparation treatment of blading and double discing (Figure 9). It should be noted, however, that trees measured included both newly initiated and older suckers and the growth rates are not directly comparable to the control treatment.

Figure 9. Satellite Trial A mean aspen height increment for 1987



Total height of aspen in the Velpar treatment did not significantly differ from that of the control treatment. Height increment for the first growing season after Velpar @ 3 kg ai/ha treatment, however, was significantly reduced by 27% (Fig. 10).

Figure 10. Satellite Trial A Control and Velpar treatment aspen total height and height increment

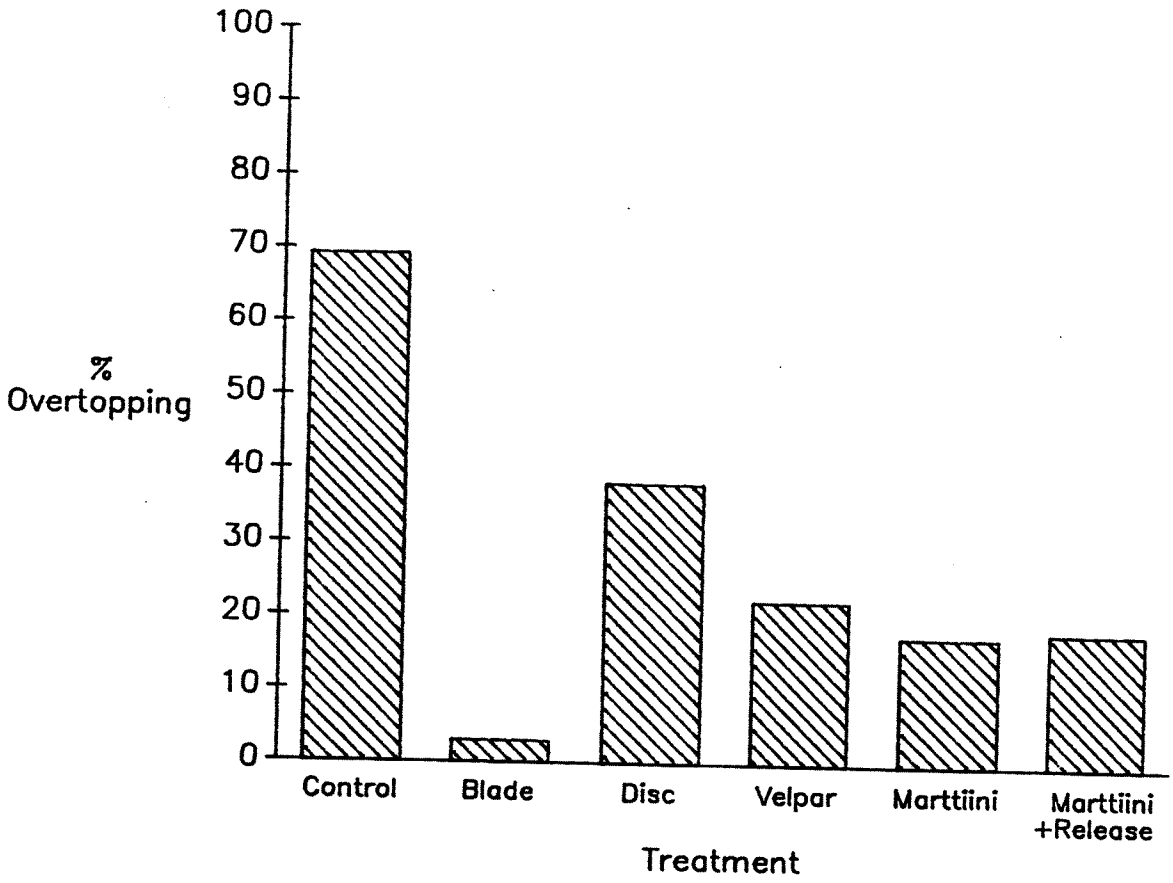


The two marttiini treatments mean total height differ significantly from the control treatment but the mean height increments in the first growing season after treatment were not significantly different from the control.

Overtopping of Crop tree

Each of the four crop trees within the 20 subplots were rated as to degree of overtopping. The ratings are (0) free to grow, (1) threatened, or (2) overtopped. Overtopped is defined as "...the leader of the crop tree is at present overtopped by surrounding vegetation; crop tree available sunlight is greatly reduced," (Herring and Pollack, 1985).

Figure 11. Satellite Trial A frequency of crop tree overtopping

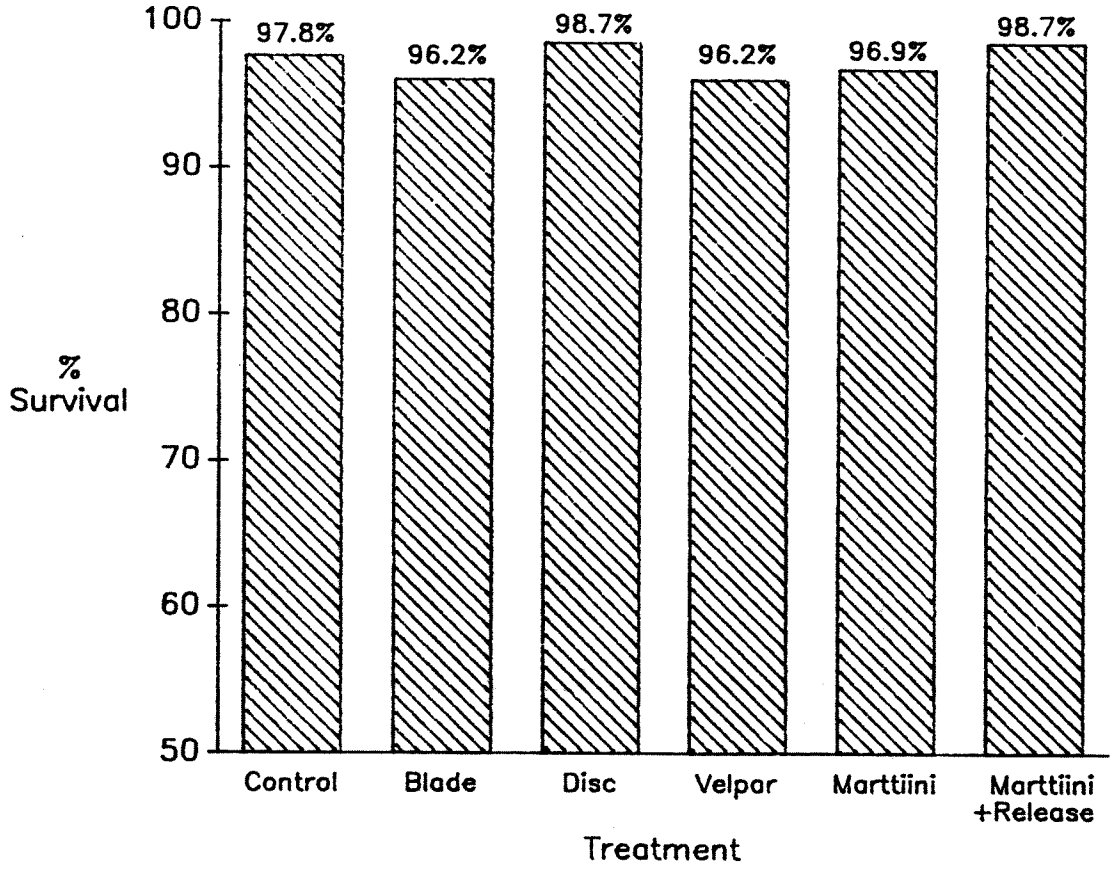


All of the treatments significantly reduced overtopping (Figure 11). The disc treatment seemed to enhance shrubs, reproduction and growth, therefore the overtopping was unexpectedly elevated. The blade treatment greatly reduced overtopping.

Crop tree survival and growth

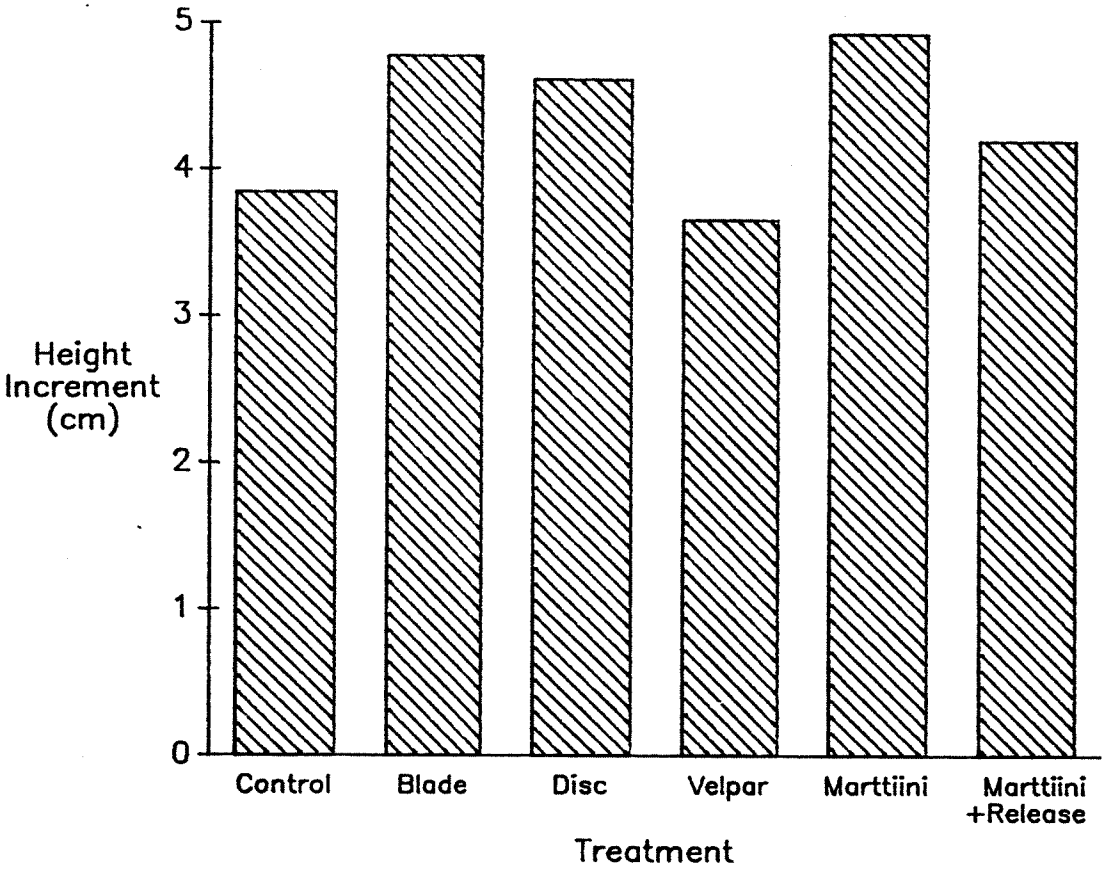
The trial was planted with 3 + 0 white spruce on May 11-14, 1987. Four trees were planted in each subplot. The first year survival of these seedlings is very high and there is no significant difference between treatments (Figure 12).

Figure 12. Satellite Trial A percent crop tree survival, August 1987



There were however, significant differences in seedling height increment between treatments. (Figure 13). All of the mechanical treatments had a significantly greater increment than than the control and Velpar treatments though it should be noted that the actual differences were very small (approx. 1.0 cm). Several years of observation (minimum 5 years) will be needed to demonstrate growth differences of planted trees as affected by various treatments.

Figure 13. Satellite Trial A spruce mean height increment for 1987



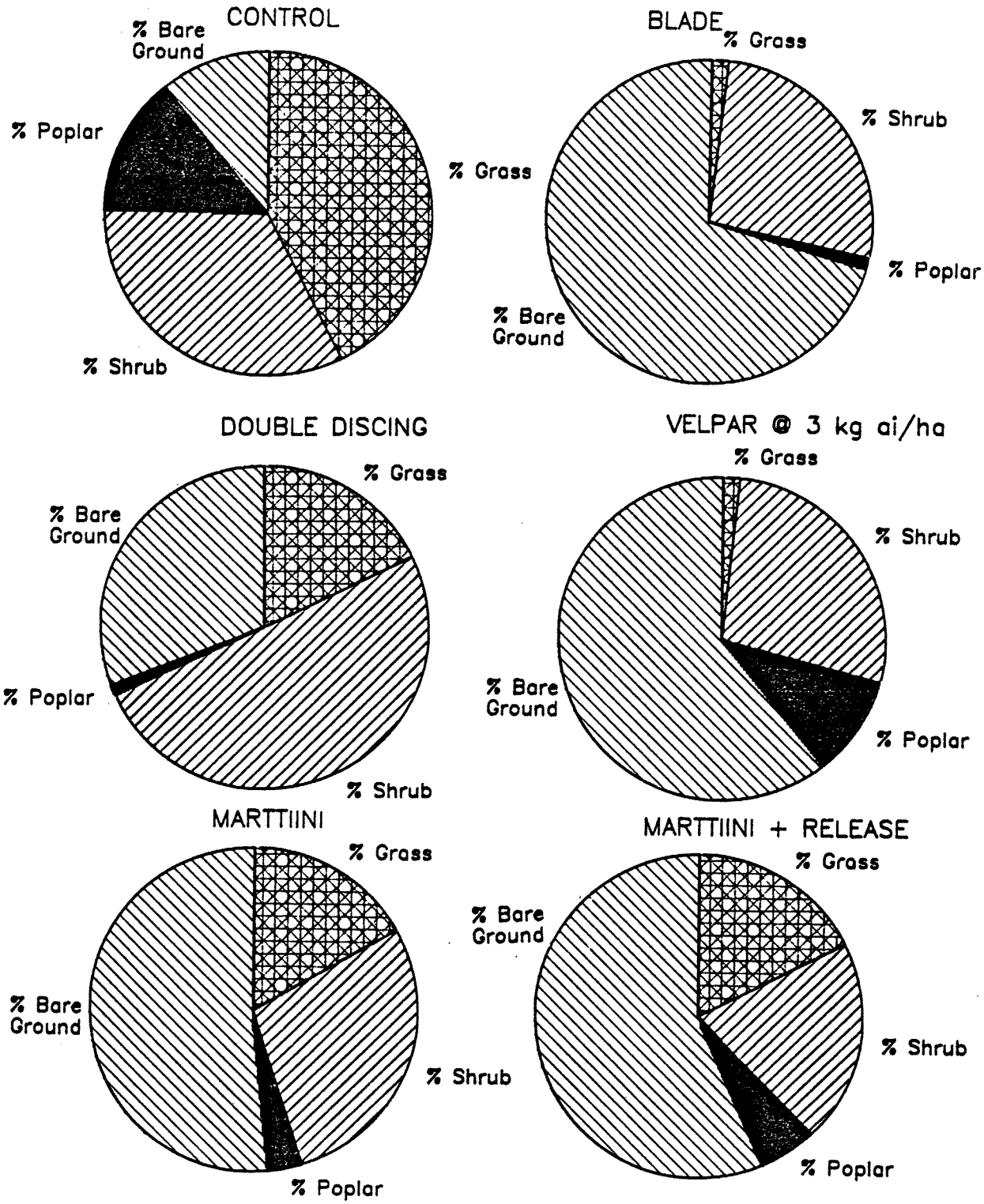
Ground Cover

Ground cover by grass, shrubs, poplars, and bare ground was estimated for each subplot as a percent of the total plot area (Figure 14).

All treatments significantly reduced the percent of grass cover. The blade and velpar @3 kg ai/ha were most effective, with grass representing less than 2% of total ground cover.

The percent shrub cover did not vary among treatments although the double discing treatment did have a higher shrub cover than the other treatments. The shrub classification was a

Figure 14. Satellite Trial A percent ground cover of bare ground, poplar, shrub, and grass



catch all category and included forbes and herbs.

The percent of poplar cover differed significantly among treatments. The mechanical treatments of double disc, blade and marttiini had significantly (0.05 level) lower poplar cover from the control treatment. The percent poplar category includes both aspen and balsam poplar.

The percent of bare ground also differed significantly (0.05 level) among treatments. The blade, velpar and marttiini treatments had greater than 50% bare ground cover. The bare ground is not a mineral soil exposure rating but rather a measure of area with no vegetation cover. Bare ground is desirable when endeavouring to reforest an area. Warmer soil temperatures encourage root growth, open canopy implies more sunlight, and reduced competition means more available moisture and nutrients.

It is expected that the cover will change gradually over the next few years and extended monitoring would be necessary to ascertain the trends.

SATELLITE TRIAL B: WEBERVILLE DEMONSTRATION AREA - PEACE RIVER

Objective

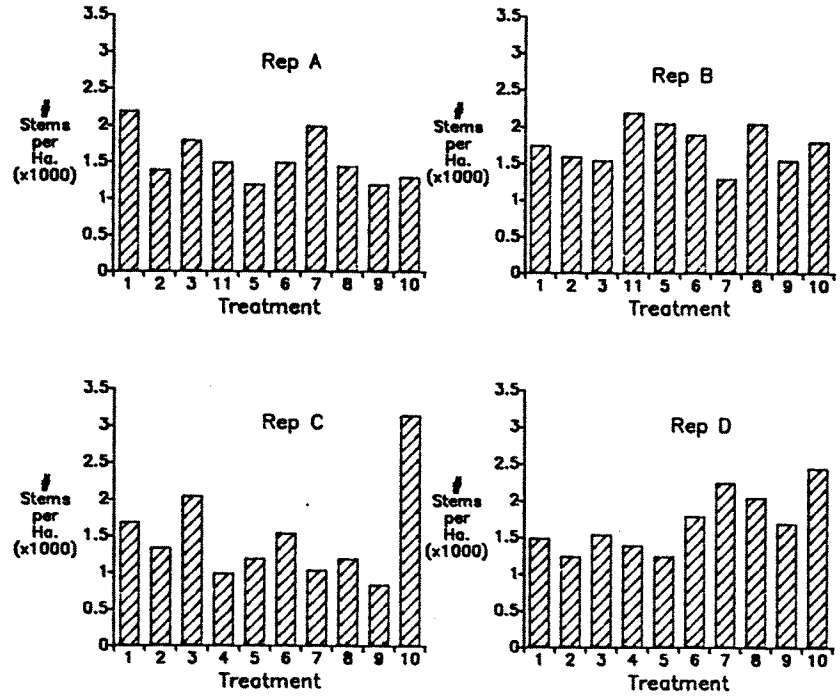
The objective of satellite trial B is to compare the efficacies of pre-harvest, single-tree applications of herbicides, pre-harvest spot-gun application of Velpar and post-harvest Rome discing of different intensity and timing for the control of aspen suckering.

Trial Area Description

The trial is located in the Weberville Demonstration Area about 50 kilometers north of the town of Peace River. The area is described on the Phase III map as a D2A-H that originated in about 1910. The area has good drainage and soil type is a heavy clay, Orthic Gray Luvisol. (Description in the appendix).

To determine the density and uniformity of aspen in the parent stand a cruise survey was completed. The aspen densities ranged from 1000 stems/ha to 3150 stems/ha, the mean diameter was 13.5 cm, mean height was 16.1 m and the ages ranged from 32-65 (field aging by increment bore is often misleading for aspen). In overall, aspen densities were fairly uniform (Figure 15).

Figure 15. Satellite Trial B mature aspen density (>5 cm dbh) prior to cutting



Trial Design

The trial is laid out in a randomized complete block design with four blocks and ten treatments (Figure 16). Each treatment replicate is .2125 hectare in size with a 5 m buffer around the inside of the treatment area and, within this, there are twenty $20m^2$ circular subplots. The circular subplots will be monitored for aspen sucker density and growth and performance of planted crop trees.

Description of Treatments

The original plan of the Satellite trial B was altered due to the moratorium on herbicides application in 1986 and consequently the original schedule of the trial was postponed. These changes required, as well, some modification of the trial treatments.

In addition, the Swedish injection gun application was changed to the similar dry-tablet application due to the reluctance of a Swedish company to export herbicide materials to Canada.

The hypohatchet application was modified to "punch and fill" application owing to the problems in calibration of the hypohatchet.

The treatments applied in 1987 and the remaining treatments to be applied in 1988 are listed below.

The pesticide permit No. 87-GA20 (Appendix) was received on June 15, 1987 and the chemical treatments were applied shortly after.

1. Modified Hack and Squirt - Vision
   Supplier: Monsanto
   Active Ingredient: Glyphosate
   Dosage: 1 ml concentrated solution/5 cm dbh

2. Gel-Cap
   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 dbh

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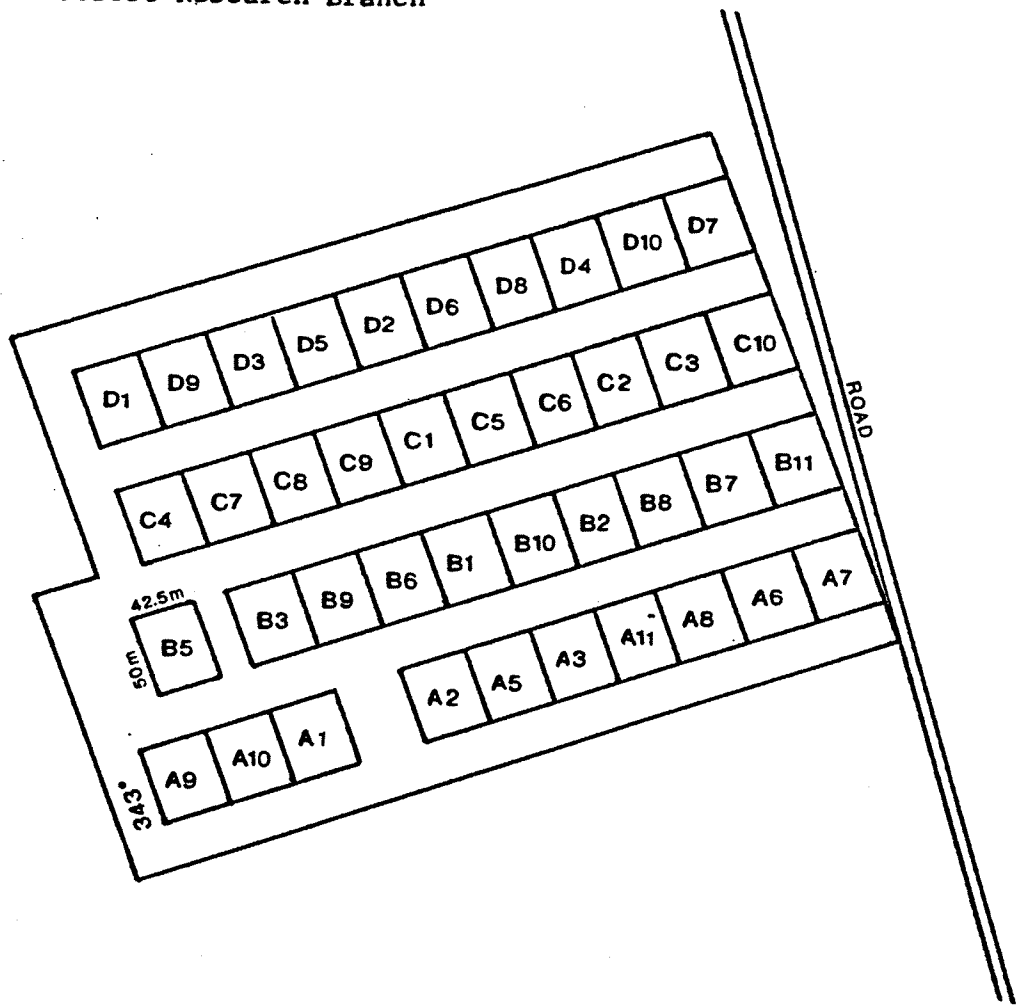

Figure 16. Satellite Trial B Layout

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(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. Modified Hack and Squirt - Velpar
   Supplier: Dupont
   Active Ingredient: Hexazinone
   Dosage: 1 ml/2.5 cm dbh (50% solution)

7. Control - no treatment

8. Single pass Rome disc - June 1988

9. Double pass Rome disc - June 1988

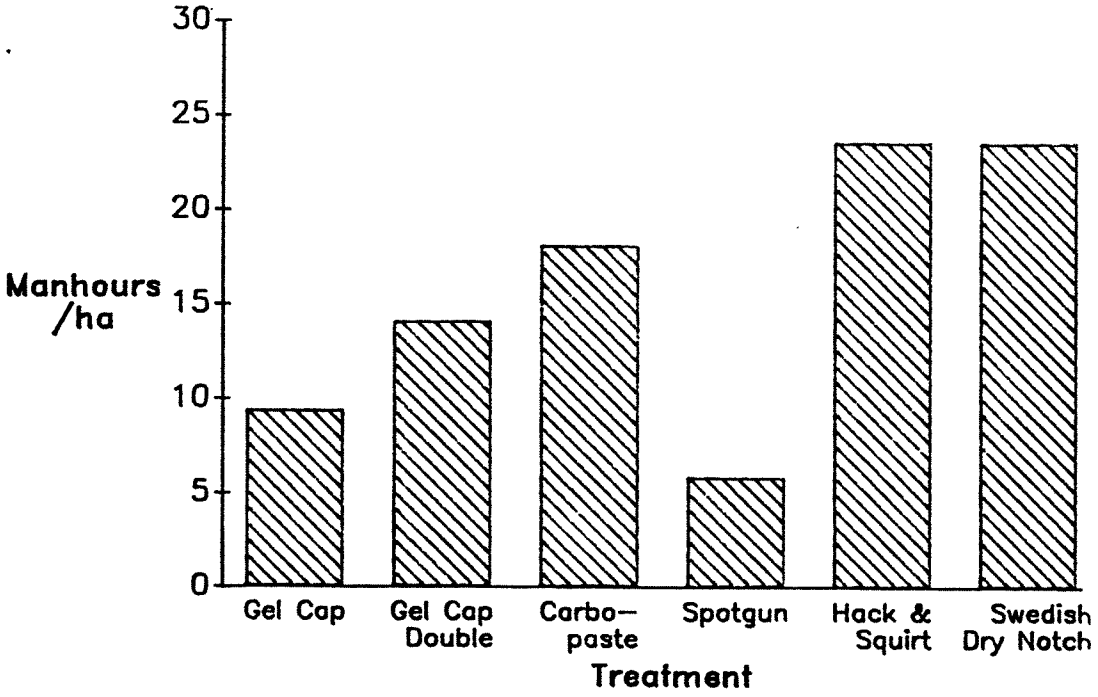
10. Single pass Rome disc on two separate times, in June and in August 1988

11. Gel-Cap (in blocks A & B only)
    Supplier: Pace Chemicals
    Active Ingredient: Glyphosate
    Dosage: 2 capsules/10 cm dbh (doubled recommended dosage)

Due to the breakage of dry tablets, the treatment 4 was applied in the blocks C and D only. The remaining replicates in the blocks A and B were substituted with the treatment #11 - double-dosage Gel-Cap application.

The mean time required to do the various treatments is summarized in figure 17. The calculations do not include the time it takes to refill applicators. The nature of the project must be taken into consideration; this is a research application and as such the exact dosages must be administered. The carbo-paste treatment would be much more efficient if the exact chemical measurement was not necessary.

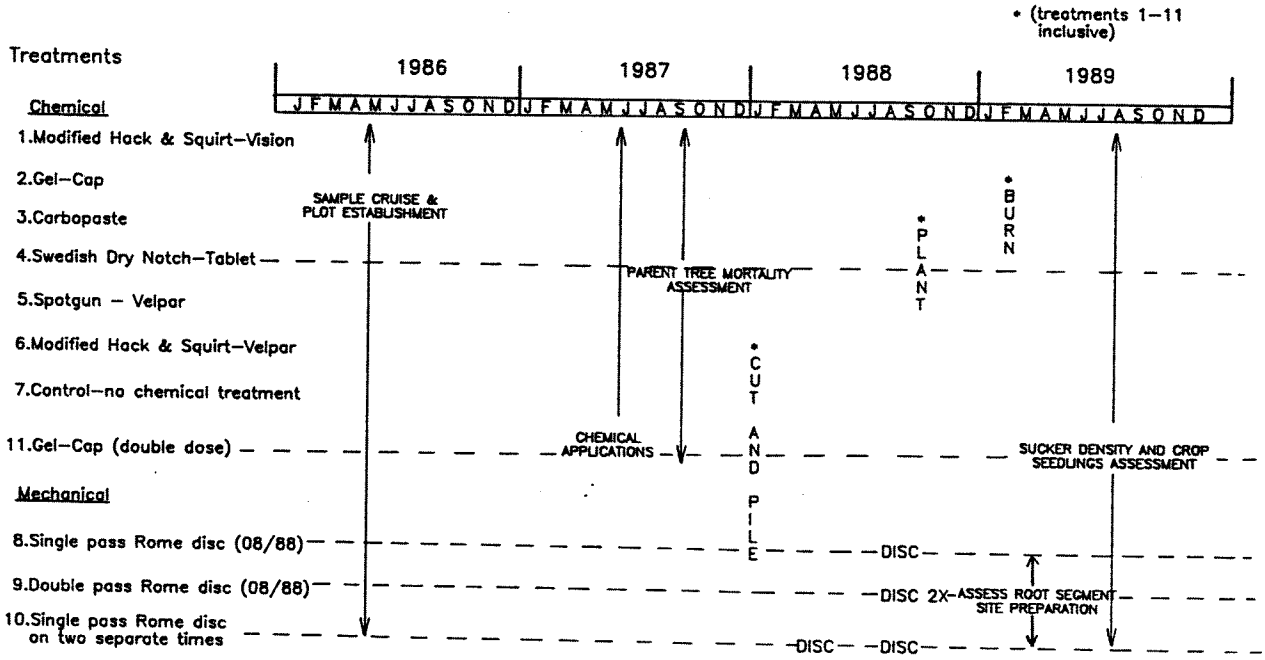
Figure 17. Satellite Trial B manhours per hectare to treat



Time Schedule

The current time schedule is outlined in Figure 18.

Figure 18. Satellite Trial B – Weberville Demonstration Area
Modified Time Schedule



All chemical treatments were completed in June of 1987. Parent tree mortality was assessed in September. The cutting and piling of the parent stand was done in January 1988. Site preparation is scheduled for May 1988 and August 1988. The crop Sw container-grown seedlings will be planted in the fall of 1988.

The density, condition and growth of aspen will be assessed and crop seedlings monitored yearly for the duration of the Canada-Alberta FRD Agreement. To fulfill the objectives of the project, monitoring and assessment of crop trees and aspen competition should be continued for at least five years after planting (till 1993). The assessments will be in accordance with the guidelines of Herring and Pollack (1985).

Findings to Date

The parent stand mortality was assessed two months (August 19, 1987) and three months (September 21-22, 1987) after treatment. Two months after the treatments hack and squirt applications of hexazinone and glyphosate resulted in the greatest tree mortality and crown kill, followed up by spotgun application of Velpar and carbopaste treatment (Table 3).

Three months after treatments, twenty trees from each treatment replicate were randomly selected and bark and crown defoliation were estimated in 20% class intervals. The results are presented in figures 19 - 20. At the time of assessment fall defoliation was in progress and the extent of mean defoliation should be considered relative to control.

The carbopaste treatment appeared to be the best overall killing treatment in terms of combined bark and crown kill.

Cuts in the stem required for application of the carbopaste practically girdled the tree which may have accounted for the greater amount of bark kill. Conversely, the spotgun treatment did not cause any wounding to the bark and therefore very little bark mortality occurred initially with this treatment. Overall the glyphosate treatments caused greater bark mortality than hexazinone treatments.

The treatments with the least effect on the trees were the Gel Cap at normal dosage and the Swedish dry notch method. Two months after treatment, the tablets were observed to be still undissolved in the notches of the Swedish dry notch treatment. Also a few gel caps had fallen off the trees and others did not appear to have tapped the tree phloem. Although these two methods were the safest in terms of protecting the applicator, their form may have limited their effectiveness in killing trees.

The greatest control, as evidenced by crown defoliation, was given by the hack and squirt glyphosate treatment followed closely by the carbopaste and hexazinone treatments. The trees

treated with glyphosate had dead leaves still clinging to the branches. The hexazinone treated trees had both brown, necrotized leaves and a flush of small leaves ranging in color from yellow to greenish brown.

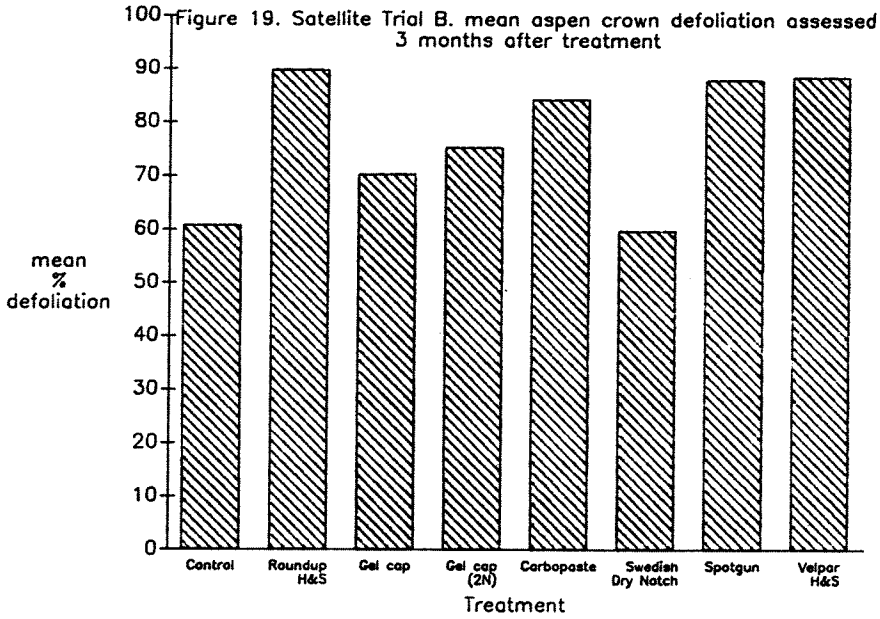


Figure 19. Satellite Trial B. mean aspen crown defoliation assessed 3 months after treatment

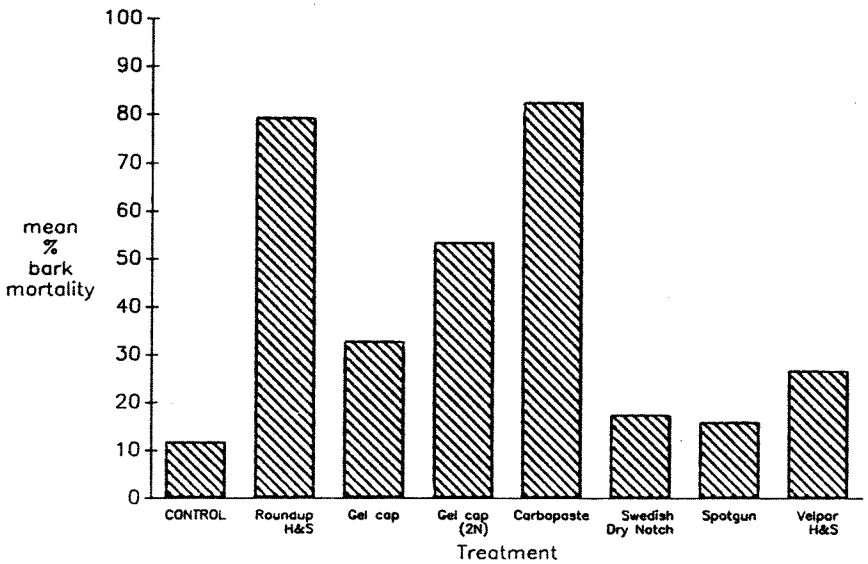


Figure 20. Satellite Trial B. mean aspen bark mortality assessed 3 months treatment

Table 3. Incidence of parent tree morality and crown kill two months after treatments.

Satellite trial B, Weberville
Replicates A and B.

Treatment	Average parent stand mortality % incidence	Average extent of crown kill in %
#1 Hack and Squirt Vision (Glyphosate)	100	100 (leaves necrotized or fallen off)
#2 Gel-Cap Glyphosate	10	variable, yellowing to browning of foliage
#3 Carbopaste Glyphosate	75	70 - 100 (yellowing to total necrotization)
#4 Swedish Dry Notch Tablets Hexazinone	tablets undissolved, no effect	
#5 Spotgun ground appl. Velpar (Hexazinone)	85	85 (70-100) (parts of crowns yellow to total necrotization)
#6 Hack and Squirt Velpar (Hexazinone)	100	100 some yellow, undersized leaves, refoliation?

SATELLITE TRIAL C: HINES CREEK - PEACE RIVER FOREST

Objective

Satellite trial C was designed to test the effects of single-tree chemical treatments of aspen component, in a mature mixedwood stand for control of aspen competition. The focus was on testing the efficacy of pre-harvest chemical treatments of standing trees for control of aspen suckering after logging.

Trial Area Description

The original area for the Satellite trial C was located in the Edson Forest, St. Regis Forest Products Ltd. working circle. Owing to the controversy surrounding herbicide use in Hinton area, the trial has been relocated to the Peace River Forest.

The trial is now located near Stoney Lake, north of Hines Creek. The stand is a mature (120 - 150 year old) spruce-aspen, in which, the aspen component is quite low (25%) and evenly dispersed. A reservation has been placed on the trial area to prevent disturbance.

Trial Design

The trial was laid out in a randomized complete block design with four replicates and five treatments (4 treatments & 1 control). (Figure 21).

Each treatment replicate is 0.42 ha in size. The buffer width is equivalent to the average tree height and within the assessment area there is ideally, a minimum of ten mature aspen. The assessment plots after harvest will extend in cardinal directions from the base of each sample tree. along a transect as described by Herring and Pollack (1985) for single tree vegetation control monitoring.

Description of Treatments

1. Swedish Dry Notch Method
   Supplier: F.I.C., Sweden
   Active Ingredient: hexazinone
   Dosage - 1 tablet/5 cm dbh

2. Hack and Squirt - Formula 40 (double dosage)
   Supplier: Dow Chemicals
   Active Ingredient: 2,4-D (33% solution)
   Dosage - 1 ml/1.5 cm dbh

3. Hack and Squirt - Velpar
   Supplier: Dupont
   Active Ingredient: hexazinone (50% solution 1 ml/2.5 cm dbh)

CANADA-ALBERTA FRDA - FOREST VEGETATION MANAGEMENT PROGRAM

Project: Control of aspen development in areas designated for soft-wood production.

Alberta Forest Service
Forest Research Branch

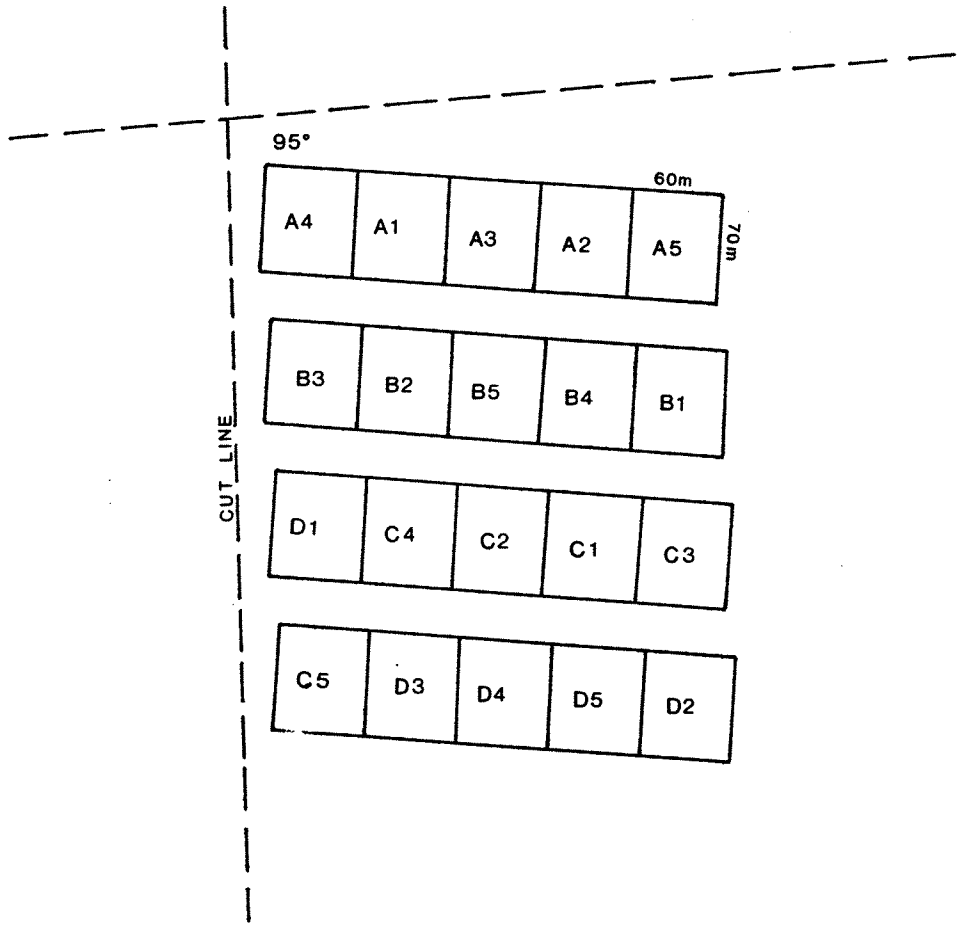


Figure 21. Satellite Trial C Layout

SCALE 1:4800

Dosage: 1 ml/5 cm dbh

4. Hack and Squirt - Formula 40 (recommended dosage)
   Supplier: Dow Chemicals
   Active Ingredient: 2,4-D (33% solution)
   Dosage: 1 ml/3.0 cm dbh

5. Control - No treatment

Time Schedule

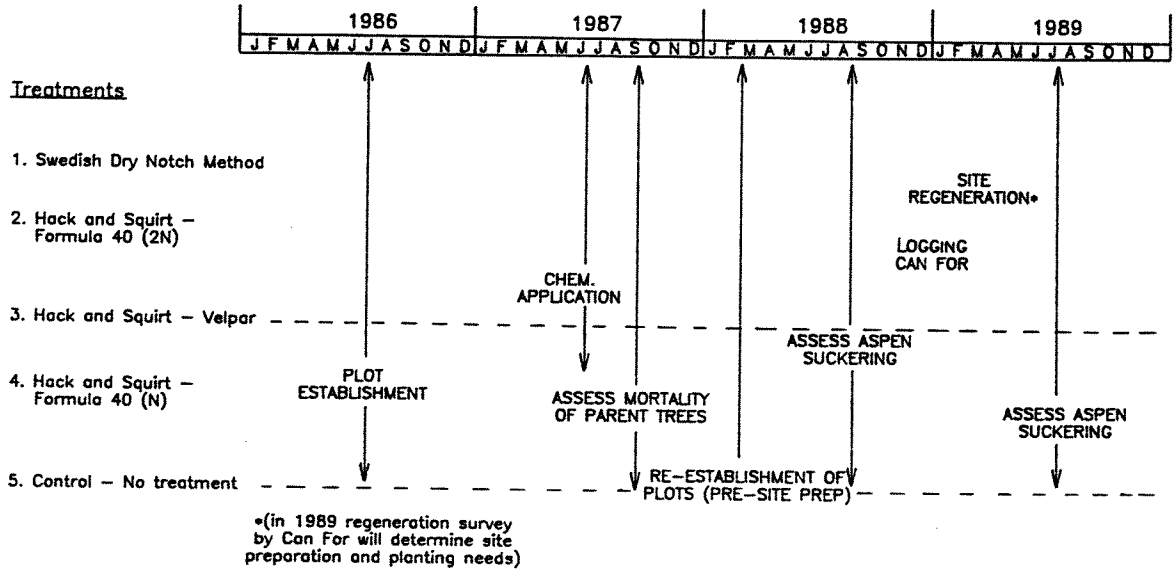
The treatments were originally scheduled for June, 1986 to allow two seasons for the effects of herbicide to occur prior to logging.

The unavailability of a herbicide permit in 1986 shortened this period to one season, or approximately 6 months prior to logging. This short period of herbicidal activity may not be sufficient to spread into and kill large root systems of parent trees. As a result, the time of harvesting has been renegotiated and postponed until the 1988-89 winter. The treatmented trees will be left two growing seasons before harvesting.

The pesticide permit No. 87-GA19 (Appendix) pertaining to the Satellite trial C was obtained on June 15, 1987 and the treatments were applied shortly after.

The current schedule of the Satellite trial C is shown below in Figure 22.

Figure 22. Satellite Trial C Hines Creek Modified Time Schedule



Findings to Date

Mortality three months after treatments was assessed on September 19, 1988. At this time ten treated trees from each treatment were examined for bark mortality and crown defoliation or damage. Percent bark mortality was estimated and classified into one of 5 percent categories (ie. 0-20%, 21-40%, 41-60%, 61-80%, 81-100%).

The crown damage was assessed by degree of damage to foliage and the classes were foliated, partially foliated (damaged) and alive.

The results are presented in figures 23 and 24.

Figure 23. Satellite Trial C. mean aspen bark mortality assessed 3 months after treatment

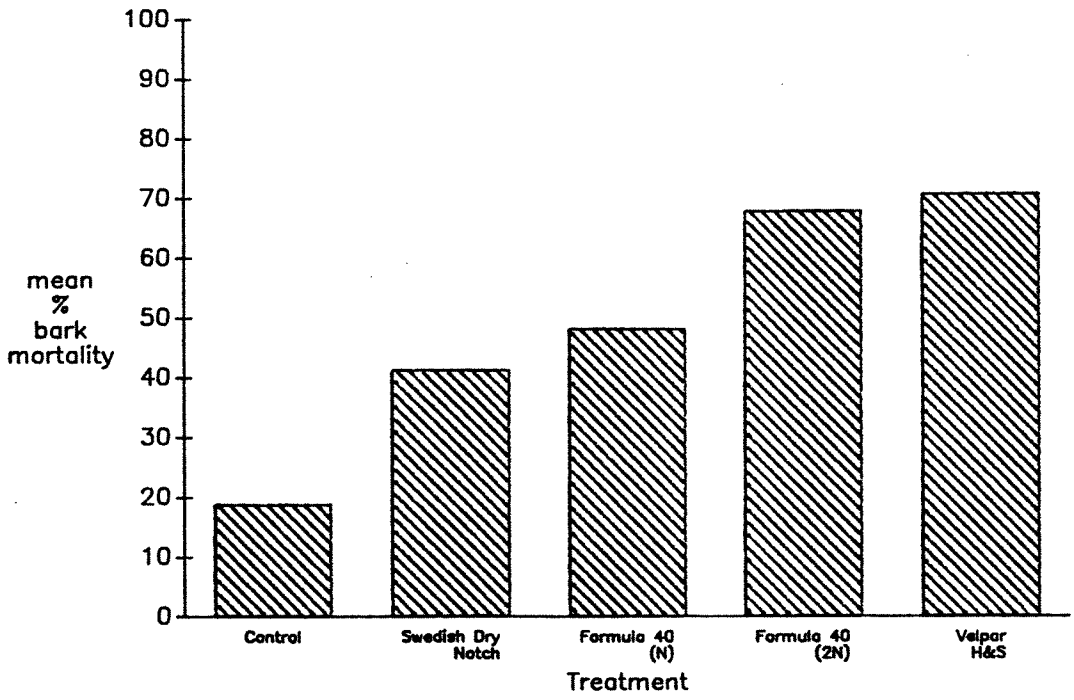
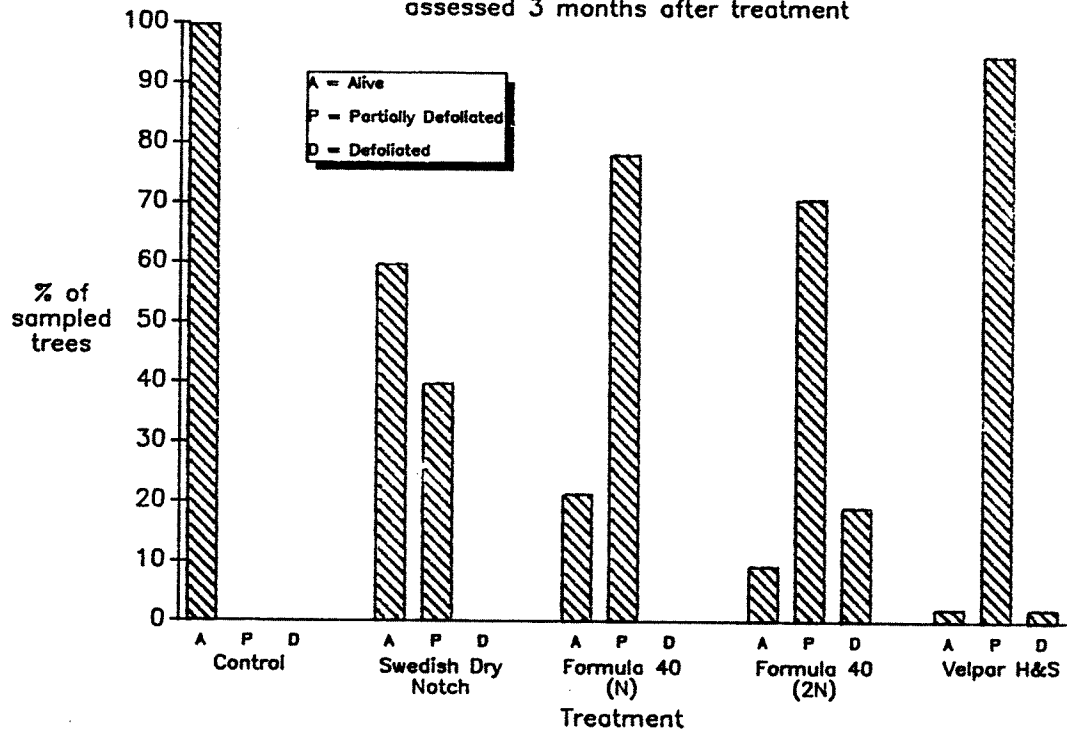


Figure 24. Satellite Trial C frequency of sampled trees in each crown class assessed 3 months after treatment



The Swedish Dry Notch (hexazinone tablet) was least effective and it was observed that the tablets had not yet completely disolved. The Velpar Hack and Squirt treatment which was also a hexazinone treatment was most effective in terms of bark kill. Both treatments were observed to have a fair amount of reflushing. The new leaves were light green to greenish brown in color and small in size. The reflushing has been observed in other treatments with hexazinone containing products.

The Formula 40 (2,4-D) treatment at the double dose level was quite effective in terms of bark mortality and crown defoliation but the normal dosage level appeared to be only moderately effective. It was observed that the trees treated with 2,4-D had dead and curled leaves clinging to the branches likely killed prior to natural abscission.

It appears that all of the treatments have partially effected the parent trees. The 1988 mortality assessment should provide a clearer understanding of the extent of toxicity to parent trees.

Assessments of post-harvest suckering of aspen and crop tree performance will need to be extended until 1994.

ACKNOWLEDGEMENTS

The authors wish to thank Lorne Brace for his guidance as the project scientific authority and Joe Feng for advice and assistance in the development of the soil sampling and hexazinone monitoring protocol. Also, Neil Barker, Geoff Becker, and Ken Yackimec of the Lac La Biche Forest, Doug Schultz and Vern Danes of the Peace River Forest have been very helpful in trial site selection and in assisting with the field work. Pace Chemicals Ltd., Monsanto Canada Inc. and Dow Chemical Canada Inc. supplied various forms of chemicals and advice.

REFERENCE

Herring, L.J. and J.C. Pollack. 1985. Experimental design protocol for forest vegetation management research: Level B trials -- first approximation. B.C. Min. For. Research Report RR84013 - HQ.

APPENDIX

Soil Descriptions A & B

Herbicide Permits for A, B & C

Soil Herbicide Residue Sampling Protocol

Herbicide Residue Analysis for Fall 1986, Spring 1987, Fall 1987

Anova tables for the Calling Lake data

Peace River Parent Tree Mortality Assessment

Hines Creek Parent Tree Mortality Assessment

SOIL DESCRIPTION FROM SATELLITE TRIAL A

Classification: Gleyed Gray Luvisol
Topography: level
Drainage: mesic to subhygric
Vegetation: Populus tremuloides, Populus balsamifera Calamagrostis Canadensis
Elevation: 594 m
Location: Rep #3 Treatment #4

Profile Description

Horizon	Depth (cm)	Description
LFH	8-0	Black (5 YR 2.5/1 m); silty
Ahg	0-2	loam; fine granular; pH 5.5
Aeg	2-12	Brown (10 YR 5/3 m); sandy loam; fine platy; pH 5.5
Aeg_2	12-28	Yellowish brown (10 YR 5/6 m); sandy loam; medium platy, pH 5.5
ABg	28-41 cm	Dark yellowish brown (10 YR 4/4 m); sandy clay; weak fine subangular blocky; pH 5.5
Btg	41-58	Brown (10 YR 4/3 m); sandy clay; medium subangular blocky; pH 5.5
BC	58-60	Dark brown (10 YR 3/3 m); sandy clay; medium subangular blocky; pH 5.5
Cg	66+	Very dark grayish brown 10 YR 3/2 m); sandy clay; massive; pH 5.5

SOIL DESCRIPTION FROM SATELLITE TRIAL B

Classification: Orthic Gray Luvisol
Topography: Level
Drainage: Mesic
Vegetation: Populus tremuloides, Populus balsamilfera
Pit location: Between Rep 2 and 3 about 20 m from the east end

Profile Description

Horizon	Depth (cm)	Description
LFH	2.5 - 0	
Ahg	0.2	Black (10 YR 2/m), silty loam, fine granular; pH 8.0
Ahe	2 - 7	Dark gray brown (10 yr 4/2 m); silty clay; weak, fine platy; pH 8.0
AC	7 - 12	Yellow brown (10 Yr 5/4 m); silty clay; moderate, fine platy; pH 8.0
Bt	12 - 39	Dark yellow brown (10 YR 4/4 m); Clay; fine subangular blocky microstructuring medium columnar macro-structure; pH 70
BC	39+	Very dark grey brown (10 YR 3/2 m); heavy clay, fine subangular blocky; weakly calcareous; pH 8.0

Alberta
ENVIRONMENT
Environmental Protection Services
Pollution Control Division

Oxbridge Place, 9820 - 106 Street, Edmonton, Alberta, Canada T5K 2J6 403/427-6270 Environment Emergency 1-800-222-6514

THE AGRICULTURAL CHEMICALS ACT

PESTICIDES PERMIT

PERMIT NO. 86-GA96

To: Alberta Forestry, Lands & Wildlife
Resource Evaluation & Planning Division
Forest Branch
9915 - 108 Street
Edmonton, Alberta
T5K 2C9

Attention: Mr. J. Soos, Director

In accordance with Ms. J. Lane's application, Alberta Forestry, Lands & Wildlife is hereby permitted to apply VELPAR L HERBICIDE (P.C.P. No. 18197), hereon referred to as the herbicide(s), for research purposes in forest planting site preparation, within the Green Area of the Lac La Biche Forest, subject to the conditions and requirements specified below:

1. All application crews will be knowledgeable of the conditions and requirements specified in this permit and a copy of this permit will be in their possession at each application site.

2. The following individuals shall be notified a maximum of fourteen (14) and a minimum of two (2) working days prior to the commencement of the herbicide treatments:

Mr. Wayne Inkpen	and	Mr. L.G. Huberdeau
Head, Biology Section		Superintendent
Alberta Environment		Lac La Biche Forest
phone 427-5855		phone 623-5240

3. The herbicide applications shall be confined within the boundaries of the research plots located within Sections 33, Township 70, Range 21, West of the 4th Meridian.

. . . . 2

4. The ground application of herbicides shall be conducted or supervised by a Class "D" or "G" Alberta Pesticide Applicator who shall be on site during all applications.

5. Alberta Forestry, Lands & Wildlife shall have an employee cognizant of this program on site at all times while the herbicide applications are in progress.

6. The rate of application of the herbicide shall be in compliance with the directions specified on the manufacturer's label.

7. No herbicide shall be applied within 30 horizontal metres of any river, stream, intermittent stream, or open body of water greater than four hectares in area.

8. No herbicide shall be applied when the wind speed at the application site exceeds 16 km/hr.

9. A Herbicide Soil Residue monitoring program, approved by the Pesticide Chemicals Branch prior to application of the herbicide, shall be conducted and the results be forwarded to the Pesticide Chemicals Branch on an annual basis for the duration of the project.

10. Signs shall be posted at all access points to the treatment area advising the public that a herbicide research project is being undertaken.

11. Any vegetation affected by the herbicide treatments located beyond the research plot boundaries shall be removed and disposed of in accordance with the directions of the Forest Superintendent.

12. All private landowners and lessees adjoining the treatment site shall be notified of the herbicide application a minimum of 72 hours prior to commencement of the treatment.

13. All empty herbicide containers shall be disposed of at a government approved pesticide container collection site or at a regional sanitary landfill.

14. In the event of a spill or unauthorized dumping of any herbicide approved in this permit, the Director of Pollution Control must be notified immediately; telephone 1-800-222-6514.

15. A summary of the herbicide used, dates of treatment and total area treated shall be forwarded to the Director of Pollution Control before November 30, 1986. (Form included for this purpose).

. . . . 3

Written approval from the Director of Pollution Control must be obtained if there is a change in the treatment program from the original application and if future vegetation control programs are to be undertaken.

This permit is issued according to the provisions of Alberta Regulation 213/80, Section 4(1) and on the basis of present data and knowledge, and may be revised should the Director of Pollution Control deem it necessary.

EXPIRY DATE OF HERBICIDE APPLICATIONS: October 15, 1986

DATED AT EDMONTON: September 3, 1986

For: R. N. Briggs, M.Sc., P.Eng.
Director
Pollution Control Division

RVE/as

Enclosure

cc: M. Anderson
J. Lane
I. Huberdeau
G. Ehrentrant
J. McIntosh
W. Inkpen

Alberta
ENVIRONMENT
Environmental Protection Services
Pollution Control Division

Oxbridge Place, 9820 - 106 Street, Edmonton, Alberta, Canada T5K 2J6 403/427-6270 Environment Emergency 1-800-222-6514 Telex 037-2006

THE AGRICULTURAL CHEMICALS ACT

PESTICIDES PERMIT

PERMIT NO. 87-GA20

To: Alberta Forestry, Lands & Wildlife
Alberta Forest Service
Forest Research Branch
215 McLeod Avenue
Spruce Grove, Alberta
T0E 2C0

Attention: Mr. S. Navratil, Acting Director

In accordance with Ms. J. Lane's application, Alberta Forestry, Lands & Wildlife is hereby permitted to apply VELPAR L HERBICIDE (P.C.P. NO. 18197), and ROUNDUP (P.C.P. NO. 13644), hereon referred to as the herbicide(s), for research purposes in forest management, at Satellite Trial B, subject to the conditions and requirements specified below:

1. All application crews will be knowledgeable of the conditions and requirements specified in this permit and a copy of this permit will be in their possession at each application site.

2. The following individuals shall be notified in advance of the herbicide treatments:

Mr. Wayne Inkpen, Head Field Services Section Alberta Environment Phone: 427-5855	and	Mr. C. W. Leary Superintendent Peace River Forest Phone: 624-6221

. . . . 2

3. The herbicide applications shall be confined within the boundaries of the research plots located within Sections 25 & 36, Township 87, Range 21, West of the 5th Meridian and the treatments shall not exceed 5.1 hectares in area.

4. The herbicide applications shall be conducted or supervised by a Class "D" or "G" Alberta Pesticide Applicator who shall be on site during all applications.

5. Alberta Forestry, Lands & Wildlife shall have an employee cognizant of this research program on site at all times while the herbicide applications are in progress.

6. The herbicide applications shall be in compliance with the directions specified on the manufacturer's labels for hack & squirt, and spotgun treatments.

7. No herbicide shall be applied within 30 horizontal metres of any river, stream, or open body of water greater than four hectares in area.

8. During the herbicide applications, the main access routes to the treatment areas shall be posted with signs advising the public that herbicide treatments are being undertaken. These signs must remain in place for the duration of this research program.

9. All empty herbicide containers shall be disposed of at a government-approved pesticide container collection site.

10. In the event of a spill or unauthorized dumping of any herbicide approved in this permit, the Director of Pollution Control must be notified immediately; telephone 1-800-222-6514.

11. A summary of the herbicides used; dates of treatment and total area treated shall be forwarded to the Director of Pollution Control before January 31, 1988 (form included for this purpose).

12. A copy of the research results shall be forwarded to the Director of Pollution Control upon the completion of this research project.

Written approval from the Director of Pollution Control must be obtained if there is a change in the treatment program from the original application and if future vegetation control programs are to be undertaken.

. . . . 3

This permit is issued according to the provisions of Alberta Regulation 213/80, Section 4(1) and on the basis of present data and knowledge, and may be revised should the Director of Pollution Control deem it necessary.

EXPIRY DATE OF HERBICIDE APPLICATIONS: December 31, 1987

DATED AT EDMONTON: June 15, 1987

R. N. Briggs, M.Sc., P.Eng.
Director
Pollution Control Division

NW/as

Enclosure

cc: M. Anderson
J. Lane
C. Leary
J. Drew
V. Servant

Alberta
ENVIRONMENT
Environmental Protection Services
Pollution Control Division

Oxbridge Place, 9820 - 106 Street, Edmonton, Alberta, Canada T5K 2J6 403/427-6270 Environment Emergency 1-800-222-6514 Telex 037-2006

THE AGRICULTURAL CHEMICALS ACT

PESTICIDES PERMIT

PERMIT NO. 87-GA19

To: Alberta Forestry, Lands & Wildlife
Alberta Forest Service
Forest Research Branch
215 McLeod Avenue
Spruce Grove, Alberta
T0E 2C0

Attention: Mr. S. Navratil, Acting Director

In accordance with Ms. J. Lane's application, Alberta Forestry, Lands & Wildlife is hereby permitted to apply VELPAR L HERBICIDE (P.C.P. NO. 18197), and FORMULA 40F FORESTRY HERBICIDE (P.C.P. 16994), hereon referred to as the herbicide(s), for research purposes in forest management, at Satellite Trial C, subject to the conditions and requirements specified below:

1. All application crews will be knowledgeable of the conditions and requirements specified in this permit and a copy of this permit will be in their possession at each application site.

2. The following individuals shall be notified in advance of the herbicide treatments:

Mr. Wayne Inkpen, Head Field Services Section Alberta Environment Phone: 427-5855	and	Mr. C. W. Leary Superintendent Peace River Forest Phone: 624-6221

. . . . 2

3. The herbicide applications shall be confined within the boundaries of the research plots located within Sections 32 & 33, Township 86, Range 3, West of the 6th Meridian and the treatments shall not exceed 6.7 hectares in area.

4. The herbicide applications shall be conducted or supervised by a Class "D" or "G" Alberta Pesticide Applicator who shall be on site during all applications.

5. Alberta Forestry, Lands & Wildlife shall have an employee cognizant of this research program on site at all times while the herbicide applications are in progress.

6. The herbicide applications shall be in compliance with the directions specified on the manufacturer's labels for cut surface & injection treatments.

7. No herbicide shall be applied within 30 horizontal metres of any river, stream, or open body of water greater than four hectares in area.

8. During the herbicide applications, the main access routes to the treatment areas shall be posted with signs advising the public that herbicide treatments are being undertaken. These signs must remain in place for the duration of the research project.

9. All empty containers shall be disposed of at a government-approved pesticide container collection site.

10. In the event of a spill or unauthorized dumping of any herbicide approved in this permit, the Director of Pollution Control must be notified immediately; telephone 1-800-222-6514.

11. A summary of the herbicides used, dates of treatment and total area treated shall be forwarded to the Director of Pollution Control before January 31, 1988 (form included for this purpose).

12. A copy of the research results shall be forwarded to the Director of Pollution Control upon the completion of this research project.

Written approval from the Director of Pollution Control must be obtained if there is a change in the treatment program from the original application and if future vegetation control programs are to be undertaken.

. . . . 3

This permit is issued according to the provisions of Alberta Regulation 213/80, Section 4(1) and on the basis of present data and knowledge, and may be revised should the Director of Pollution Control deem it necessary.

EXPIRY DATE OF HERBICIDE APPLICATIONS: December 31, 1987

DATED AT EDMONTON: June 15, 1987

R. N. Briggs, M.Sc., P.Eng.
Director
Pollution Control Division

RVE/fc

Enclosure

cc: M. Anderson
J. Lane
C. Leary
J. Drew
V. Servant

Forest Research Branch. Alberta Forest Service
Project: "Control of aspen competition in the areas designated for softwood production:

PROCEDURES FOR SOIL SAMPLING AND MONITORING FOR HEXAZINONE RESIDUE ON SATELLITE TRIAL A, CALLING LAKE
Prepared by S. Navratil and J. Lane
(based on discussion with J. Feng, CFS, Northern Forestry Centre and W. Inkpen, Alberta Department of Environment, ECW materials, J. Feng also provided additional expertise)

Treatments in Satellite trial A:
mechnical: four
chemical: one: ground application of Velpar by portable sprayer with boom, simulating aerial application, width of one swath 2 meters: concentration 3 kg ai/ha
replicates: four

Soil conditions: Type: gleyed grey luvisol
Texture: silty loam to sandy clay
Organic Layer depth: average of 8 cm

Time frame of sampling:
1. baseline, pretreatment
2. immediately after treatment (September 16-17, 1986)
3. May 1987
4. September 1987
5. May 1988
6. September 1988
7. May and September 1989 (if needed)

Type and number of samples: soil core samples taken with Dr. Campbell/Feng sampler and jar samples embedded in the ground

a. pre-treatment, baseline sampling: two cores from each treatment replicate

one core from each control replicate

each core separated into two layers 0-15cm and 15-30 cm

b. immediately after application: two cores from each treatment replicate, one layer 0-15

four jar samples from each treatment replicate, (later bulked into 2 bulk-jar samples from each replicate)

c. May and September 1987: two core samples from each treatment replicate separately for 0-15 cm and 16-30 cm

one core sample from each replicate of control treatment, separated for 0-15 cm and 16-30 cm layers

d. May and September of 1988 and 1989, the same as in 1987

Time flow of work:

1. Establish soil sampling area, marked with colored pins and labels in control (one in each replicate) and treatment (two in each replicate) blocks

   The size of a soil sampling area 2x3 m, in the treatment blocks lengthwise with the application swath.

2. Embed jars in the TREATMENT sampling areas

3. Collect cores in the TREATMENT sampling areas (4x2)

4. Collect cores in the Control sampling areas (4x1)

5. Application of Velpar

6. Collect jar samples and core samples in the TREATMENT sampling areas

7. Temporarily store and transport the samples in coolers with freezer packs

8. Air-dry samples in dust-free room

9. Determine weight of air-dried samples

10. Ship samples to the laboratory or store in a freezer

Shipping and addresses:

1. Ship by Purolator in a close container, pack samples tightly ; on the outside of the package attach a letter describing the content, for customs office.

   Address: ANS Environmental Testing Inc.
   Rd. #1, Box 1228
   Lessport, Penn. 19533, USA
   Attention: Steve Stupp 215-373-8256 (Home)
   215-926-6602 (Lab)

1

CORE SAMPLING PROCEDURE

Materials:

- 10 cm core sampler
- Garbage Bags
- Scrub Brush
- Surgical Gloves
2 - Small Paint Brushes
- Scalpel
- Wash Bottle
- Tin Foil
- Masking Tape
- Screwdriver
- Soil sample bags
- Freezer packs
- Ruler
- Felt markers
- Sledge Hammer
- Trowel carved to fit the inside of sampler
- Paper towel
- Shovel

Field Procedure:

1. With a felt pen mark on the outside of the sampler the desired depth plus 5 cm for discard. eg. If the desired depth is 30 cm, place a mark 35 cm from the bottom of the sampler.

2. Choose an area that has not been trampled and remove large debris.

3. Pound the sampler down until the mark is level with the ground; try to maintain the pounder in an upright position.

4. The method used to remove soil sampler depends on the type of soil. If the soil contains a lot of moist clay when lifting the sampler, the soil may be sucked out. In this case dig down along side the sampler and slice the sample, then lift out. When sampling dry clay pan soils one may need a 2 ton jack under the sampler handles to lift it out of the ground. In most cases the sampler can be easily lifted out of the ground by two people.

5. Brush loose soil off the outside of the sampler.

6. Person "A" must put on surgical gloves - sterile. Person B does not need.

7. Person "A" - tape tin foil on the side of the sampler that does not open.

   Person "B" - set the sampler, foil side down, on a clear incontaminated garbage bag. (Garbage bags must be changed between samples). At no time should the sampler be tipped upside down.

8. "B" remove the screws and open the core.

9. "A" measure the sample. If the sample is less than the desired depth, compaction has occurred.

   To compensate for compaction, assume the humus layer only compacted. Measure the humus layer (H), then measure from the bottom of the humas layer to the O line (A) to find the before compaction depth.

   $$\frac{A}{H} = \text{correction factor}$$

10. Measure and describe the depths of the horizons.

11. "B" mark the core at 15 cm and 30 cm using the trowel.

12. "B" wipe trowel, remove bottom 5 cm with the trowel. "A" brush the core with the paint brush to remove residual soil.

13. "A" pull the soil bag over the bottom of the core, even with the 15 cm mark on the core. As "B" lifts the soil sampler.

14. "A" holds the bag in place as "B" slices the 15-30 cm core off with the trowel and slides it into the bag. A scalpel may be needed to sever roots.

15. "A" brushes the remaining soil that may be stuck to the core into the bag and also any that has spilled over the edge of the sampler.

16. Label the sample with date-site-depth and double bag.

17. Repeat steps 13-16 for the 0-15 cm portion of the core but use a different paint brush.

18. After double bagging place both samples together in a larger bag.

19. The samples should be placed in a cooler and with ice packs.

20. Prepare for next sample by washing the sampler 3 times with water and wipe with paper towel. Wash trowel, throw away surgical gloves and change plastic garbage bag.

Lab Procedure

1. Weigh the samples and record.
2. Air dry sample on a tray 3 - 4 days and weigh again.
3. Blend the sample and sieve.
4. Double bag samples, label clearly and ship to lab.
5. Calculate % H_2O $\frac{FW-DW}{DW} \times 100$
6. Calculate bulk density $\frac{DWg}{volume}$

   Volume (cm^2) length of core x (10 cm ÷ 2)^2 π

JAR SAMPLING PROCEDURE

Materials:

- 16 glass jars
- shovel
- mineral soil from the top 15 cm (uncontaminated).

Procedure

1. Fill the jars 1/2 full of mineral soil, mixed A & B horizons from control areas.
2. Prior to application bury them in the ground with just mouth exposed.
3. After application add another 3-5 cm of mineral soil.
4. Seal the jars and transport to the lab in a cooler.
5. Determine FW
6. Determine DW (air-dried)

4

SYSTEM OF LABELLING

Place
CL - Calling Lake

Sample - Pretreatment - P
Application - 0
Spring 1987 - S'87
Fall 1987 - F'87
Spring 1988 - S'88
Fall 1988 - F'88
Spring 1989 - S'89
Fall 1989 - F'89

Date: MONTH/DAY/YEAR

Plot Location -

Replicate - 1,2,3 or 4
Block - Control - C
- Treatment - T
Plot - East - E
West - W

Thus a label could be:

CL-P-Sept/15/86-1-T-E

Herbicide Soil Deposition Analysis from Calling Lake immediately after application, Fall 1986

Sample	MW(g)	DW(g)	%MC	Bulk Density	*PPM	kg ai/ha
Replicate 1 North Jars	----	538	----	----	2.8	4.15
Replicate 1 South Jars	----	572	----	----	2.6	4.10
Replicate 1 0-15 cm soil	1181	625	89.0	.53	1.7	0.67
Replicate 2 East Jars	----	468	----	----	3.0	3.87
Replicate 2 West Jars	----	594	----	----	2.7	4.42
Replicate 2 0-15 cm soil	924	647	42.8	.54	1.6	0.66
Replicate 3 East Jars	----	545	----	----	1.3	1.95
Replicate 3 West Jars	----	520	----	----	1.6	2.29
Replicate 3 0-15 cm soil	853	442	93.0	.37	1.6	0.45
Replicate 4 East Jars	----	658	----	----	2.1	3.81
Replicate 4 West Jars	----	610	----	----	3.5	5.88
Replicate 4 0-15 cm soil	1461	990	47.6	.83	1.4	0.88

*The soil recovery rate was 95%

Herbicide Soil Residue Analysis from Calling Lake in the Spring 1987

Sample	MW(g)	DW(g)	%MC	Bulk Density	*PPM	kg ai/ha
Replicate 1 0.0 - 15.0 cm	1586.68	709.52	123.6	4.52	6.20	2.802
Replicate 1 15.1 - 30.0 cm	4649.36	3783.03	22.9	24.08	0.09	0.217
Replicate 2 0.0 - 15.0 cm	1439.07	980.38	46.8	6.24	2.50	1.560
Replicate 2 15.1 - 30.0 cm	4597.03	3969.68	15.8	25.27	0.27	0.682
Replicate 3 0.0 - 15.0 cm	1053.20	561.18	87.7	3.57	2.40	0.857
Replicate 3 15.1 - 30.0 cm	4169.89	3253.41	28.2	20.71	0.32	0.663
Replicate 4 0.0 - 15.0 cm	1647.76	950.96	73.3	6.05	0.94	0.569
Replicate 4 15.1 - 30.0 cm	4716.42	3896.87	23.9	24.24	0.20	0.485

Herbicide Soil Residue Analysis from Calling Lake in the Fall 1987

Sample	MW(g)	DW(g)	%MC	Bulk Density	*PPM	kg ai/ha
Replicate 1 0.05 - 15.0 cm	2549.44	1761.03	39.7	11.21	0.21	0.235
Replicate 1 15.1 - 30.0 cm	4639.73	3905.69	18.8	24.87	0.02	0.050
Replicate 2 0.0 - 15.0 cm	2807.58	2280.19	23.1	14.52	0.06	0.087
Replicate 2 15.1 - 30.0 cm	4719.28	4157.80	13.5	26.47	0.03	0.079
Replicate 3 0.0 - 15.0 cm	1614.47	970.11	66.4	6.18	0.16	0.099
Replicate 3 15.1 - 30.0 cm	4343.58	3415.18	25.9	21.74	0.05	0.109
Replicate 4 0.0 - 15.0 cm	1726.16	1160.05	48.8	7.39	0.79	0.584
Replicate 4 15.1 - 30.0 cm	4388.77	3494.12	25.6	22.24	0.08	0.178

Calling Lake - Vegetation Assessment 1987.

Parameter: DENSITY ANALYSIS (COVARIANCE)

Source of Variation	SS	DF	MS	F
Error 1	28741.08	14	2052.93	52.69
Regression	108165.92	1	108165.92	*3.22
Treatment	33003.10	5	6600.62	

* F significant at the 0.05 level.

Table of Means:
(total #trees/plot)

Treatment	Mean	*Post Hoc
CONTROL	39.41	A
MARTTIINI 2	37.98	A
VELPAR	35.93	AB
MARTTIINI 1	22.01	BC
DISK	14.68	C
BLADE	14.16	C

* Means followed by common letters do not differ significantly by Duncans Multiple Range Test (0.05 level).

Calling Lake - Vegetation Assessment 1987.

Parameter: POST TREATMENT DENSITY 0 - 1 YR

Source of Variation	SS	DF	MS	F
Error				
Treatment				

* F significant at the 0.05 level.

Table of Means:
(#trees/plot)

Treatment	Mean	*Post Hoc
MARTTIINI 2	32.8125	A
MARTTIINI 1	19.1875	B
DISC	14.2000	B
BLADE	14.1646	B
VELPAR	5.5125	C
CONTROL	4.0886	D

* Means followed by common letters do not differ significantly by Duncans Multiple Range Test (0.05 level).

Calling Lake - Vegetation Assessment 1987.

Parameter: DENSITY OF TREES - 1-2yrs old in 1987

PRETREATMENT TREES/POST TREATMENT TIME

Source of Variation	SS	DF	MS	F
Error	99538.4371	5	19907.6874	*37.8219
Treatment	237911.8969	452	526.3538	

* F significant at the 0.05 level.

Table of Means:
(#trees/plot)

Treatment	Mean	*Post Hoc
CONTROL	35.3165	A
VELPAR	30.4125	A
MARTTIINI 2	5.1625	B
MARTTIINI 1	2.8250	B
DISC	0.4833	B
BLADE	0.0	B

* Means followed by common letters do not differ significantly by Duncans Multiple Range Test (0.05 level).

Calling Lake - Vegetation Assessment 1987.

Parameter: SPECIMEN TREE (ASPEN) HEIGHT - (POST TREATMENT DATA)

Source of Variation	SS	DF	MS	F
Error 1	56426.69	15	3761.78	*28.71
Treatment	540064.15	5	108012.83	

* F significant at the 0.05 level.

Table of Means:
(specimen tree height in cm)

Treatment	Mean	*Post Hoc
CONTROL	102.31	A
VELPAR	89.27	A
MARTTIINI 1	55.36	B
MARTTIINI 2	52.25	B
DISK	34.48	C
BLADE	23.81	C

* Means followed by common letters do not differ significantly by Duncans Multiple Range Test (0.05 level).

Calling Lake - Vegetation Assessment 1987.

Parameter: ASPEN HEIGHT INCREMENT (POST TREATMENT DATA)

Source of Variation	SS	DF	MS	F
Error 1	19546.51	15	1303.10	*7.60
Treatment	49533.97	5	9906.79	

* F significant at the 0.05 level.

Table of Means:
(specimen tree incr)
in cm

Treatment	Mean	*Post Hoc
CONTROL	48.31	A
MARTTIINI 1	46.78	A
MARTTIINI 2	41.73	AB
VELPAR	34.86	B
DISK	33.63	B
BLADE	23.81	C

* Means followed by common letters do not differ significantly by Duncans Multiple Range Test (0.05 level).

Calling Lake - Vegetation Assessment 1987.

Parameter: % OVERTOPPING - (POST TREATMENT DATA)

Source of Variation	SS	DF	MS	F
Error (within)	4106.28	17	241.55	*8.74
Treatment	10555.57	5	2111.11	

* F significant at the 0.05 level.

Table of Means:
(% trees severely overtopped)

Treatment	Mean	*Post Hoc
CONTROL	69.6	A
DISK	38.5	B
VELPAR	22.6	BC
MARTTIINI 2	18.7	BC
MARTTIINI 1	17.9	BC
BLADE	3.3	C

* Means followed by common letters do not differ significantly by Duncans Multiple Range Test (0.05 level).

Calling Lake - Vegetation Assessment 1987.

Parameter: % CROP TREE SURVIVAL - (POST TREATMENT DATA)

Source of Variation	SS	DF	MS	F
Error	100.48	17	5.91	0.859 N.S.
Treatment	25.38	5	5.08	

* F significant at the 0.05 level.

Table of Means:

(% Crop Tree Survival)

Treatment	Mean	*Post Hoc
DISK	98.7	A
MARTTIINI 2	98.7	A
CONTROL	97.8	A
MARTTIINI 1	96.9	A
BLADE	96.2	A
VELPAR	96.2	A

* Means followed by common letters do not differ significantly by Duncans Multiple Range Test (0.05 level).

Calling Lake - Vegetation Assessment 1987.

Parameter: CROP TREE INCREMENT - (POST TREATMENT DATA)

Source of Variation	SS	DF	MS	F
Error 1	268.88	15	17.93	*4.51
Treatment	404.66	5	80.93	

* F significant at the 0.05 level.

Table of Means:
(1yr increment in cm)

Treatment	Mean	*Post Hoc
MARTTIINI 1	4.94	A
BLADE	4.79	A
DISK	4.63	AB
MARTTIINI 2	4.21	ABC
CONTROL	3.86	BC
VELPAR	3.67	C

* Means followed by common letters do not differ significantly by Duncans Multiple Range Test (0.05 level).

Calling Lake - Vegetation Assessment 1987.

Parameter: % COVER - BARE GROUND

Source of Variation	SS	DF	MS	F
Error	54927.94	15	3661.86	*9.84
Treatment	180082.92	5	36016.58	

* F significant at the 0.05 level.

Table of Means:
(% Bare Ground)

Treatment	Mean	*Post Hoc
BLADE	70.53	A
VELPAR	60.76	A
MARTTIINI 2	56.53	A
MARTTIINI 1	51.39	AB
DISK	30.67	BC
CONTROL	10.74	C

* Means followed by common letters do not differ significantly by Duncans Multiple Range Test (0.05 level).

Calling Lake - Vegetation Assessment 1987.

Parameter: % POPLAR COVER

Source of Variation	SS	DF	MS	F
Error	9830.94	15	655.40	*3.33
Treatment	10916.39	5	2183.28	

* F significant at the 0.05 level.

Table of Means:
(% cover)

Treatment	Mean	*Post Hoc
CONTROL	14.03	A
VELPAR	9.84	AB
MARTTIINI 2	5.50	AB
MARTTIINI 1	3.35	B
DISK	1.13	B
BLADE	0.82	B

* Means followed by common letters do not differ significantly by Duncans Multiple Range Test (0.05 level).

Calling Lake - Vegetation Assessment 1987.

Parameter: % SHRUB COVER

Source of Variation	SS	DF	MS	F
Error 1	72641.71	15	4842.78	0.55 N.S.
Treatment	13395.42	5	2679.08	

* F significant at the 0.05 level.

Table of Means:
(% COVER)

Treatment	Mean	*Post Hoc
DISK	50.47	A
CONTROL	32.84	A
MARTTIINI 1	28.13	A
VELPAR	27.50	A
BLADE	26.94	A
MARTTIINI 2	20.04	A

* Means followed by common letters do not differ significantly by Duncans Multiple Range Test (0.05 level).

Calling Lake - Vegetation Assessment 1987.

Parameter: % OTHER TREES COVER

Source of Variation	SS	DF	MS	F
Error 1	54.55	15	3.64	1.09 NS
Treatment	19.76	5	3.95	

* F significant at the 0.05 level.

Table of Means:
(% Cover)

Treatment	Mean	*Post Hoc
VELPAR	0.58	A
CONTROL	0.46	A
MARTTIINI 1	0.14	A
MARTTIINI 2	0.12	A
DISK	0.08	A
BLADE	0.01	A

* Means followed by common letters do not differ significantly by Duncans Multiple Range Test (0.05 level).

Calling Lake - Vegetation Assessment 1987.

Parameter: % GRASS COVER (POST TREATMENT DATA)

Source of Variation	SS	DF	MS	F
Error 1	34529.17	15	2301.94	*8.08
Treatment	92998.09	5	18599.62	

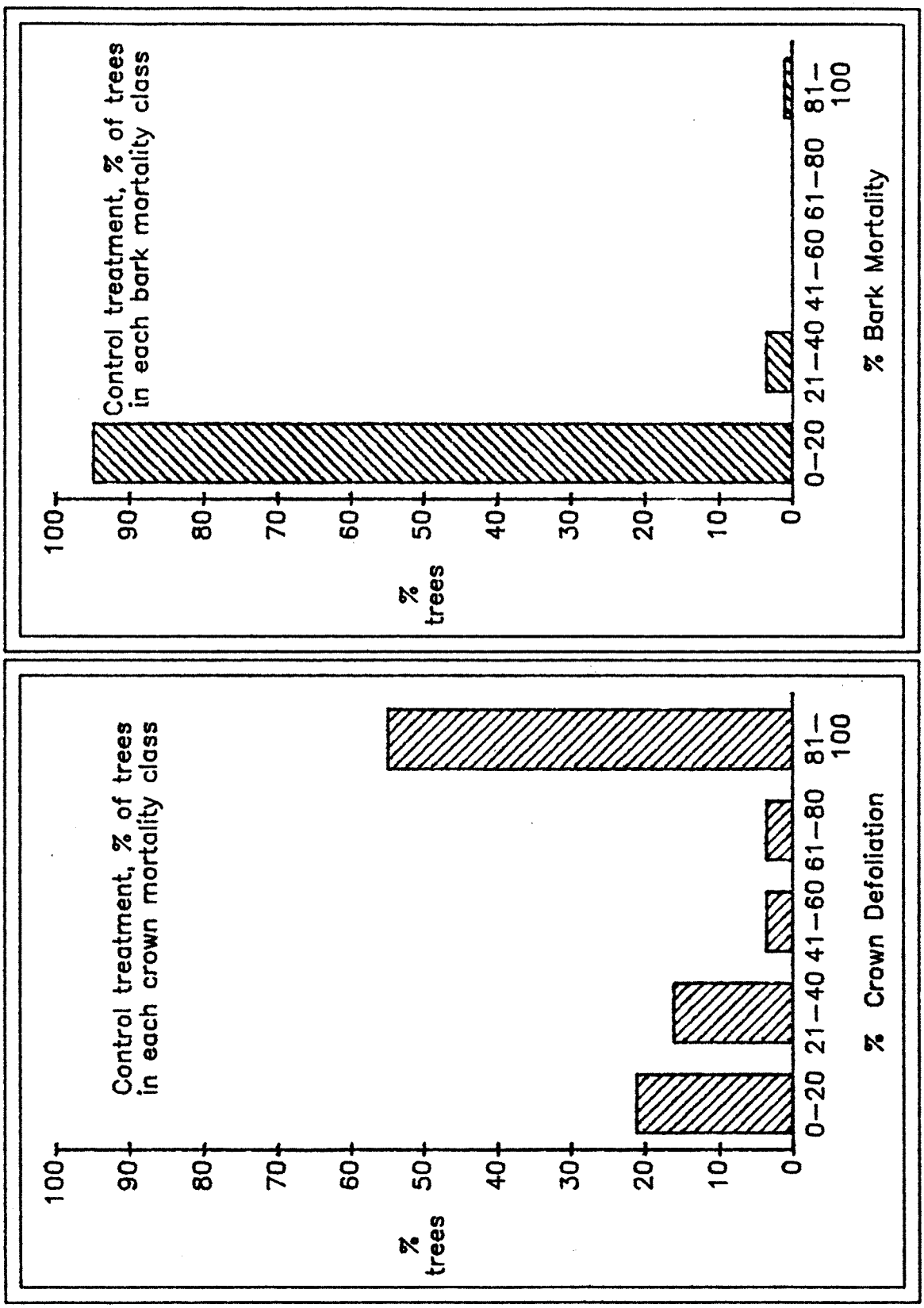
* F significant at the 0.05 level.

Table of Means:
(% Grass Cover)

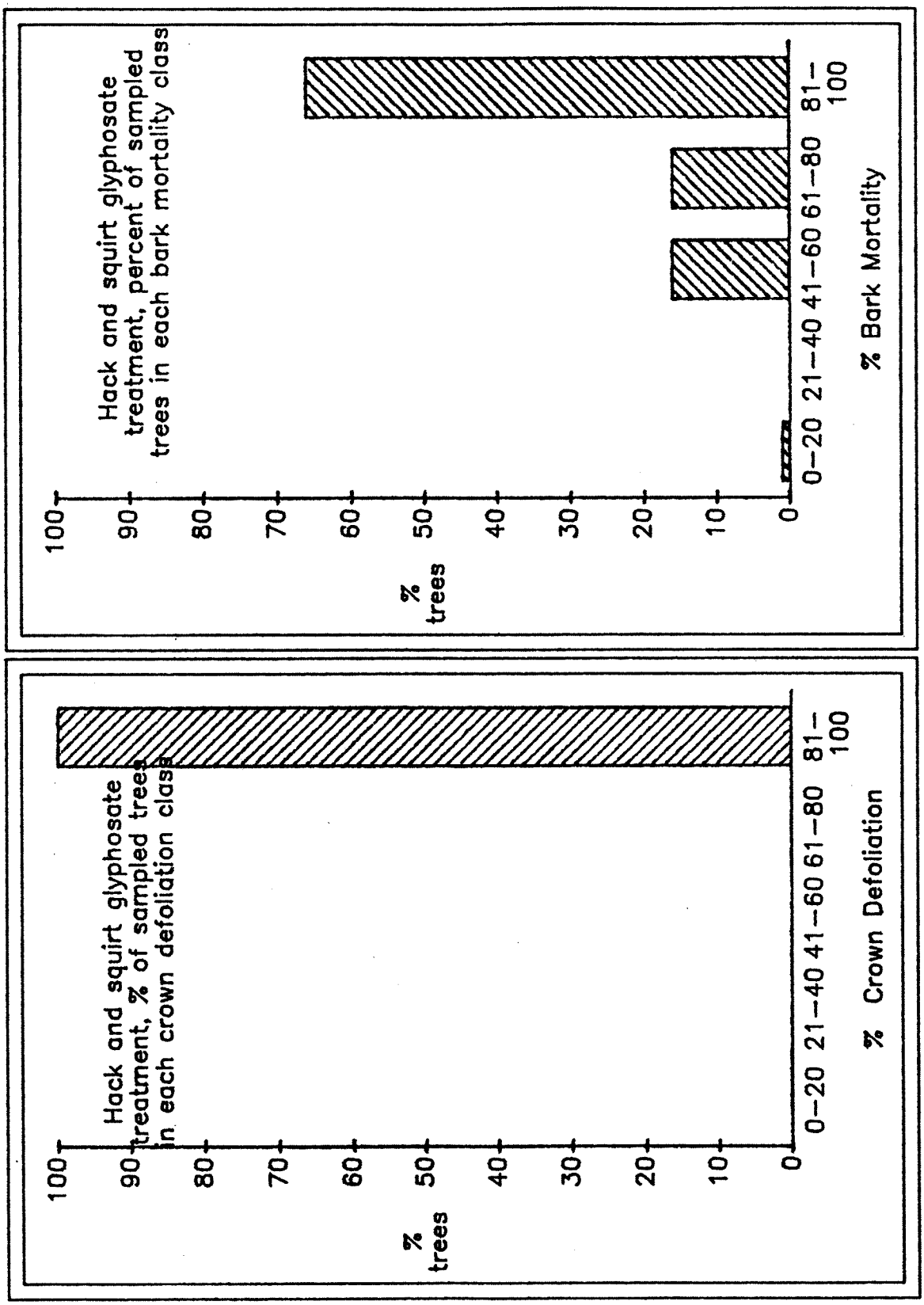
Treatment	Mean	*Post Hoc
CONTROL	42.50	A
DISK	18.05	B
MARTTIINI 2	17.68	B
MARTTIINI 1	16.66	B
VELPAR	1.83	B
BLADE	1.70	B

* Means followed by common letters do not differ significantly by Duncans Multiple Range Test (0.05 level).

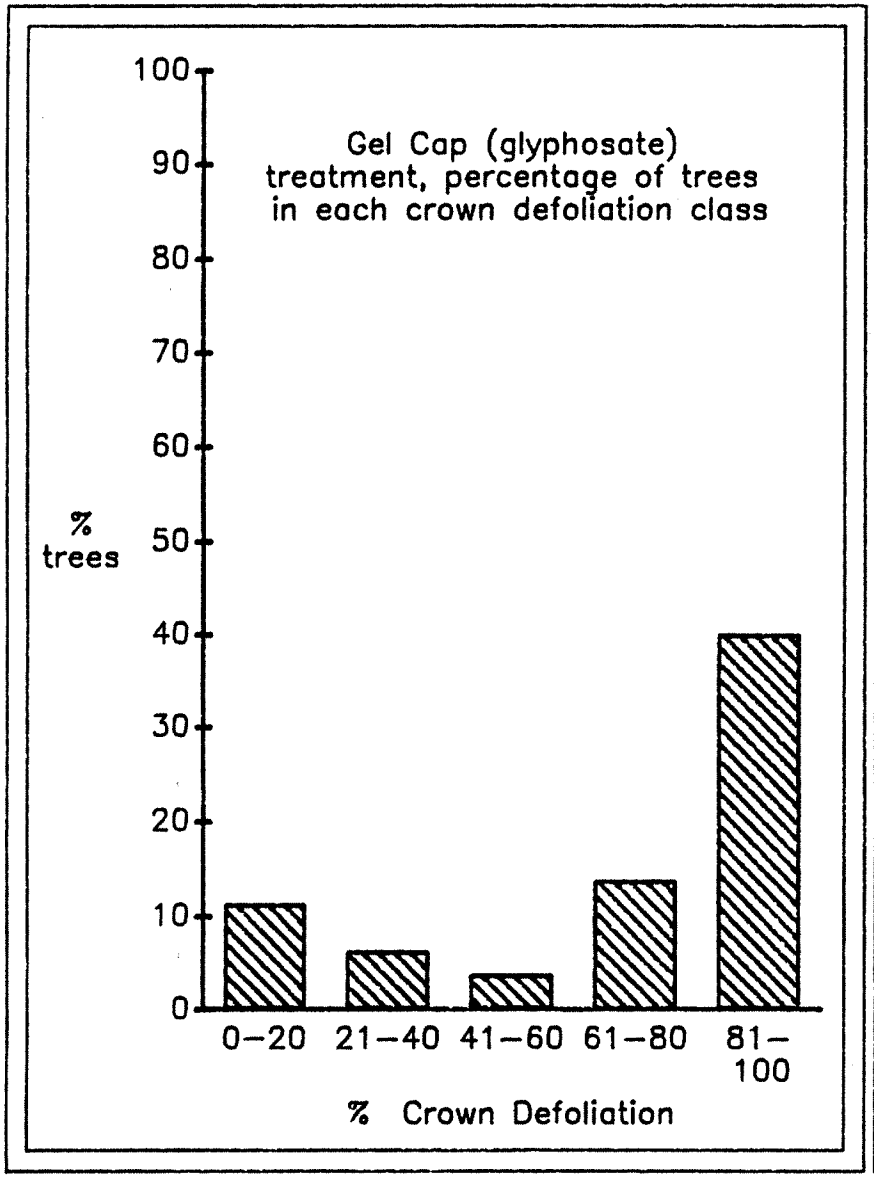
Satellite Trial B Peace River: Control treatment

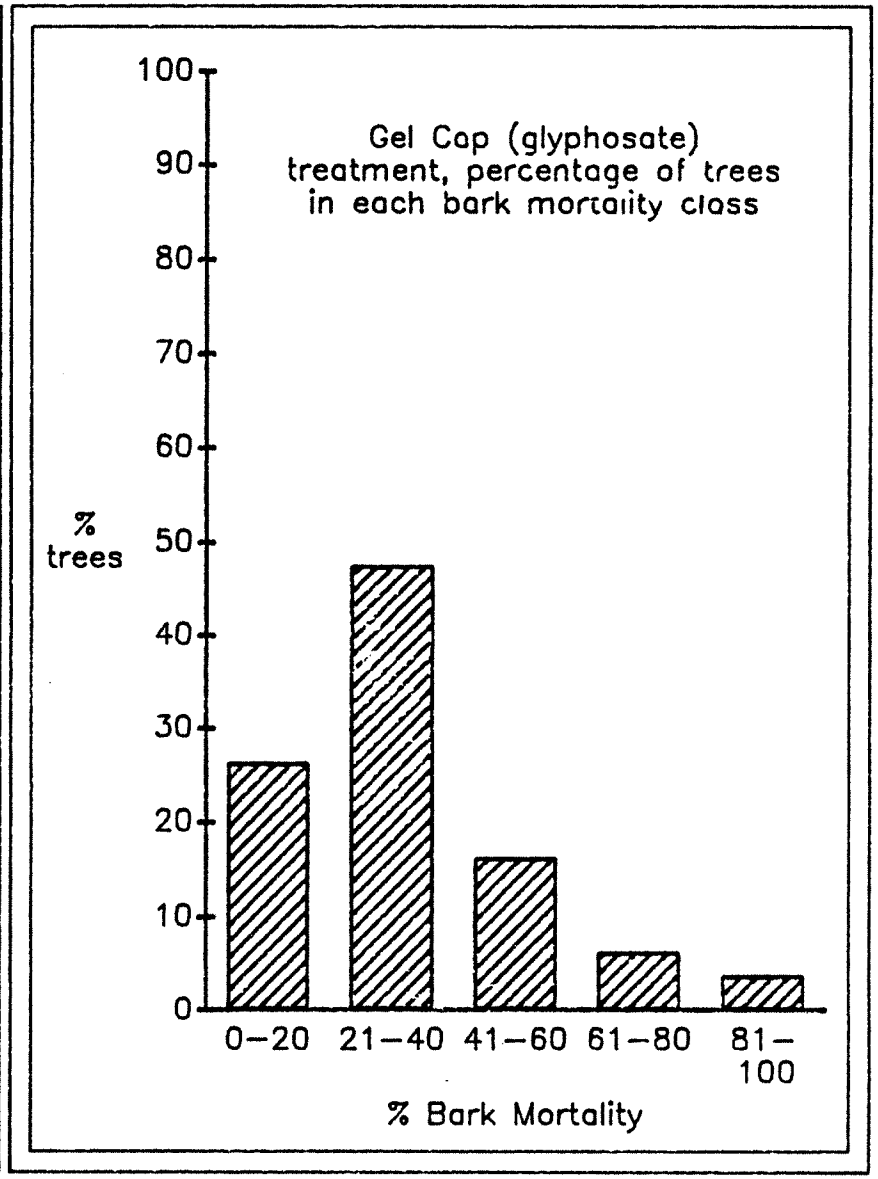


Satellite Trial B Peace River: Hack and Squirt glyphosate treatment

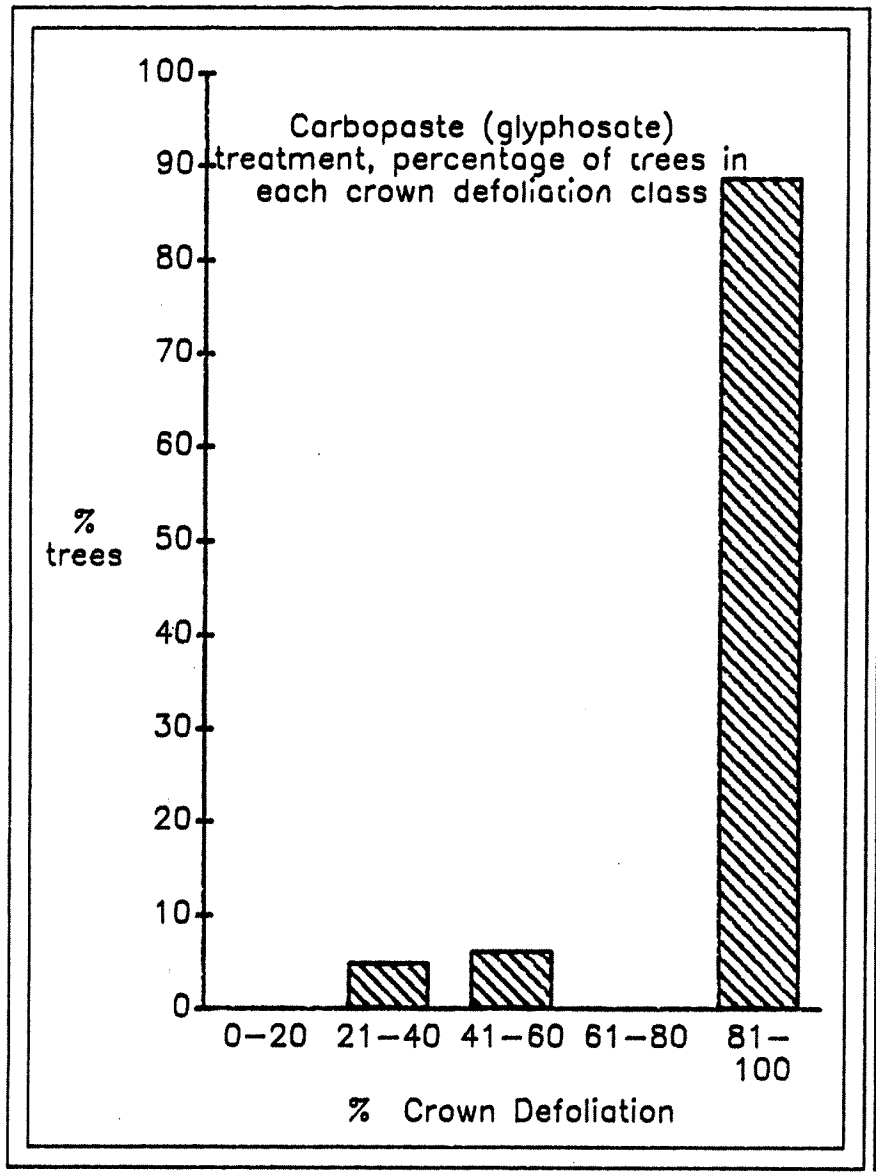


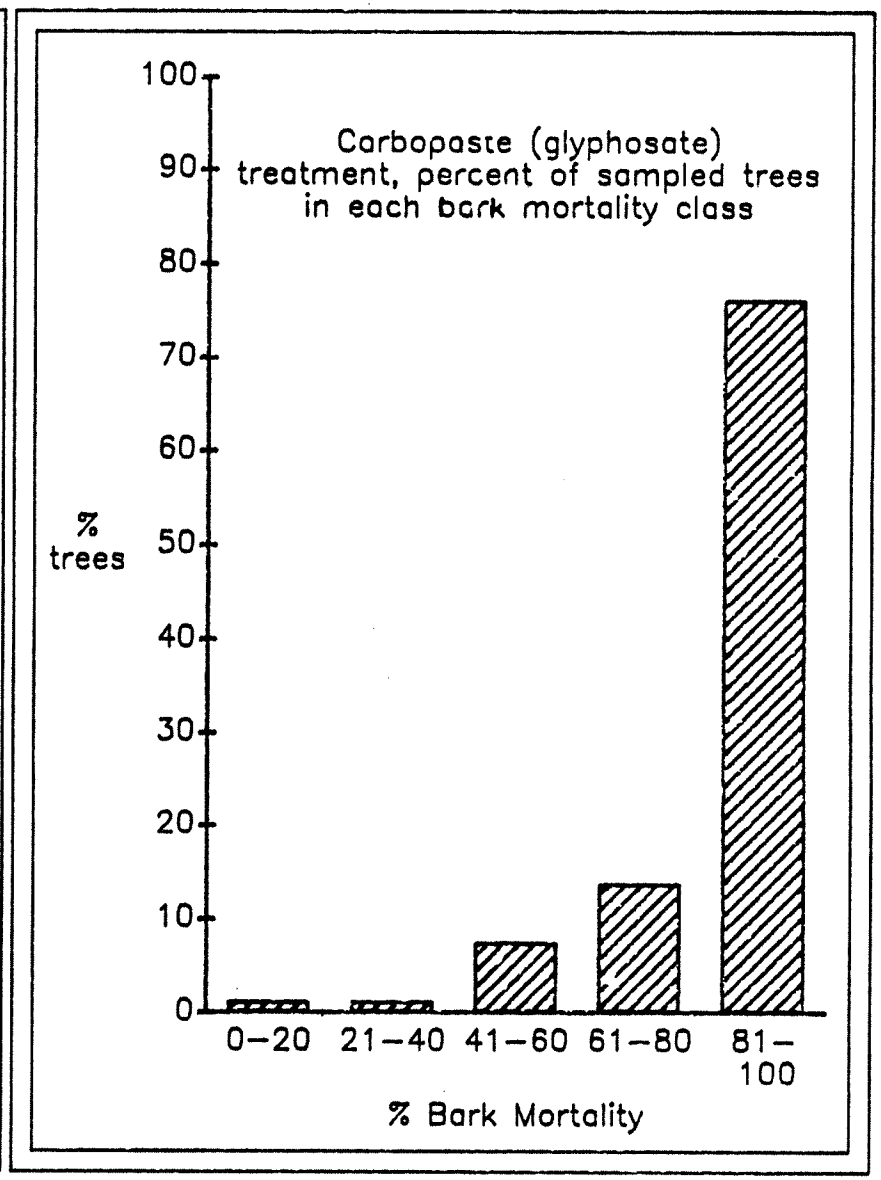
Satellite Trial B Peace River: Gel Cap (glyphosate) treatment



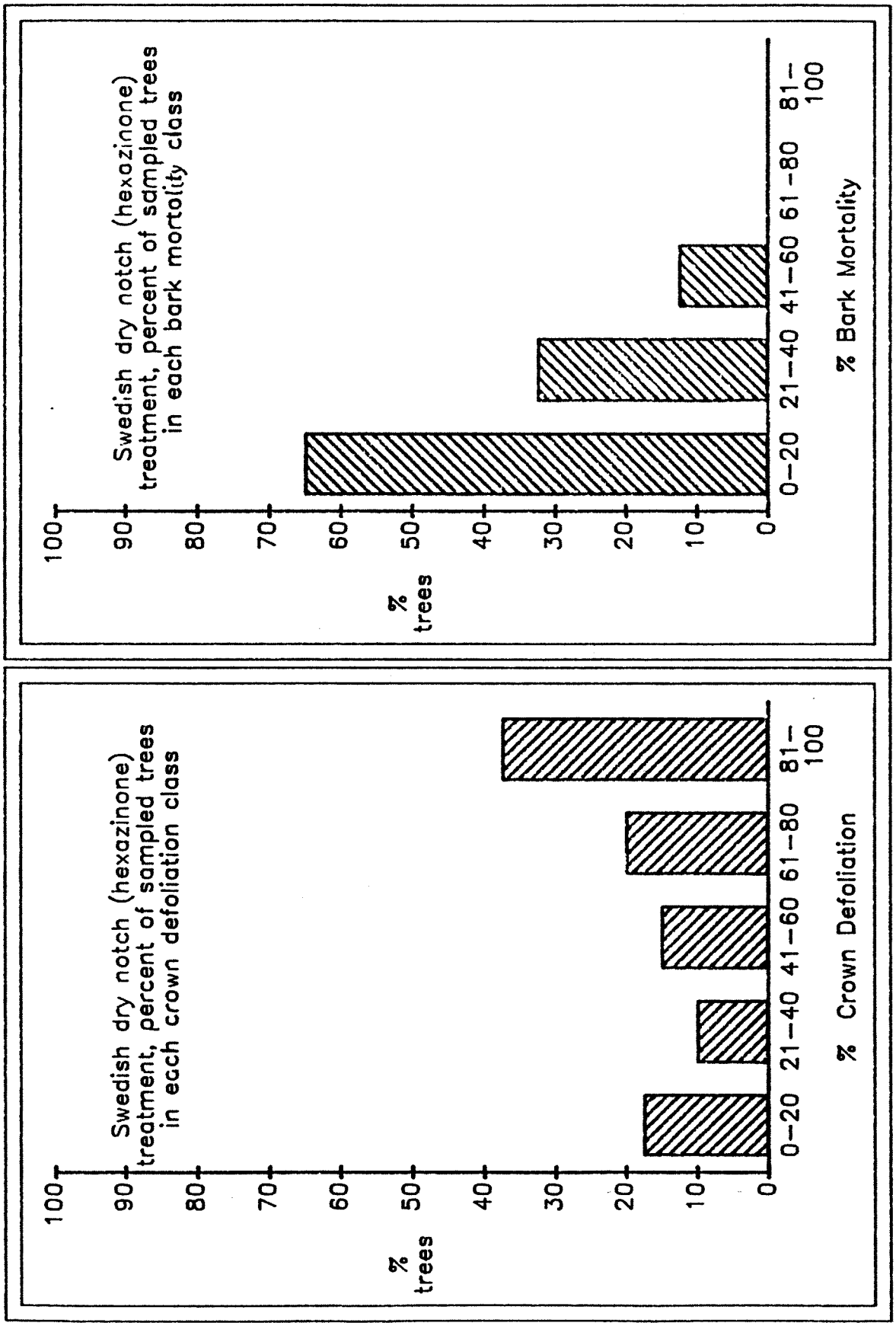


Satellite Trial B Peace River: Carbopaste (glyphosate) treatment

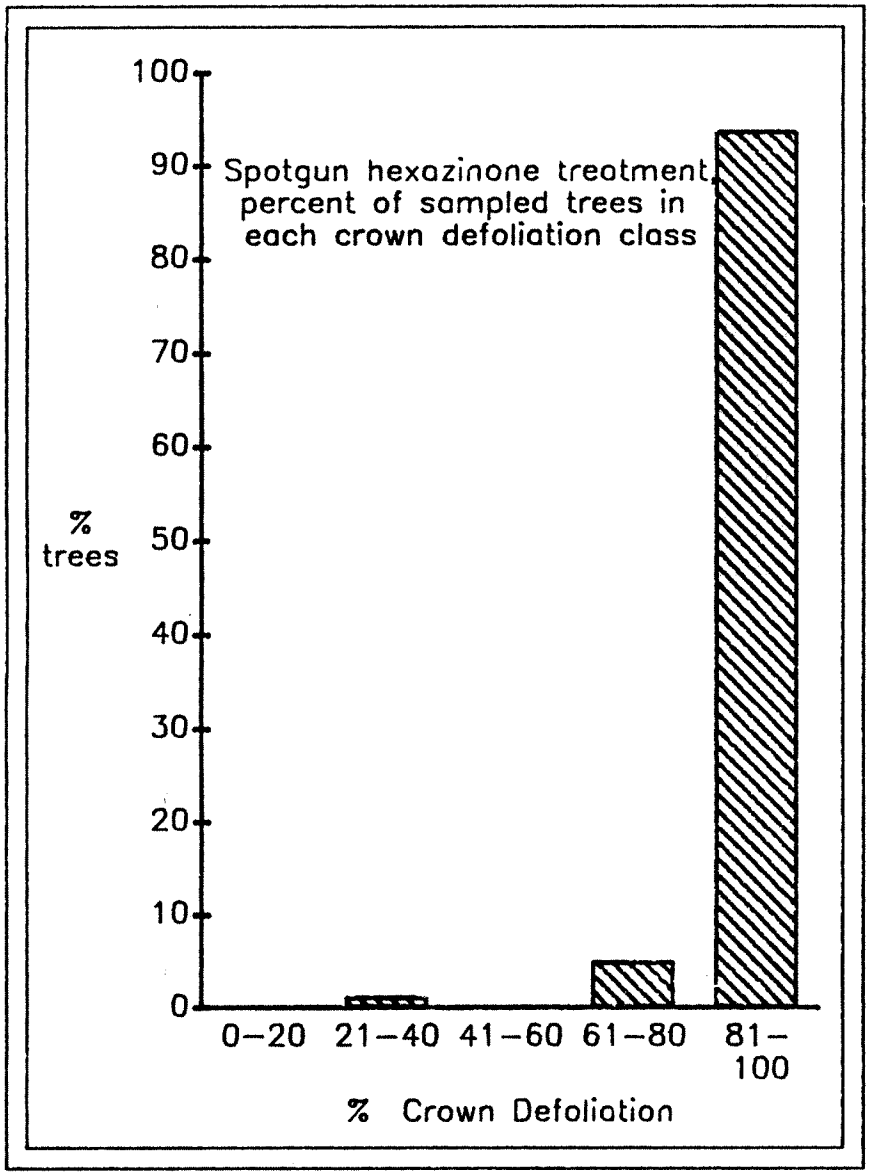


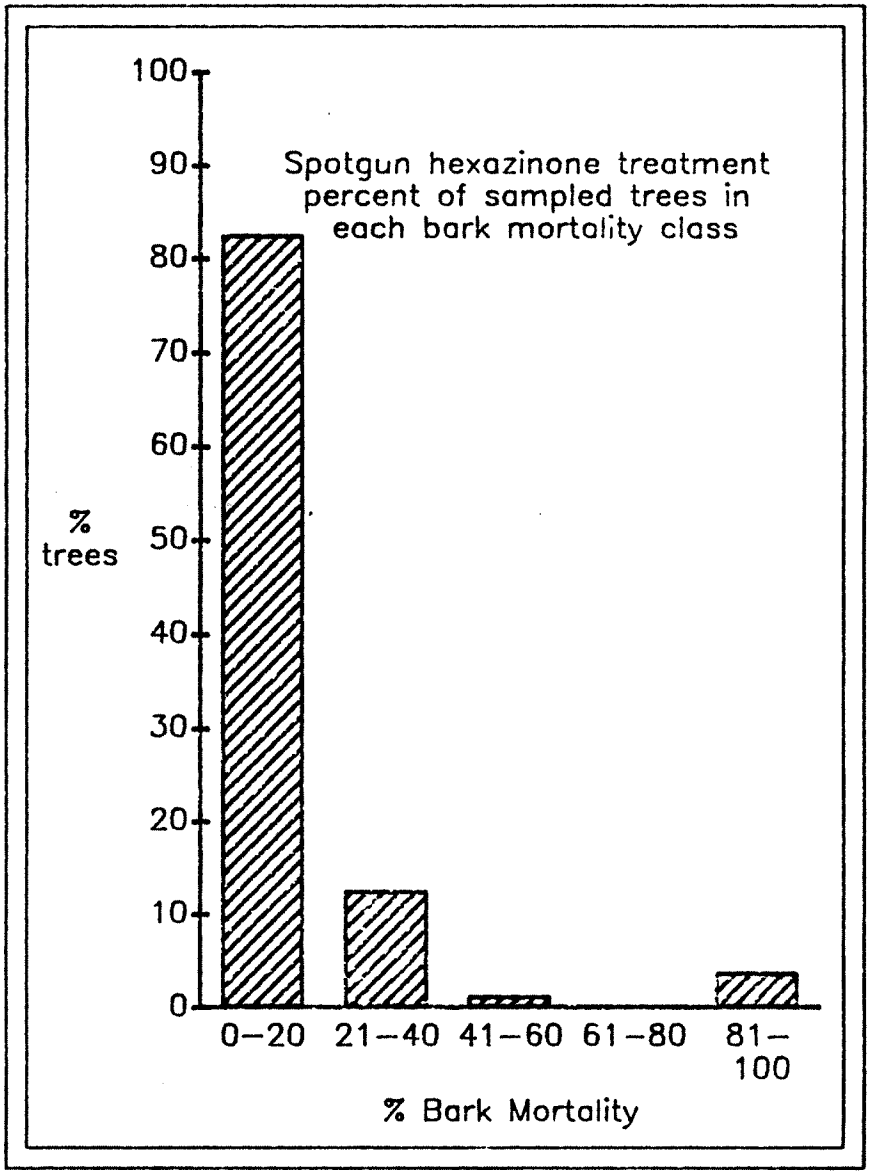


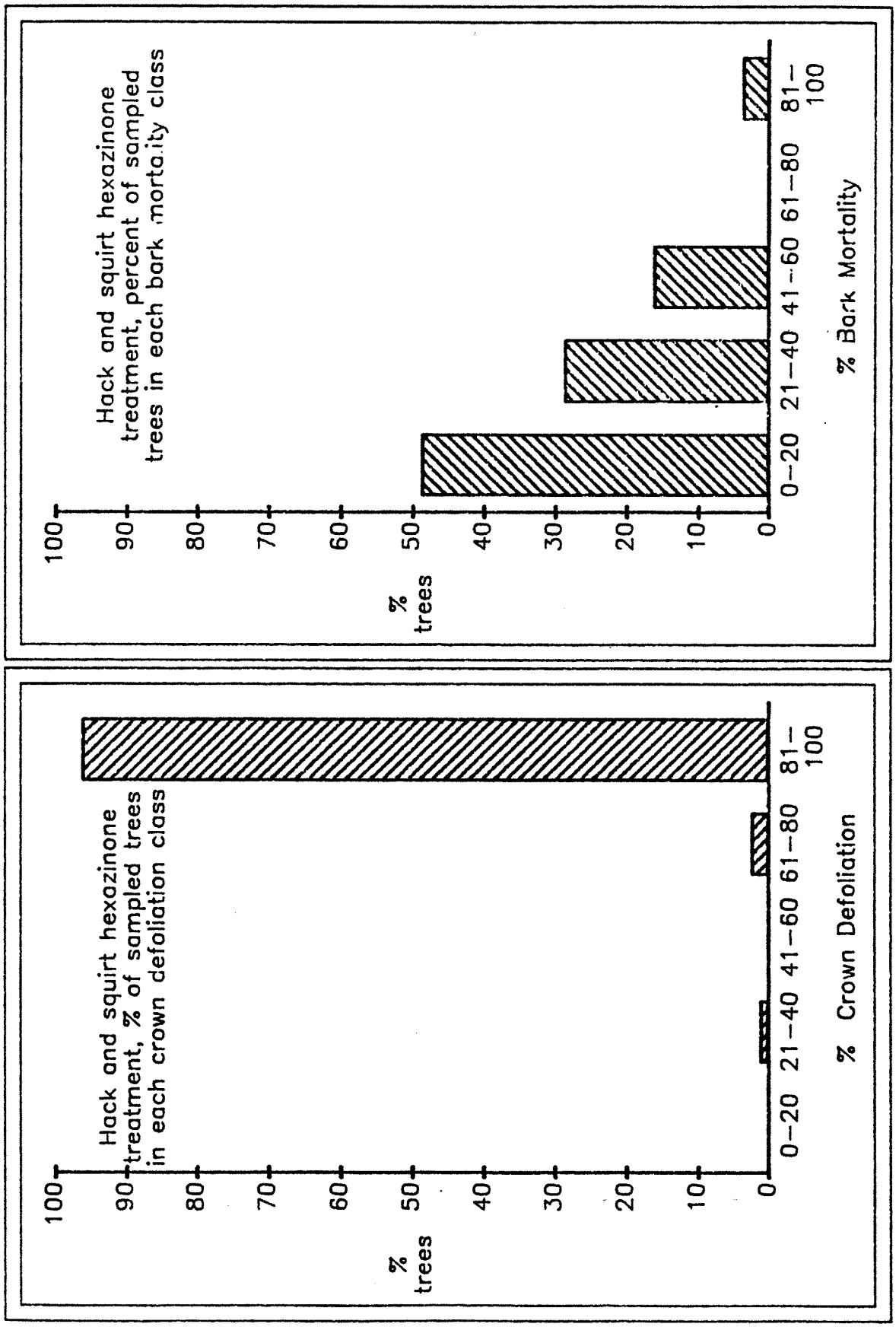
Satellite Trial B Peace River: Swedish dry notch (hexazinone) treatment



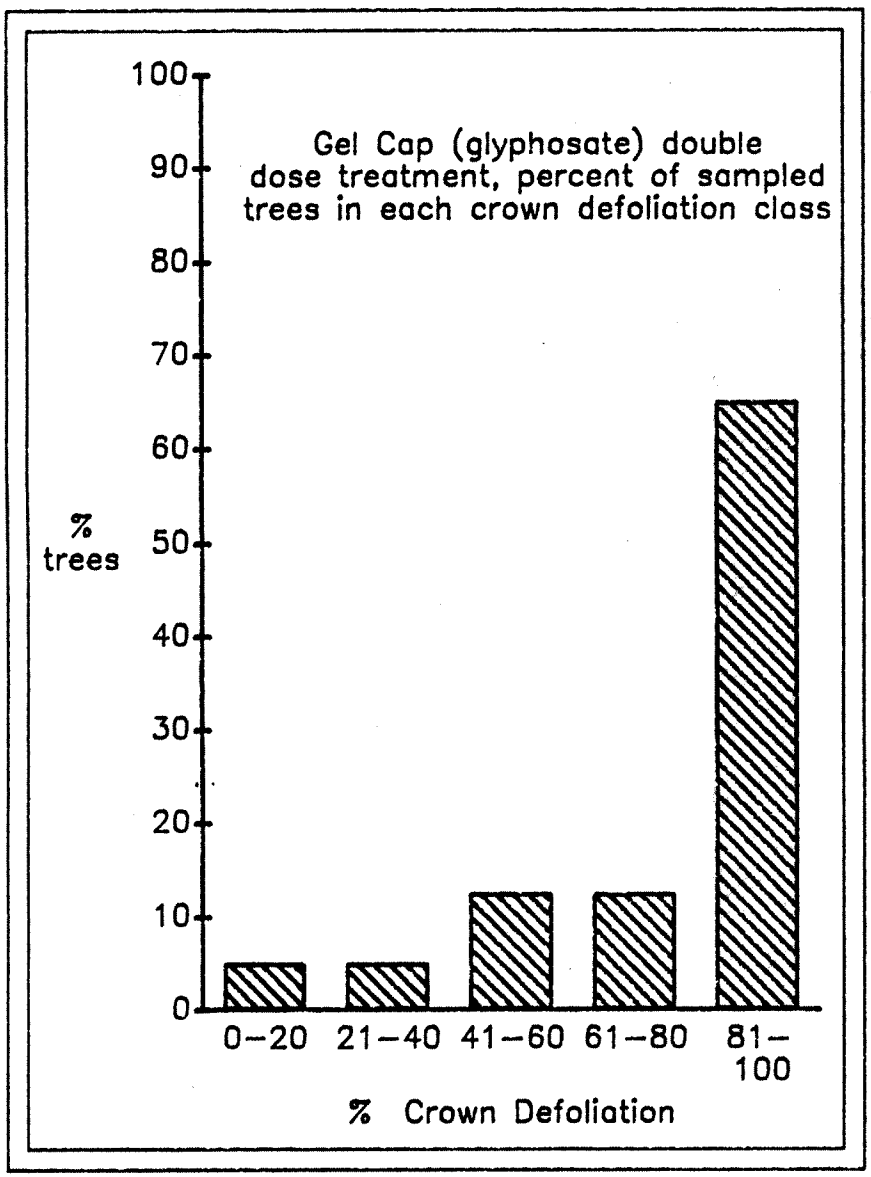
Satellite Trial B Peace River: Spotgun hexazinone treatment

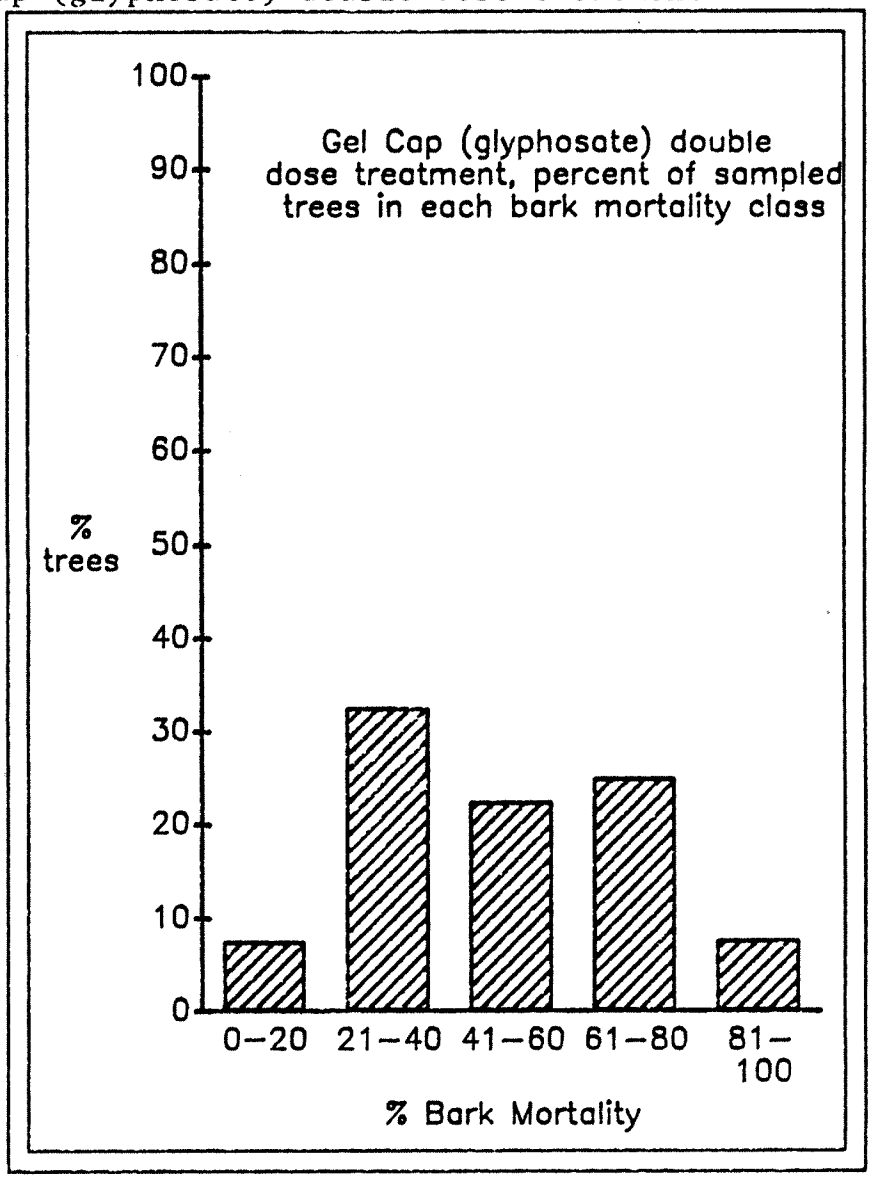




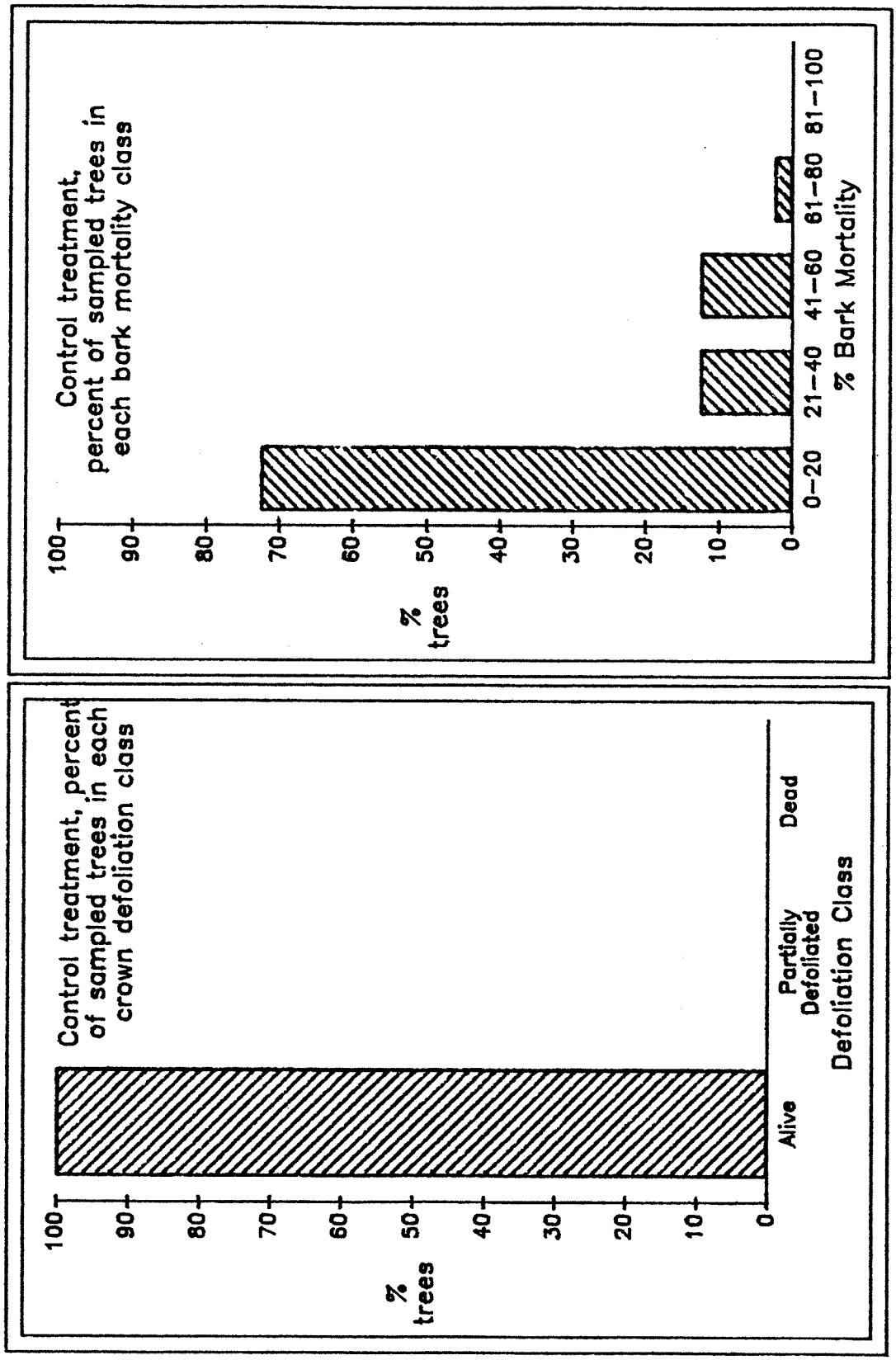

Satellite Trial B Peace River: Hack and Squirt hexazinone treatment
Hack and squirt hexazinone treatment, % of sampled trees in each crown defoliation class
% trees
100
90
80
70
60
50
40
30
20
10
0
0–20
21–40
41–60
61–80
81–100
% Crown Defoliation
Hack and squirt hexazinone treatment, percent of sampled trees in each bark mortality class
% trees
% Bark Mortality

Satellite Trial B Peace River: Gel Cap (glyphosate) double dose treatment

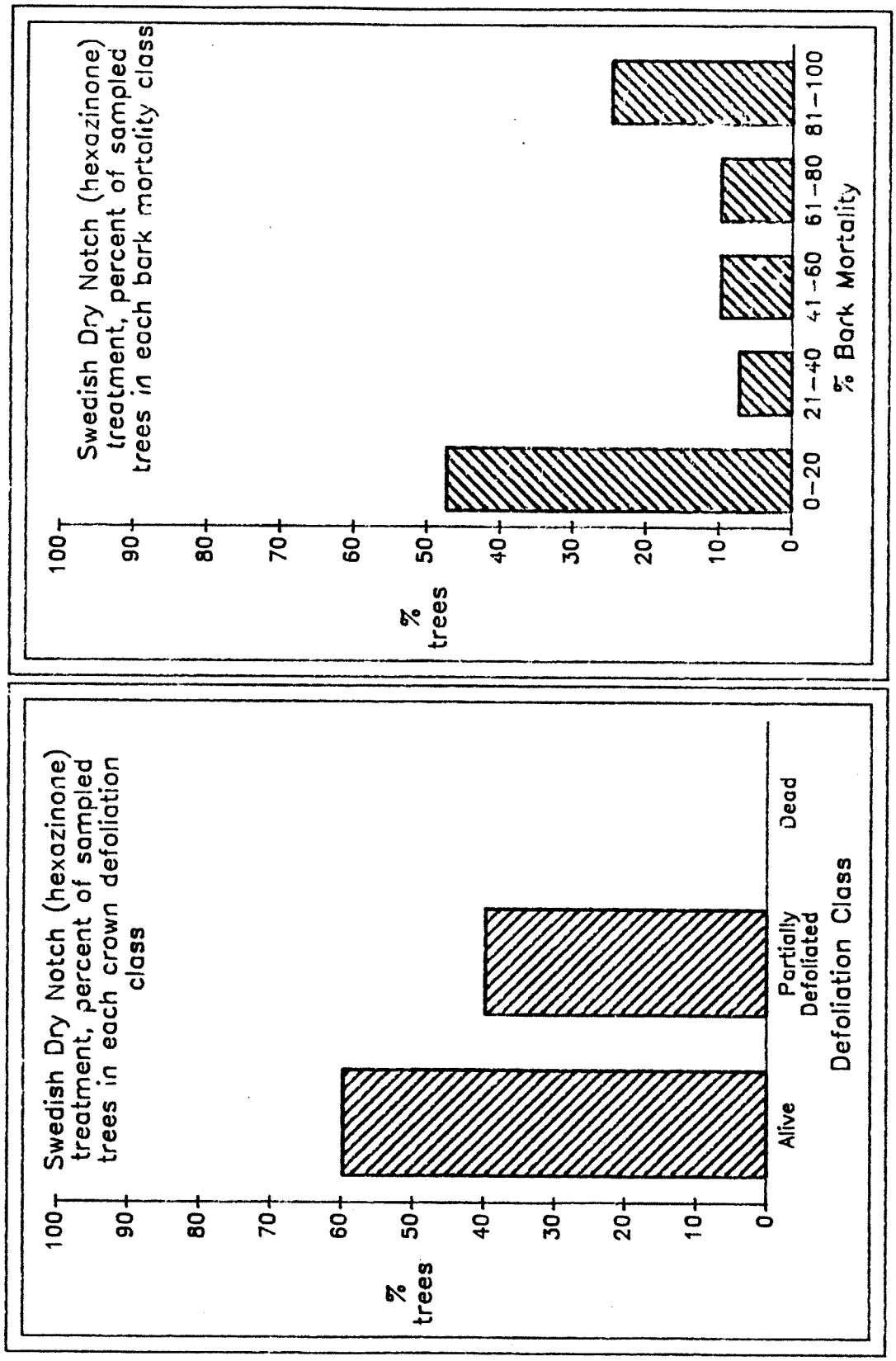




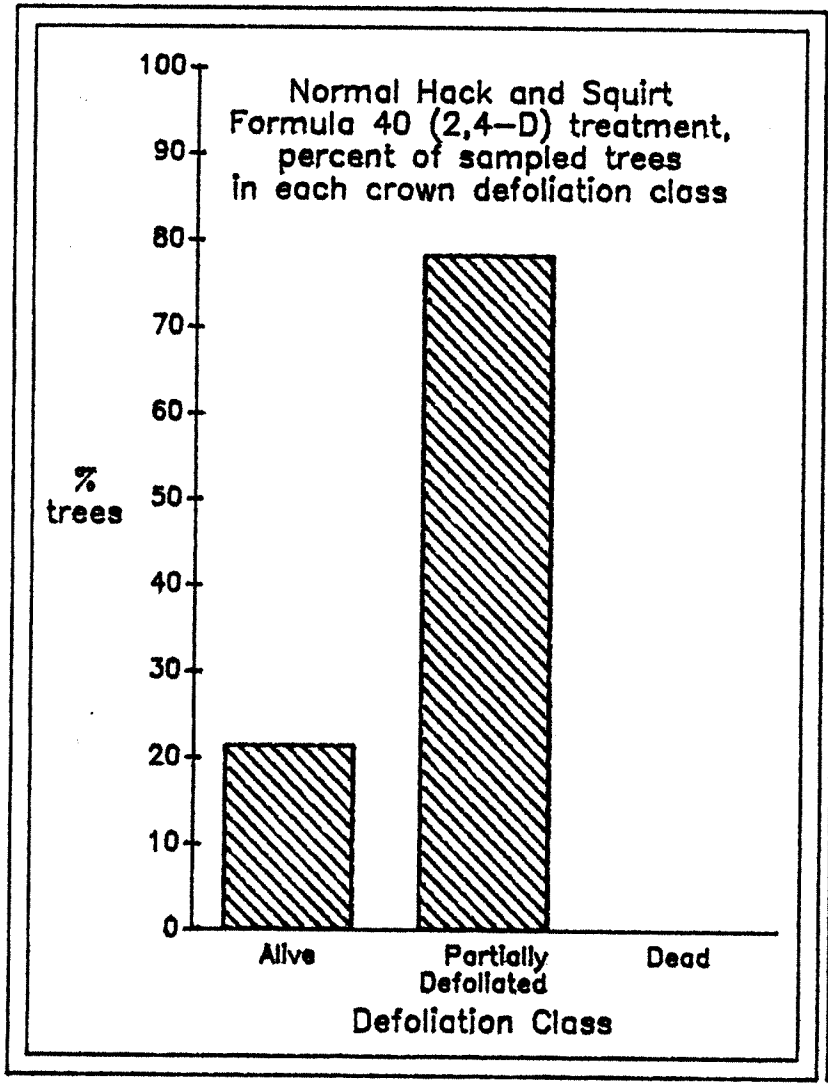
Satellite Trial C Hines Creek: Control treatment

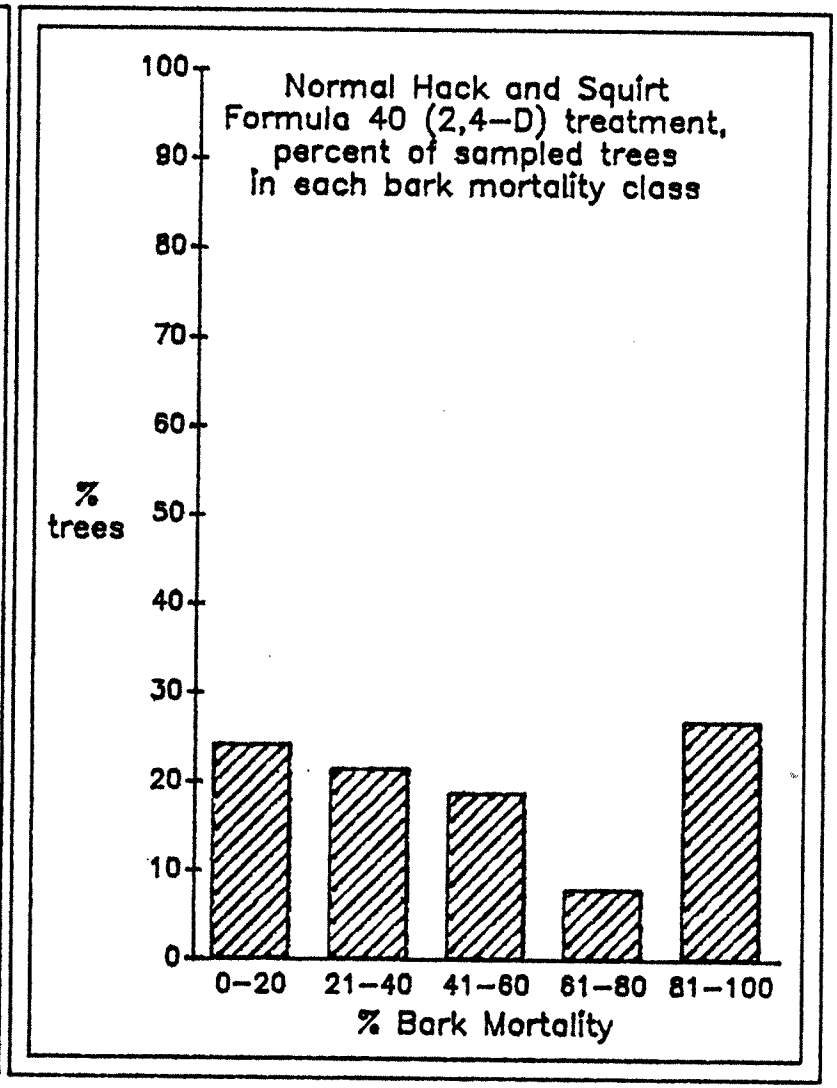


Satellite Trial C Hines Creek: Swedish Dry Notch (hexazinone) treatment

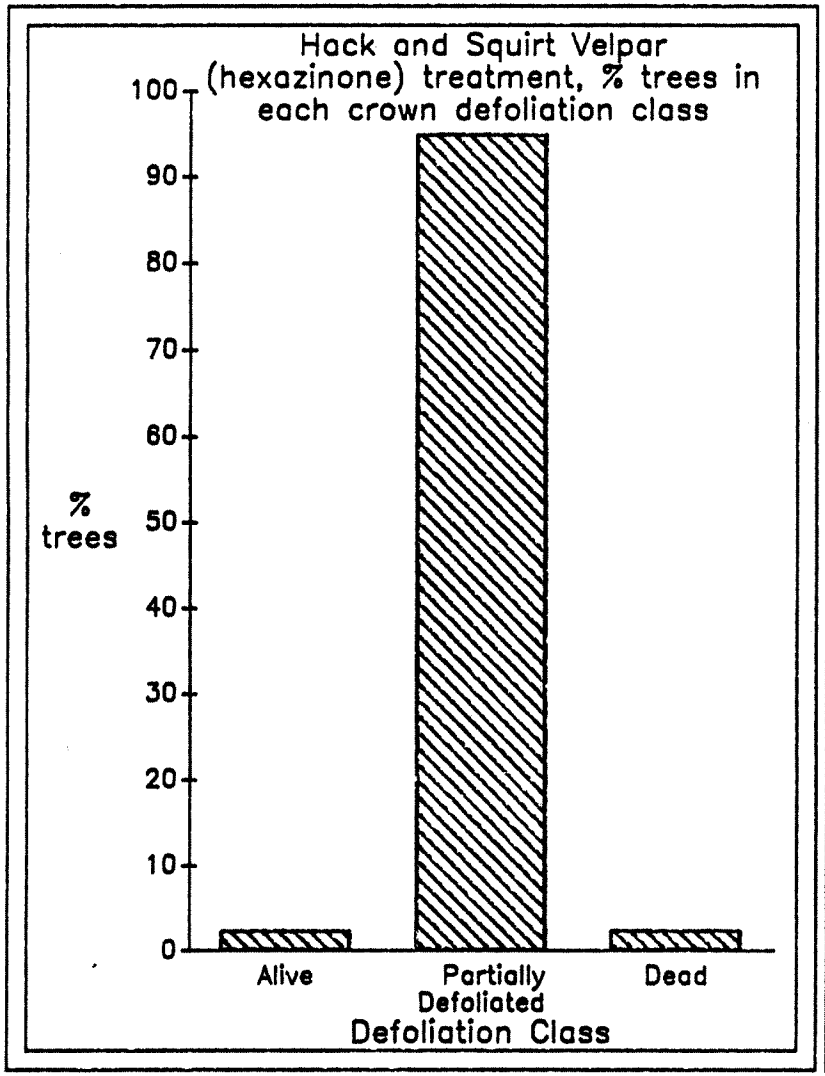


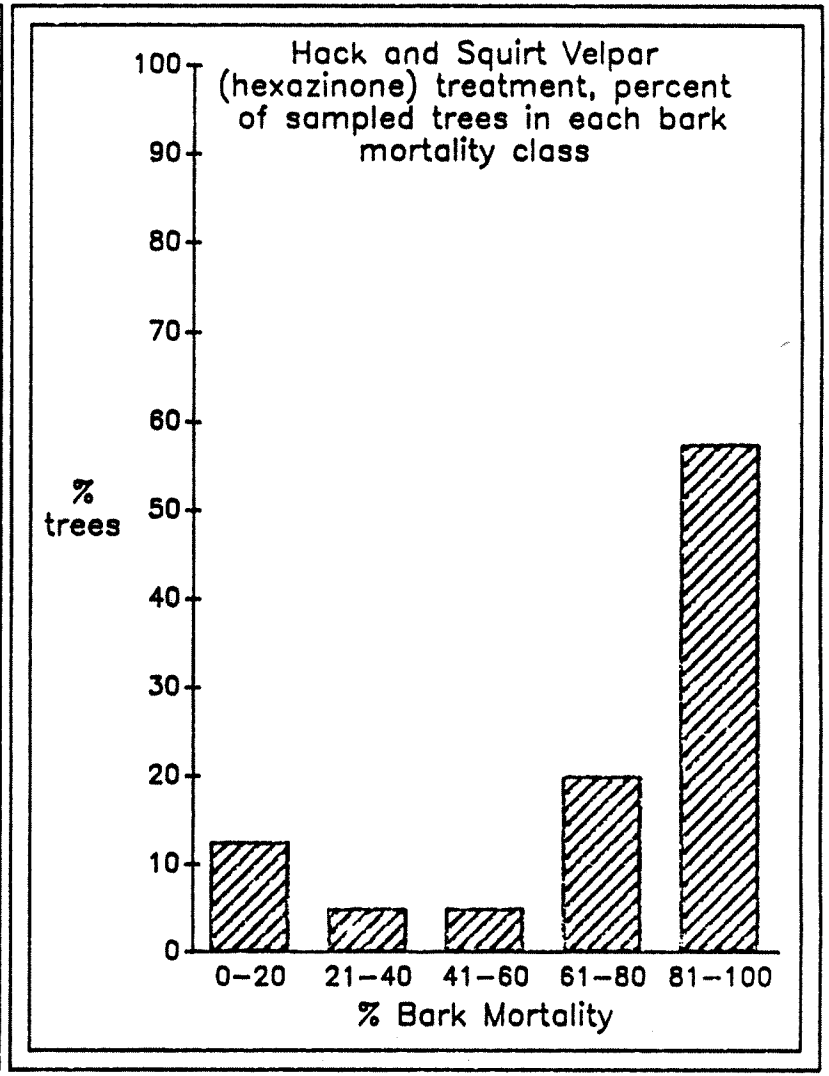
Satellite Trial C Hines Creek: Normal Hack and Squirt Formula 40 (2,4-D) treatment





Satellite Trial C Hines Creek: Hack and Squirt Velpar (hexazinone) treatment





Satellite Trial C Hines Creek: Double Hack and Squirt Formula 40 (2,4-D) treatment