HERBICIDE EFFICACY TRIALS IN ALBERTA AND MANITOBA, 1980-85

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ABSTRACT

Vegetation control trials in Alberta and Manitoba in 1980–85 tested nine herbicides to determine their capabilities for conifer release, chemical thinning, and site preparation. The herbicides tested were hexazinone in liquid, grid ball (10 and 20%), and granular (10 and 20%) formulations, metsulfuron methyl, fluazifop–butyl, bromacil, and fosamine ammonium. Data were obtained on conifer growth and tolerance to the herbicides, weed control, optimum timing of application, techniques, and equipment performance.

RESUME

Des essais visant à déterminer le potentiel d'utilisation de neuf herbicides pour le dégagement des conifères, l'éclaircie chimique et la préparation du terrain ont été effectués de 1980 à 1985 en Alberta et en Saskatchewan. Les herbicides étudiés sont l'hexazinone en préparation liquide, en granulés (10 et 20%) et sous forme de boules *grid ball* (10 et 20%), le metsulfuron–méthyl, le fluazifop–butyl, le bromacil et le fosamine–ammonium. Des données ont été obtenues sur la croissance et la tolérance des conifères exposés aux herbicides, l'élimination de la végétation indésirable, le moment optimal d'application, les techniques et l'efficacité de l'équipement.

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NOTE

This publication reports research involving herbicides. All herbicides must be handled and applied properly according to directions. All herbicides are registered by Agriculture Canada for experimental use and have provincial approval before they can be applied. The exclusion of certain manufactured products does not necessarily imply disapproval nor does the mention of other products necessarily imply endorsement by Forestry Canada.

INTRODUCTION

In the Canadian prairies, the Mixedwood Forest Section extends from southwestern Manitoba to northeastern British Columbia, occupying the southern portion of the Boreal Forest Region (Rowe 1972). Up to 245 km wide in central Saskatchewan, it is considerably wider in Alberta and significantly narrower in Manitoba. The characteristic forests on well-drained uplands are mixtures of trembling aspen (*Populus tremuloides* Michx.), balsam poplar (*Populus balsamifera* L.), white birch (*Betula papyrifera* Marsh.), white spruce (*Picea glauca* (Moench) Voss), and balsam fir (*Abies balsamea* (L.) Mill.). Jack pine (*Pinus banksiana* Lamb.) occurs on sandy sites and, as the land rises in west-central Alberta, gives way to lodgepole pine (*Pinus contorta* Dougl.). Black spruce (*Picea mariana* (Mill.) B.S.P.) and tamarack (*Larix laricina* (Du Roi) K. Koch) are found in wet areas.

One of the most acute regional silvicultural problems revolves around the need to successfully establish and bring softwoods (especially spruce) to a free-to-grow state on mixedwood sites. Herbicides provide a possible tool for reducing brush and grass competition in plantations. They can be applied using variations of six basic techniques: 1) aerial liquid sprays applied with a standard boom or microfoil, 2) aerial granular application with sling buckets or fixed-wing venturi systems, 3) mist from backpack sprayers or tanks on motorized units such as trucks, 4) the hack and squirt method in which a small amount of herbicide is injected into or squirted onto a cut on the weed tree, 5) the spot gun method, which is an exact delivery application used on a grid system or at the base of trees, and 6) ground application of granular formulations using manual or motorized equipment.

Forestry Canada (formerly the Canadian Forestry Service) has been involved in testing various pesticides since 1960. In 1980, the Northern Forestry Centre defined objectives for the chemical control of vegetation in managed forests. The section then conducting efficacy trials on pesticides was assigned to assess needs in herbicide research and development and to conduct efficacy trials to provide data for the registration of candidate chemicals. In 1980 Forestry Canada had a priority list of chemicals showing good potential for forestry use put forward by the Forest Pest Management Institute in Sault Ste. Marie, Ontario. These were Roundup, Krenite, Garlon, Velpar L, and Pronone 10G and two registered products, 2,4-D and 2,4,5-T. The status of Roundup (glyphosate), Krenite (fosamine ammonium), Velpar L (hexazinone), and 2,4,5-T has since changed. Roundup is fully registered, Krenite is promoted only for rights-of-way, Velpar L is registered for woodland use (less than 500 ha and ground application only), and 2,4,5-T is no longer being sold. A current summary of these and other chemicals with potential for forestry use is shown in Table 1.

In 1984, growing interest in forest vegetation management created a need for research on a wide range of vegetation control systems and techniques. To ensure quality and cost effectiveness of research information, the development of a guideline for experimentation was developed by the Research Branch of the B.C. Ministry of Forests (BCMF)[1]. A two-level (A and B) experimental design protocol was developed. The level A, or screening trial, protocol defines minimum standards for vegetation control trials. Screening trials monitor short-term crop tree response and treatment efficacy for a minimum number of target species. Level A methodology identifies the most promising treatments from a large group; these treatments can then be studied in more detail. The more-comprehensive level B protocols document short- and long-term responses of crop trees and target species as well as shifts in community vegetation. Both level A and level B protocols have common design and assessment conventions, so that data from both are compatible and complementary.

The Silviculture Group of the Expert Committee on Weeds (ECW), Western Canada, has adopted these protocols from the BCMF for vegetation management studies (Table 2). Starting in 1984, these protocols were used in the Northern Forestry Centre field trials in Alberta at Faust (Strawberry Creek), Grande Prairie (Economy Tower Supplemental Area), and Calling Lake. Only the Calling Lake trial will be remeasured in the 5-year assessment plan for 1989.

The Northern Forestry Centre herbicide field trials during 1980-85 are discussed in the following sections and are summarized in Appendixes 1 and 2. These trials deal primarily with hexazinone in liquid (Velpar L), grid ball (Velpar Gridballs), and granular (Velpar 20% and Pronone 10G) formulations. Velpar L (240 g/L) is a Dupont formulation. Velpar Gridballs (10% and 20% hexazinone) and granules (20% hexazinone) are discontinued Dupont formulations. Pronone 10G (10%), a Pro-Serve Inc. (Pfizer is the Canadian distributor) formu-

[1] Herring, J.; Pollack, J.C. 1985. Experimental design protocol for forest vegetation. Management research: level B trials and level A trials. B.C. Ministry of Forests, Forest Service, Victoria, B.C. Unpublished report.

Table 1. Herbicides showing potential for use in forestry

Trade name	Form[a]	Common name	Manufacturer/ distributor	Potential for use
Ally	SG	Metsulfuron methyl	Dupont	Brush, broadleaf weeds
Antor 4ES	L	Diethatyl ethyl	Hercules	Grass, broadleaf weeds
Banvel	L	Dicamba	Sandoz Agro	Annual broadleaf weeds, brush
Devrinol	L	Napropamide	Stauffer	Grass, annual broadleaf weeds
Dowpan	L	Dalapon	Dow	Annual and perennial grasses
Dycleer	L	Dicamba	Sandoz Agro	Grass, brush
Esteron 600	L	2,4-D (ester)	Dow	Brush, broadleaf weeds
Formula 40F	L	2,4-D (amine)	Dow	Brush, broadleaf weeds
Fusilade	L	Fluazifop-butyl	Chipman	Brush, broadleaf weeds
Gesagard 80W	L	Prometryne	Ciba-Geigy	Grass, annual broadleaf weeds
Goal	L	Oxyfluorfen	Rohm and Haas	Grass, annual broadleaf weeds
Herbec 20P	SG	Tebuthiuron	Elanco	Brush control
Hoe	L	Linuron	Hoechst	Grass, annual broadleaf weeds
Hyvar-XL	L	Bromacil	Dupont	Grass, broadleaf weeds
Poast	L	Sethoxydim	BASF	Annual grass, quack grass
Pronone 10G	G	Hexazinone	Pro-Serve/Pfizer	Selective brush, grasses, broadleaf weeds
Primatol Nine-O	SG	Atrazine	Ciba-Geigy	Grass, broadleaf weeds
Princep Nine-T	SG	Simazine	Ciba-Geigy	Grass, broadleaf weeds
Spike 5G	SG	Tebuthiuron	Elanco	Brush, grass, broadleaf weeds
Spike 80W	WP	Tebuthiuron	Elanco	Brush, grass, broadleaf weeds
Garlon 4	L	Trichlopyr	Dow	Brush, broadleaf weeds
Velpar L	L	Hexazinone	Dupont	Selective brush, grasses, broadleaf weeds
Velpar Gridballs	GB	Hexazinone	Dupont	Selective brush, grass, broadleaf weeds
Vision (Roundup)	L	Glyphosate	Monsanto	Brush, grass, broadleaf weeds
Oust	SG	Sulfomethuron methyl	Dupont	Grass, broadleaf weeds

[a] G = granular, L = liquid, WP = wettable powder, E = ester, SG = soluble granule, GB = grid ball.

lation, is similar in shape to granular hexazinone, although its manufacturing process is quite different. Hexazinone is a relatively persistent, soil-active herbicide that enters the plant primarily through the root system and inhibits photosynthesis. It appears to have potential for both site preparation and conifer release.

Unless otherwise stated, the general methodology for assessment included a) identifying 10–15 crop trees for yearly growth measurements and herbicide tolerance (control and replicated treated plots); b) rating weed control on a scale of 0–9 as per the rating scale established by the ECW Western Canada Section (Table 2) and rating crop tolerance as good (7–9), fair (4–6), poor (1–3), and 100% mortality (0) (Table 3); c) establishing plots at 0.04 ha (1/10 acre); and d) specifying all dosages in active ingredients.

Table 2. Minimum standards protocol (level A) established by the Expert Committee on Weeds, Western Canada Section, for vegetation control screening trials and a description of western (BCMF)[a] and eastern (OMNR)[b] policies

Importance[c]	Element	Western	Eastern
M	Replication control	– 3 replications/site – 1 control/replication	– 1 replication/site – Less than 1 control/replication acceptable if site is uniform
F, PFR	Treatment plot size	– 2 ha for aerial – 0.2 ha for ground – 20 m^2 for small scale – Rate or timing trials will vary (PFR)	– 2 ha for aerial/helicopter – 4 ha for control area of at least 5/6 swaths – 0.2 ha for ground
F	Buffer widths	– Variable	– Variable
PFR, M	Number of subplots within treatment plots	– 20 circular subplots in a 4 × 4 grid (40 × 50 m total area)	– 20 4-m^2 (2 × 2 m) quadrats in a 0.2 ha plot (in two clusters)
M, F	Assessment dates	– Baseline, 1, 2, 3, and 5 (optional) growing seasons	– Baseline, 1, 2, 3, and 5 (optional) growing seasons
M, F	Herbaceous weed assessment	– Percent cover, average height, condition (flexible—up to individual)	– Percent cover or number of stems, average height, condition by height class (flexible—up to individual)
M, F	Woody weed assessment	– Tag, percent cover, height, condition	– Number of stems, average height condition by height class
M, F	Crop seedling/ sapling assessment	– Diameter, height, leader increments, condition	– Diameter, height, leader increments, conditions
M, F	Sample/plot size	– Minimum number of crop seedlings—20 – Herbaceous stems—variable – Deciduous stems—not less than number of herbaceous stems	– Crop seedlings—25 – Herbaceous stems—variable – Deciduous stems—variable
F	Permanent tagging	– Crop seedlings—yes – Herbaceous stems—no – Deciduous stems—no	– Crop seedlings—yes – Herbaceous stems—no – Deciduous stems—no
M	Assessment of overstory hardwoods	– Yes, N ≥ 20 (within plot)	– Yes, N ≥ 25 (within plot)
F	Statistical analysis	– Yes	– Variable

[a] British Columbia Ministry of Forests.
[b] Ontario Ministry of Natural Resources.
[c] M = mandatory, F = flexible, PFR = pending further research.

Table 3. Expert Committee on Weeds, Western Canada Section, 1986 rating scales for weed control and crop tolerance

Weed control		Crop tolerance	
9 Complete control	Commercially acceptable		9 Complete tolerance
8 Excellent control		Good	8 Possible effect
7 Good control			7 Slight effect
6 Fair control			6 Definite effect
5 Poor control		Fair	5 Severe effect
4 Moderate injury			4 Severe effect
3 Definite effect			3 Severe effect
2 Slight effect		Poor	2 Severe effect
1 Possible effect			1 Severe effect
0 No effect		100% mortality	0 Complete kill

RESULTS OF FIELD EFFICACY TRIALS

1980–85 Faust, Alberta, Reforestation Project

Unless otherwise mentioned, the trial sites were in a 1968 burn at Slave Lake, Alberta, in the Faust Reforestation Project (Sect. 34, 35, Tp. 72, Rng. 11, W5) (Fig. 1), which was scarified in 1969, planted with bare-root white spruce in 1969, and aerially seeded to white spruce in 1970–71. The soils are generally Orthic Gray Luvisols of clayey textures, with 3.0–12.0 cm of organic matter.

1980 Conifer Release with Hexazinone Grid Balls (Plots 1-4F, 2-5F, and 3-6F)

The area was heavily invaded by tall grasses, shrubs, and forbs. In the summer of 1980, three replicated 0.04-ha plots were hand treated with 2.0-cm^3 10% hexazinone grid balls (Velpar Gridballs) at 1.1, 2.2, and 3.3 kg/ha (July 1980 temperature 26°C, humidity 47%, and a trace of wind from the southwest). The herbicide was applied at 1.80, 1.30-, and 1.05-m grid spacings (Drouin 1981, 1982). Fifth-year assessments indicated good control at all rates, with the exception of willow control (Table 4). For the 3.3-kg/ha rate with 1.05-m grid plots, control was good on all herbaceous species as well as on aspen and birch with basal diameters of up to 5.0 cm. Some refoliation was noted, but leaf growth was stunted and erratic, and flushing was temporary. The timing for this treatment was poor, as white spruce growth was at a maximum; this resulted in higher mortality and chlorosis than would occur if the spruce were treated during dormancy. Streaking on slopes in the 3.3-kg/ha plots remained visible throughout the 5 years and caused some mortality among the white spruce. It should be noted, however, that the best growth of white spruce also occurred at the 3.3-kg/ha rate (Fig. 2).

1981 Conifer Release with Hexazinone Grid Balls (Plots 4F-1,2,3 and 5F-4,5,6)

The trial site was invaded by tall grasses, shrubs, and herbaceous weeds. In the spring of 1981, three 0.04-ha plots (4F-1,2,3) were hand treated with 0.5-cm^3 20% hexazinone grid balls (Velpar Gridballs) at 1.7, 3.4, and 5.6 kg/ha (April 1981 temperature 18°C, humidity 41%, and wind southwest to 9.6 km/h). The product was applied by hand at 1.05-, 0.75-, and 0.60-m

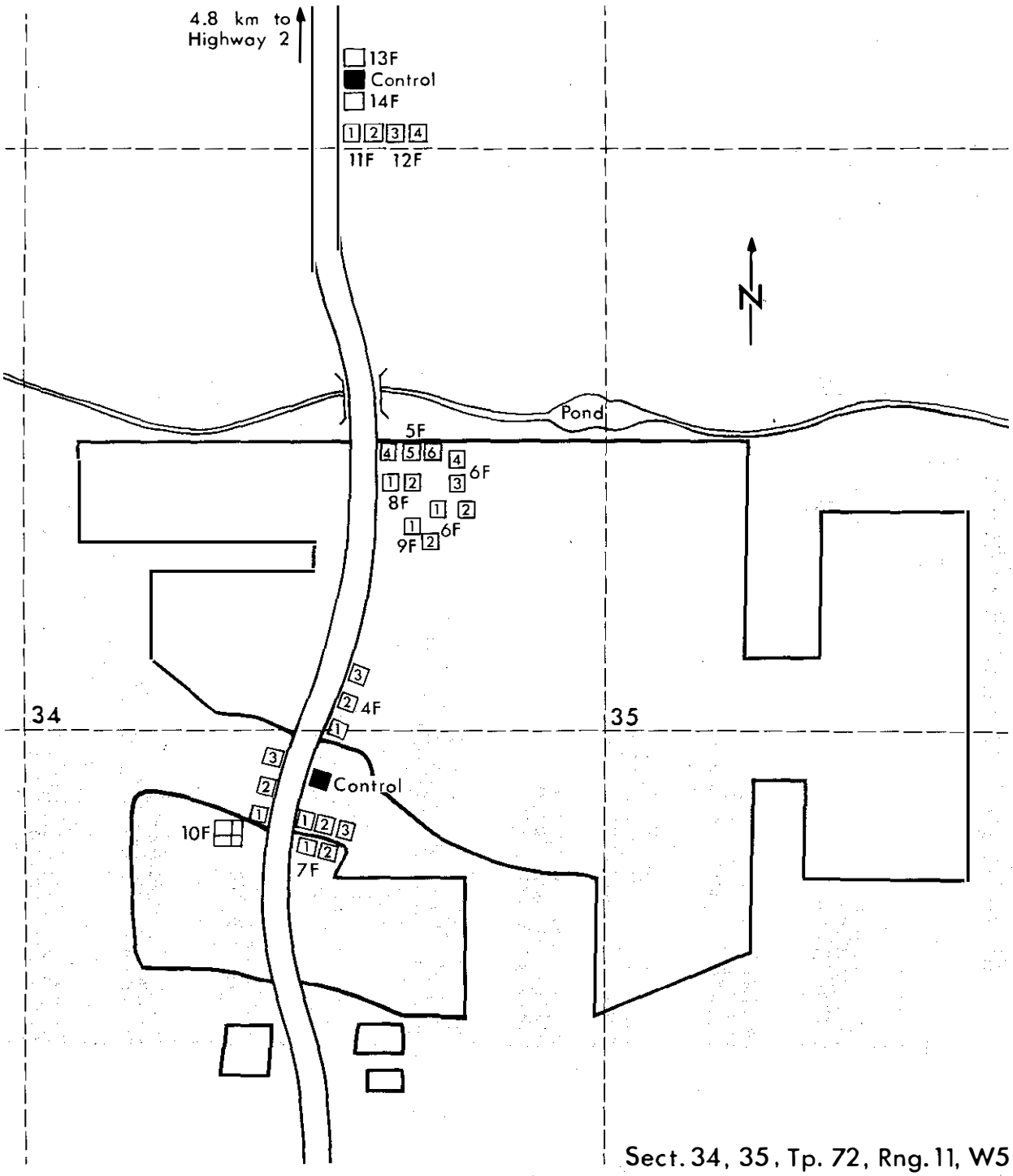

Figure 1. Conifer release plots in the Faust Reforestation Project near Slave Lake, Alberta, 1980–85.

Table 4. White spruce crop tolerance and weed control ratings in 1985 following summer 1980 application of 2.0-cm³ 10% hexazinone grid balls on plots 1-4F, 2-5F, and 3-6F near Faust, Alberta

Plot	Grid spacing (m)	Time	Rate (kg/ha)	White spruce crop tolerance	Control rating after 5 years[a]			
					Aspen/ balsam poplar	Birch	Shrubs[b]	Grasses
1-4F	1.80	Summer	1.1	Good	9	9	7	8
2-5F	1.30	Summer	2.2	Good	9	9	8	9
3-6F	1.05	Summer	3.3	Fair	9	9	9	9

[a] 0 = no control, 9 = complete control.
[b] Willow, cranberry, buffalo-berry, and dogwood.

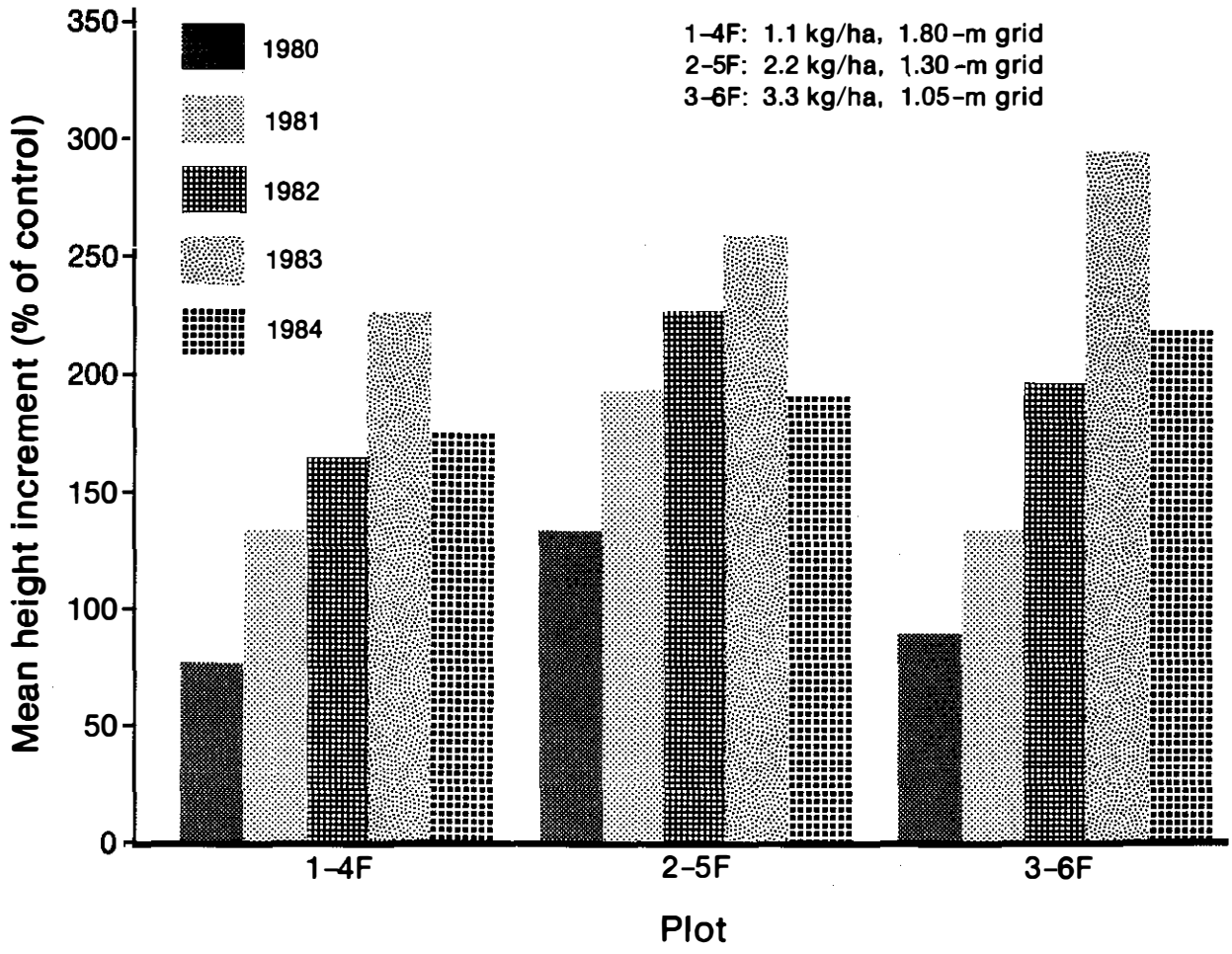

Figure 2. White spruce growth response to herbicide treatments near Faust, Alberta, showing 1980-84 mean height increment as a percentage of the control following summer 1980 application of 2.0-cm³ 10% hexazinone grid balls on plots 1-4F, 2-5F, and 3-6F.

grid spacings (Drouin 1981, 1982). Three more 0.04-ha plots (5F-4,5,6) were hand treated at the same rates with 0.5-cm³ 10% hexazinone grid balls at grid spacings of 0.51, 0.36, and 0.30 m. By the end of the first growing season poor weed control was evident with the 20% grid balls at 1.7 and 3.4 kg/ha (Table 5). The 5.6-kg/harate showed good control of all shrub species, aspen, and birch but also caused some streaking on slopes. There was no mortality among the white spruce, but chlorosis was evident in the lower third of some trees. Third- and fourth-year measurements showed poor control with both the 10% and 20% hexazinone grid balls at 1.7 kg/ha. At 3.4 kg/ha some birch and scattered 3.0-cm diameter tamarack died. At 5.6 kg/ha both strengths of grid balls showed good control of all shrubs and grasses, but streaking on slopes also occurred. Although chlorosis of white spruce was evident in the early years, these trees recovered well. The best growth of white spruce was with the 3.4-kg/ha rate and 0.36-m grid using 10% grid balls (Fig. 3).

1981 Conifer Release with Hexazinone Granules (Plots 6F-1,2,3,4)

A heavy invasion of grasses, sedges, forbs, and willow occurred in spots on this trial site. In the spring of 1981, two replicated 58-m² plots were treated with a cyclone seeder application of 20% hexazinone granules (Velpar) at 2.8 and 5.6 kg/ha (April 1981 temperature 18°C, humidity 40%, and wind southwest to 9.6 km/h) (Fig. 4). Good control was recorded during the first and second years at both dosages, although application at the lower rate appeared adequate (Table 6) (Drouin 1981, 1982). Other than scattered vetch, willow, and buffalo-berry, no vegetation remained in any of the plots. All grasses, sedges, balsam poplar, birch, and tamarack were eliminated, but there was less control on rose, willow, and alder. White spruce mortality was recorded in spots at the higher rate. Chlorosis of white spruce occurred, but recovery was quick. The best growth for the spruce was at the lower rate of 2.8 kg/ha (Fig. 5).

1981 Conifer Release with Hexazinone Granules (Plots 7F-11,12)

The trial site was heavily invaded with tall grasses, shrubs, and forbs. In the fall of 1981, two 0.04-ha plots were treated with 20% hexazinone granules (Velpar) at 2.8 and 5.6 kg/ha using a cyclone seeder (September 1981 temperature 15°C, humidity 68%, and wind northeast at 3.2-8.0 km/h). At the end of the first growing season all weeds were suppressed, although there was some temporary reflushing on willow (Table 7) (Drouin 1982). Effective defoliation of all grass species and balsam poplar occurred at both rates after 3 years. Willow and buffalo-berry were tolerant of the herbicide. There was no off-site movement in the treated plots, and borders were definite. Negligible white spruce mortality occurred. Similar to the spring application, growth response was best for the 2.8-kg/ha rate (Fig. 5). There appear to be only slight differences in the spring vs. fall applications using hexazinone granules if they are done at the optimum times. In spring, application is best after snowmelt or runoff and before the frost leaves the ground;

Table 5. White spruce crop tolerance and weed control ratings in 1985 following spring 1981 application of 0.5-cm³ 20% and 10% hexazinone grid balls on plots 4F-1,2,3 and 5F-4,5,6 near Faust, Alberta

Plot	Grid spacing (m)	Time	Rate (kg/ha)	White spruce crop tolerance	Control rating after 4 years[a]			
					Aspen/ balsam poplar	Birch	Shrubs[b]	Grasses
20% hexazinone								
4F-1	1.05	Spring	1.7	Good	5	9	7	6
4F-2	0.75	Spring	3.4	Good	5	9	7	6
4F-3	0.60	Spring	5.6	Fair	9	9	8	9
10% hexazinone								
5F-4	0.51	Spring	1.7	Good	4	9	8	6
5F-5	0.36	Spring	3.4	Good	6	9	8	6
5F-6	0.30	Spring	5.6	Fair	8	9	9	9

[a] 0 = no control, 9 = complete control.
[b] Willow, cranberry, buffalo-berry, and dogwood.

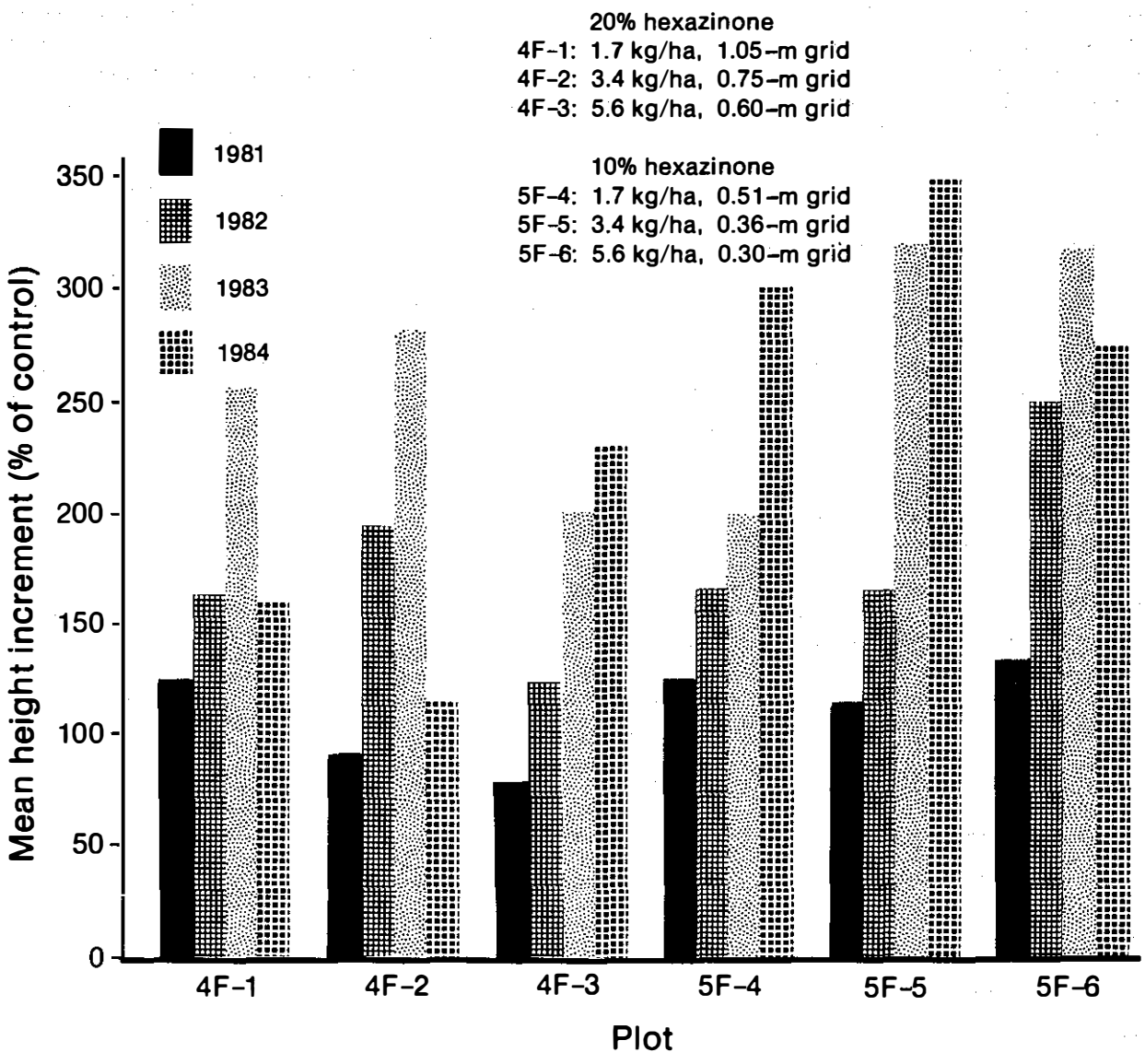

Figure 3. White spruce growth response to herbicide treatments near Faust, Alberta, showing 1981-84 mean height increment as a percentage of the control following spring 1981 application of 0.5-cm³ 20% hexazinone grid balls on plots 4F-1, 2,3 and 0.5-cm³ 10% hexazinone grid balls on plots 5F-4,5,6.

Figure 4. Spring 1981 application of 20% hexazinone granules near Faust, Alberta, with a cyclone seeder on white spruce heavily invaded by grasses and shrubs (plots 6F-1,2,3,4).

Table 6. White spruce crop tolerance and weed control ratings in 1983 following spring 1981 application of 20% hexazinone granules on plots 6F-1,2,3,4 near Faust, Alberta

Plot	Time	Rate (kg/ha)	White spruce crop tolerance	Control rating after 2 years[a]				
				Aspen/ balsam poplar	Birch	Willow	Tamarack	Grasses
6F-1,3	Spring	2.8	Good	7	7	7	5	9
6F-2,4	Spring	5.6	Fair	9	9	9	9	9

[a] 0 = no control, 9 = complete control.

Table 7. White spruce crop tolerance and weed control ratings in 1984 following fall 1981 application of 20% hexazinone granules on plots 7F-11,12 near Faust, Alberta

Plot	Time	Rate (kg/ha)	White spruce crop tolerance	Control rating after 3 years[a]			
				Aspen	Birch	Willow	Grasses
7F-11	Fall	2.8	Good	8	8	7	9
7F-12	Fall	5.6	Good	9	9	9	9

[a] 0 = no control, 9 = complete control.

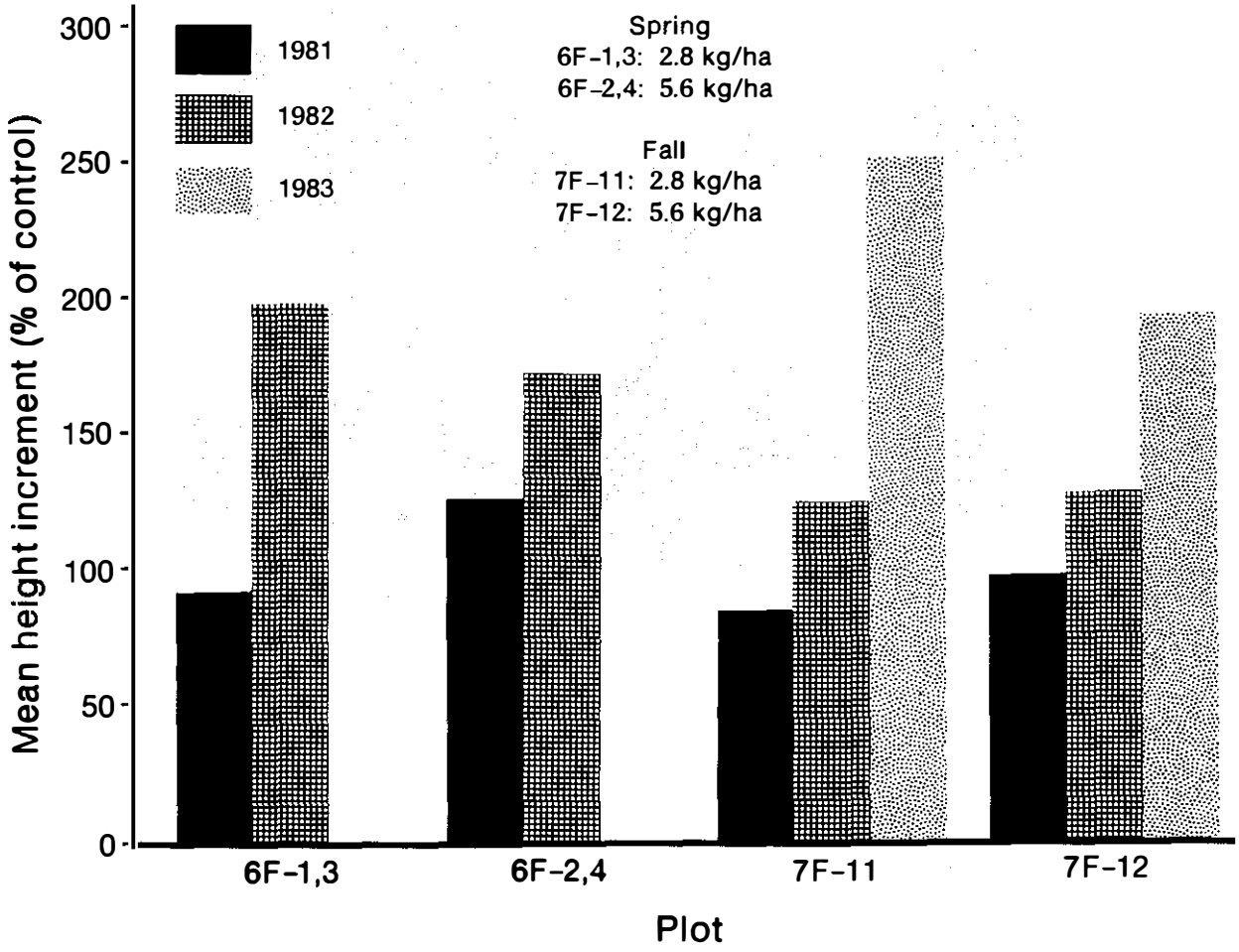

Figure 5. White spruce growth response to herbicide treatments near Faust, Alberta, showing 1981–83 mean height increment as a percentage of the control following spring 1981 application of 20% hexazinone granules on plots 6F-1,2,3,4 and fall 1981 application of 20% hexazinone granules on plots 7F-11,12.

fall application is best after there is frost and prior to snowfall.

1981 Conifer Release with Hexazinone Grid Balls (Plots 8F-13a,b)

At this trial site in the summer of 1981, two 0.04-ha plots were hand treated with 1.0-cm^3 20% hexazinone grid balls (Velpar Gridballs) at 2.2 and 4.4 kg/ha with 1.30- and 0.90-m grid spacings, respectively (July 1981 temperature 23°C, humidity 42%, and wind west at 3.2–8.0 km/h). Due to lack of rain and little moisture, the grid balls were found relatively intact at all the drop positions at the end of the first growing season. Defoliation did not occur in the grasses or shrubs. Because grid balls were no longer available in Canada and were being discontinued by the manufacturer, the plots were cancelled and further work discontinued.

1981 Conifer Release with Hexazinone Granules (Plot 9F-14)

The trial site was open and heavily invaded with marsh grasses, sedges, forbs, shrubs, and aspen saplings. In the spring of 1981, replicated 0.04-ha plots were treated with 20% hexazinone granules (Velpar) at 1.8 kg/ha using a cyclone seeder (April 1981 temperature 15°C, humidity 85%, and wind northwest to 8.0 km/h). At this light dosage, fair control was obtained in the first year. Grasses and forbs were suppressed, but willow and buffalo-berry showed little decline. Among the balsam poplar and birch, only those in the 102-cm height range

were affected to any extent. Noticeable growth occurred in the second year, but in the winter of the third year the plot areas were cleared by trappers setting up winter camps. The study was discontinued in the spring of 1983.

1982 Conifer Release with Spring, Summer, and Fall Applications of Metsulfuron Methyl (Plots 10F-15a,b,c)

The trial site had developed a medium to heavy cover of grasses, forbs, and shrubs. In the spring, summer, and fall of 1982 (temperatures 15°C, 21°C, and 15°C, humidities 60%, 42%, and 68%, respectively, and a trace of wind), 75% metsulfuron methyl (Ally), a water dispersible granular formulation, was applied on a split-plot design at 53, 188, and 375 g/ha using a Solo backpack sprayer at 240 kPa (Drouin 1983). The randomized subplots were replicated four times and were planted with 40-cm^3 Spencer-Lemaire container white spruce (14 cm mean height) at 1, 3, and 5 weeks after spraying in the spring and summer treatments. Similarly, 40-cm^3 Spencer-Lemaire container lodgepole pine (16 cm mean height) were planted after the summer and fall applications. After 2 years there were negligible differences among the 1-, 3-, and 5-week post-spray plantings. Control was very good for currant, buffalo-berry, rose, willow, birch, poplar, and cranberry (Table 8). The best results overall were with the fall application. Grasses, ferns, and horsetail showed little response. Many lodgepole pine seedlings died from chemical and high water table stress. Both natural and planted spruce suffered little damage, although some spruce yellowed from the spray treatments but regained color the following year. The spring-planted spruce showed some signs of planting shock, probably because the seedlings were actively growing when planted (Table 8). In the winter of 1983, white spruce timber permits were issued for the area, and the resulting skidder damage near the plot area and subsequent blow-down of overmature balsam poplar caused irreparable damage to the plot. The plot was abandoned in 1984.

1983 Conifer Release with Hexazinone Granules (Plots 11F-16 and 12F-17)

The species composition at the trial site was predominantly aspen, balsam poplar, birch, and willow with a range of 3-6 m in height. In the spring of 1983, replicated 0.04-ha plots were treated with 20% hexazinone granules (Velpar) using a cyclone seeder at 2.8 and 5.6 kg/ha (May 1983 temperature 7°C, humidity 57%, and winds west at 8.0-17.0 km/h). After 4 years, the lower dosage gave good control on aspen and poplar up to 8 cm diameter, releasing the spruce and opening the canopy (Drouin 1983). At the higher dosage, herbaceous weed control was somewhat better, but the double rate was not justified. No off-site or lateral movement was recorded, and treated plots showed definite boundaries. Negligible mortality occurred on the white spruce, and those showing initial chlorosis regained their color in succeeding years (Table 9). White spruce growth was slightly better with the higher rate of 5.6 kg/ha (Fig. 6).

1983 Conifer Release with Fluazifop-butyl (Plot 13F-18)

The weed species at the trial site comprised aspen, balsam poplar, birch, and willow ranging from 3 to 6 m in height. A spring 1983 application (May 1983 temperature 7°C, humidity 57%, and a trace of wind) on a

Table 8. White spruce and jack pine crop tolerances and weed control ratings in 1984 following spring, summer, and fall 1982 application of 75% metsulfuron methyl liquid on plots 10F-15a,b,c near Faust, Alberta

Plot	Time	Rate (kg/ha)	Crop tolerance		Control rating after 2 years[a]			
			White spruce	Jack pine	Aspen/ balsam poplar	Birch	Shrubs[b]	Grasses
10F-15a	Spring	53	Fair	Poor	6	5	9	0
10F-15b	Summer	188	Good	Poor	8	8	8	0
10F-15c	Fall	375	Good	Poor	9	9	9	0

[a] 0 = no control, 9 = complete control.
[b] Raspberry, buffalo-berry, rose, and cranberry.

Table 9. White spruce crop tolerance and weed control ratings in 1985 following spring 1983 application of 20% hexazinone granules on plots 11F-16 and 12F-17 near Faust, Alberta

Plot	Time	Rate (kg/ha)	White spruce crop tolerance	Control rating after 4 years[a]				
				Aspen/ balsam poplar	Birch	Willow	Shrubs[b]	Grasses
11F-16	Spring	2.8	Good	8	8	8	6	9
12F-17	Spring	5.6	Good	9	9	9	8	9

[a] 0 = no control, 9 = complete control.
[b] Rose, currant, saskatoon, cranberry, and dogwood.

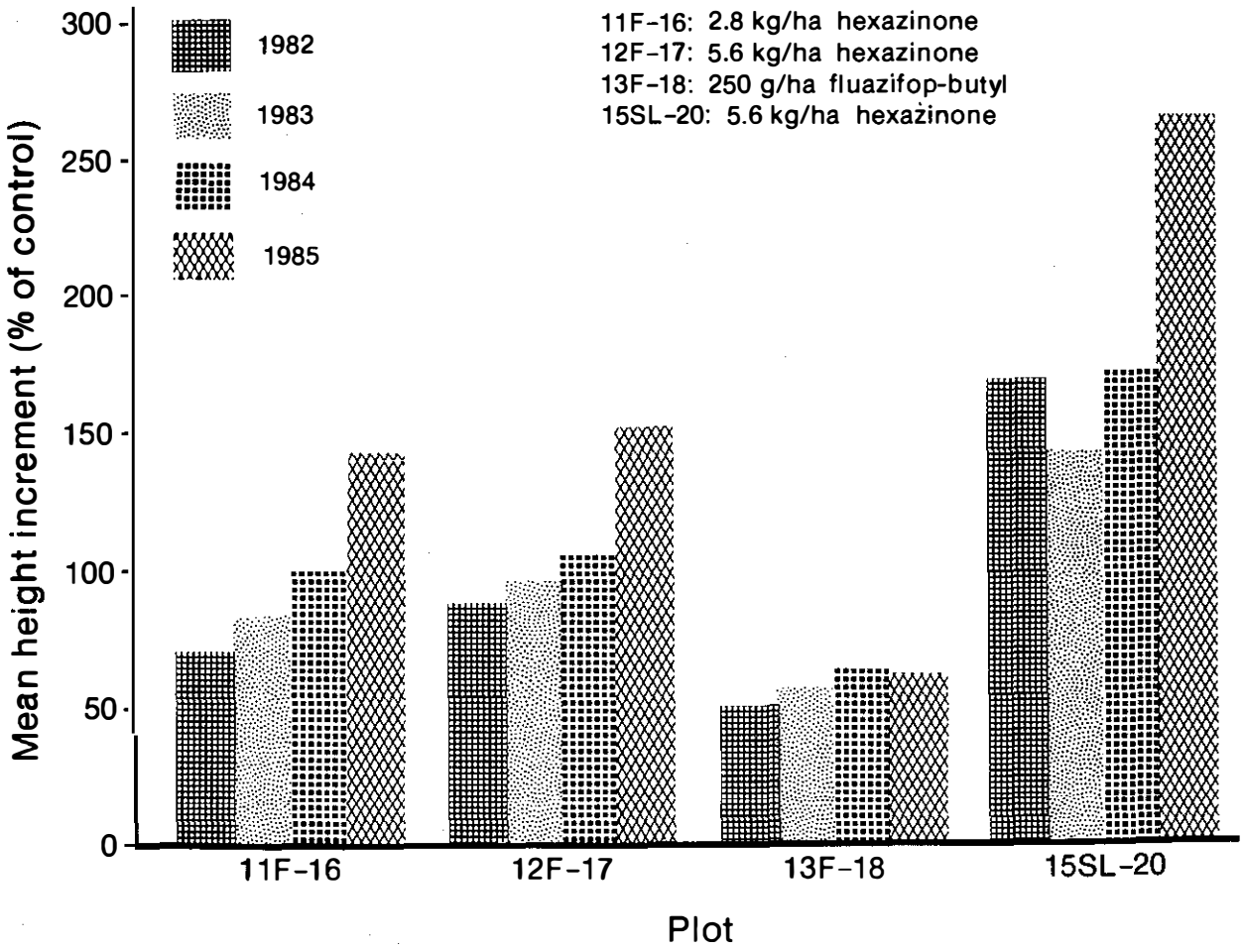

Figure 6. White spruce growth response to herbicide treatments near Faust, Alberta, showing 1982-85 mean height increment as a percentage of the control following spring 1982 application of 20% hexazinone granules on plots 11F-16, 12F-17, and 15SL-20 and 25% fluazifop-butyl on plot 13F-18.

0.02-ha plot with 250 g/ha of 25% fluazifop-butyl (Fusilade) emulsifiable concentrate (1% wetting solution of AGRAL 90) using a backpack sprayer at 240 kPa pressure gave marginal control after one growing season. There was discoloration on some plant species (Drouin 1983), although crop tolerance was good. Subsequent assessment in 1984 showed no further control, and some species previously showing chlorosis had recovered. Higher rates of application with Fusilade should be tested in the future (Fig. 6).

1983 Conifer Release with Metsulfuron Methyl (Plot 14F-19)

Metsulfuron methyl (Ally) was applied in the spring of 1983 on a 0.04-ha plot at a rate of 375 g/ha using a Solo backpack pump pressurized at 240 kPa (May 1983 temperature 51°C, humidity 54%, and wind west at 5.0–11.0 km/h). Weed species comprised aspen, balsam poplar, birch, and willow (3–6 m in height). First-year assessments showed increasing mortality of the white spruce, dead and dying buds or shoots, and increasing chlorosis. The second-year assessment showed all 15 crop trees to be dead. Good control was noted on all herbaceous plants but not on grasses or fireweed. Further tests indicate a better dosage on the clay-loam soil in this region to be 120 g/ha.

1983 Conifer Release with Hexazinone Granules (Plot 15SL-20)

The trial site is south of Slave Lake (Sect. 25, Tp. 71, Rng. 6, W5). Scarification was undertaken in 1969–70; white spruce bare-root seedlings were planted in 1969. The weed species comprised aspen, balsam poplar, birch, and willow (3–6 m in height). To test off-site movement from 0.04-ha plot boundaries near Florida Lake, 5.6 kg/ha of 20% hexazinone granules (Velpar) was applied with a cyclone seeder on a 12% slope (May 1983 temperature 15°C, humidity 65%, and a trace of wind) (Drouin 1983). Effective defoliation of both overstory and understory species including grasses resulted (Table 10). No evidence of off-site movement by the compound was noted on the lower slope. The white spruce grew well and recovered quickly from chlorotic effects (Fig. 6).

1984 Conifer Release with Hexazinone Liquid by Spot Gun Application (Plots 25F-SCa,b)

The trial site is located south of the Faust Reforestation Project (Sect. 14, Tp. 72, Rng. 11, W5) at Strawberry Creek. The site supported an overstory of 16-year-old aspen, balsam poplar, and birch and an understory of aspen, balsam poplar, birch, willow, cranberry, rose, and currant as well as white spruce ranging from 32.0 cm to 1.8 m in height. In the spring of 1984, two replicated 0.1-ha plots were treated with undiluted (240 g/L) hexazinone liquid (Velpar L) using a spot gun to apply 4 mL per 5.0-cm stem diameter at a 2.0-m grid spacing (2.4 kg/ha) and 8 mL per 5.0-cm stem diameter at a 1.5-m grid spacing (8.6 kg/ha) (June 1984 temperature 20°C, humidity 59%, and wind northwest at 8.0–13.0 km/h). Assessment of percentage defoliation on 30 overstory tagged deciduous trees, 28 understory trees and shrubs, and 80 white spruce was carried out in the fall for 3 successive years. All tagged species were assessed for percentage control on each of 20 5-m^2 assessment subplots (Table 11). While both rates were effective, the 4 mL per 5.0-cm stem diameter treatment was superior, exhibiting good "window" openings in both the overstory and understory, minimal spruce mortality or chlorosis, and best growth.

1980–81 Edson, Alberta

The trial site is located 31.7 km south of Edson, Alberta, on the Hudson Bay Gas Co. road in an old burn

Table 10. White spruce crop tolerance and weed control ratings in 1985 following spring 1983 application of 20% hexazinone granules on a 12% slope on plot 15SL-20 near Slave Lake, Alberta

Plot	Time	Rate (kg/ha)	White spruce crop tolerance	Control rating after 4 years[a]					
				Aspen/ balsam poplar	Birch	Willow	Alder	Shrubs[b]	Grasses
15SL–20	Spring	5.6	Good	9	9	9	9	9	9

[a] 0 = no control, 9 = complete control.

[b] Rose, currant, saskatoon, cranberry, and dogwood.

Table 11. White spruce crop tolerance and weed control ratings in 1985 following spring 1984 spot gun application of hexazinone liquid at 4 and 8 mL per 5.0-cm stem diameter on plots 25F-SCa,b near Faust, Alberta

Plot	Grid spacing (m)	Time	Rate (kg/ha)	White spruce crop tolerance	Control rating after 3 years[a]					
					Overstory		Understory			
					Aspen/ balsam poplar	Birch	Aspen/ balsam poplar	Birch	Willow	Shrubs[b]
4 mL/(5.0 cm)										
25F-SCa	2.0	Spring	2.4	Good	8	8	9	8	6	4
8 mL/(5.0 cm)										
25F-SCb	1.5	Spring	8.6	Poor	9	9	9	9	9	9

[a] 0 = no control, 9 = complete control.
[b] Cranberry and currant.

(Sect. 33, Tp. 50, Rng. 17, W5) (Fig. 7). The soils are generally Eluviated Dystric and Eutric Brunisols of sandy textures with 2.0-12.0 cm of organic matter.

1980 and 1981 Chemical Thinning of Lodgepole Pine with Bromacil by Spot Gun Application (Plots 1,2,4,5)

A dense 20-year-old lodgepole pine stand required thinning. In the summers of 1980 and 1981, replicated 0.04-ha plots were treated with bromacil (Hyvar-XL) on a 1.8-m grid pattern using a spot gun to apply 8.0 mL per 5.0-cm stem diameter (5.9 kg/ha) to plots 1 and 2 (August 1980 temperature 17°C, humidity 37%, and a trace of wind) and 4.0 mL per 2.5-cm stem diameter (3.0 kg/ha) to plots 4 and 5 (July 1981 temperature 23°C, humidity 40%, and a trace of wind). Assessments after two growing seasons (Drouin 1981, 1982) showed the 5.9-kg/ha dosage to be more than adequate, as two to three trees nearest the basal spot-treated trees also died. The willow clumps sprayed within the plots were alive but chlorotic and showed reduced foliage. With the 3.0-kg/ha rate not all treated trees died. Large hare populations in 1980 caused severe damage in the vicinity of the plots. In the early spring of 1981, hares were attracted to the bromacil-treated trees by some residual product from the spray. The vegetation and organic matter at the base of the sprayed trees were eaten down to mineral soil. The chemical appeared to be nontoxic, since no dead hares were found in the plot areas. Only light feedings occurred later in 1981. Heavy *Cronartium* gall rust attack was recorded in the plots. The 4.0 mL per 2.5-cm stem diameter rate had much less pine mortality than the 8.0 mL per 5.0-cm stem diameter rate. Better results should be obtained by reducing the spacing to a 1.0-m grid at the 4.0-mL rate.

1980-85 Grande Prairie, Alberta

Trial sites are located south of Grande Prairie, Alberta, in the Economy Tower Supplemental Area (Sect. 29, Tp. 65, Rng. 2, W6) (Fig. 8). The area was scarified in 1973-75 and seeded with lodgepole pine or planted with white spruce in 1975. The soils are generally Orthic Gray Luvisols of clay loam textures, with 5.0-12.0 cm of organic matter.

1980 and 1981 Conifer Release with Hexazinone Liquid (Plots GP1-1,2, GP2-1,2, GP3-1,2, GP4-1, GP5-2, and GP6-3)

The trial site was heavily invaded by tall grasses, forbs, and brush (Fig. 9). In the fall of 1980, three replicated 0.02-ha plots (GP1-1,2, GP2-1,2, and GP3-1,2) were sprayed with undiluted (240 g/L) hexazinone liquid (Velpar L) using a Solo backpack sprayer at rates of 0.9, 1.3, and 1.8 kg/ha (October 1980 temperature 20°C, humidity 40%, and wind west at 12.0-20.0 km/h). Several light frosts had occurred in the area prior to treatment, and the foliage had yellowed. In the spring of the next year, identical plots (GP4-1, GP5-2, and GP6-3) were established and treated in the same general area (Drouin 1981) (April 1981 temperature 9°C, humidity 63%, and wind southwest at 5.0 km/h). Visual assessment in July indicated that the fall application had caused less mortality to white spruce than the spring application. The fourth-year assessment in

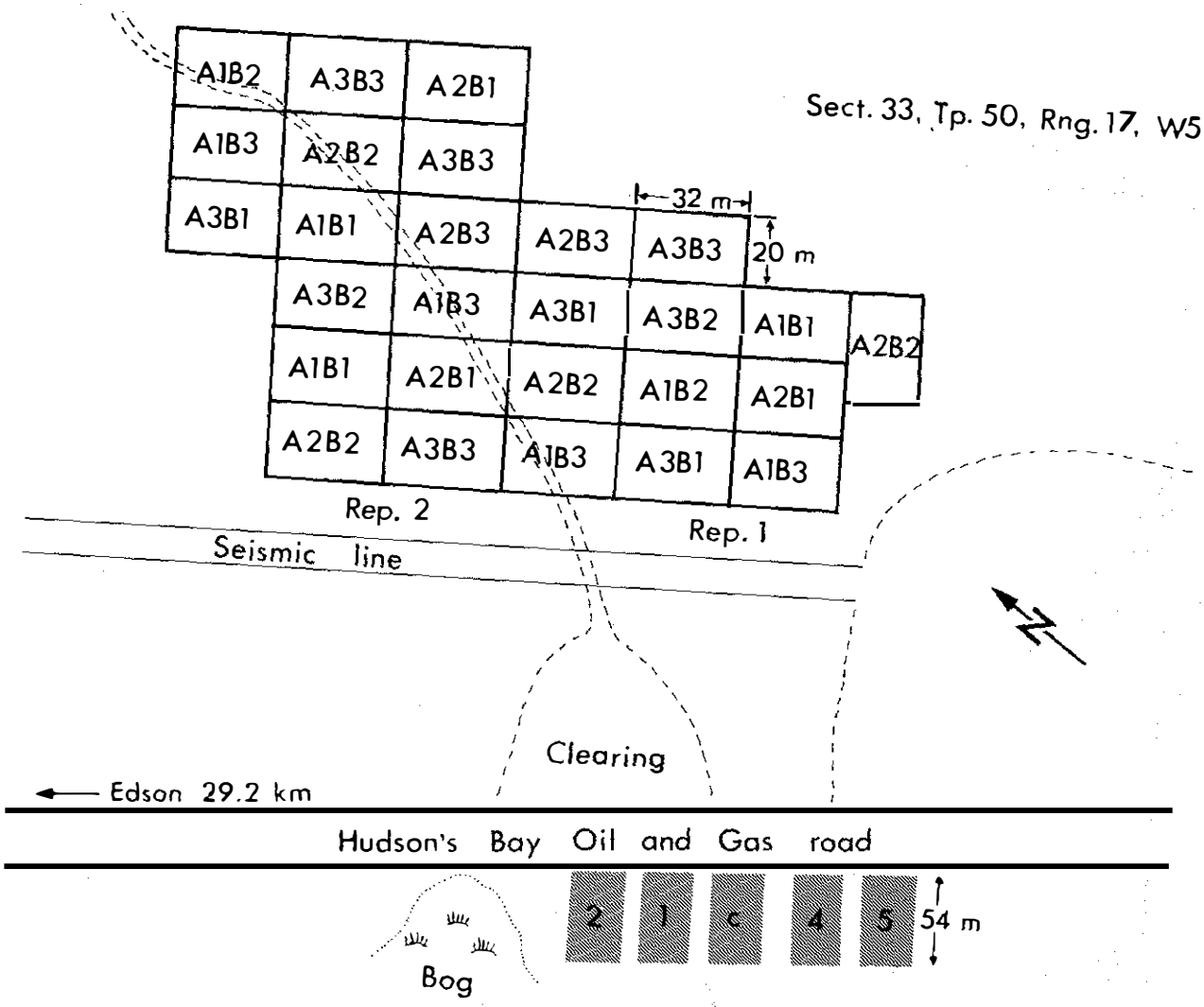

Figure 7. Chemical thinning plots near Edson, Alberta, 1980-81.

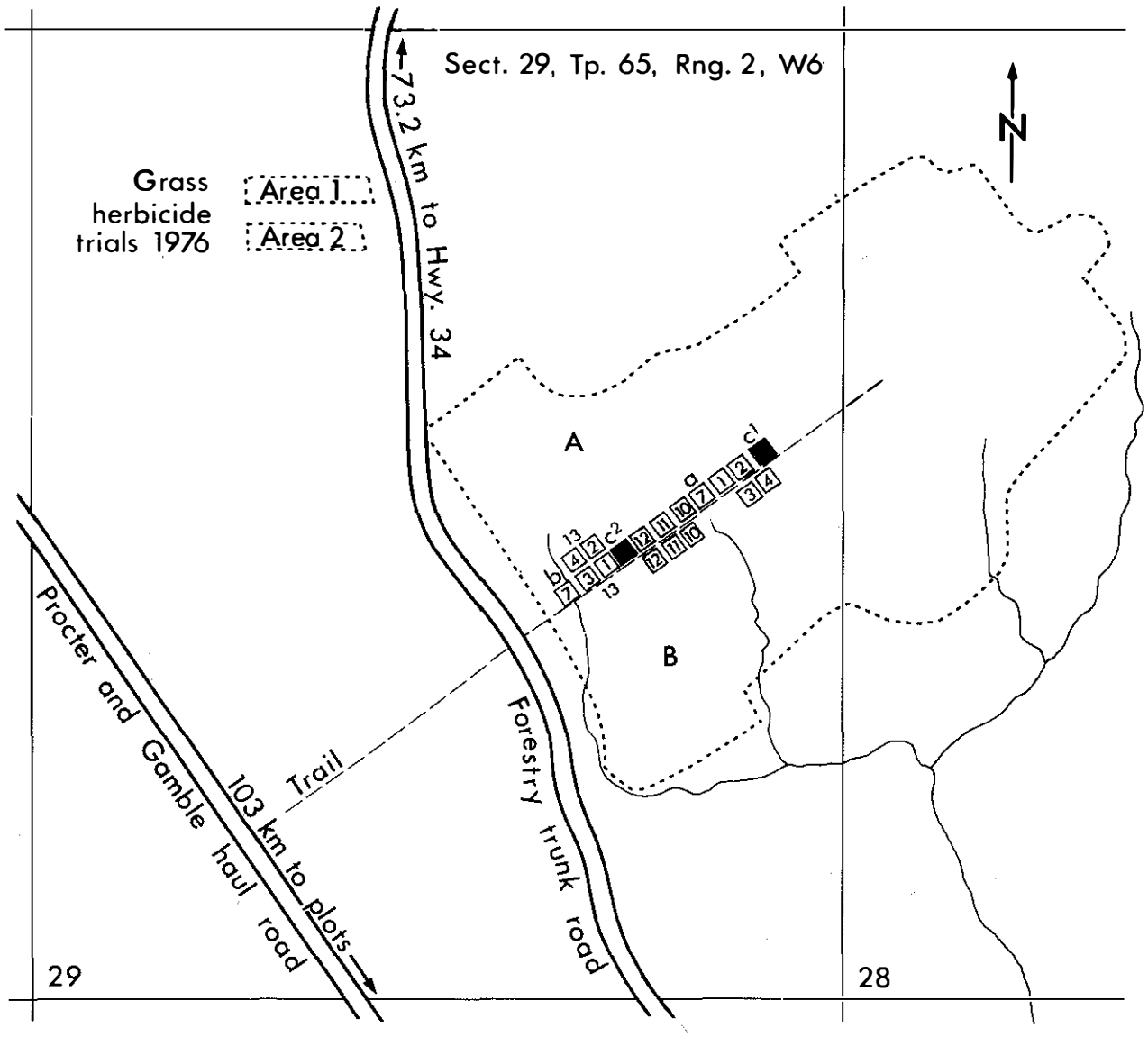

Figure 8. Conifer release plots in the Economy Tower Supplemental area near Grande Prairie, Alberta, 1981-85.

Figure 9. One year after ground spray application of hexazinone liquid at the Economy Tower Supplemental Area plots near Grande Prairie, Alberta, showing survival of white spruce and control of grasses and shrubs.

GP1-1,2, GP2-1,2, and GP3-1,2 showed the 0.9-kg/ha rate to have poor control on grasses, forbs, and shrubs. Sprayed areas were difficult to locate. At rates of 1.3 and 1.8 kg/ha, control was poor to fair, but mortality or chlorosis of white spruce increased with dosage. The spring application at the three dosages caused 40–70% mortality of white spruce. Among the spruce that lived after 4 years, growth was best with the fall application (Fig. 10).

Assessment of these plots was discontinued in 1983, because hare infestations and resulting damage to crop trees gave undependable data.

1981 Conifer Release with Bromacil (Plot GP7)

The trial site was heavily invaded by alder, balsam poplar, willow, trembling aspen, herbaceous weeds, and grasses. The crop tree was lodgepole pine. In the summer of 1981, two 0.04-ha replicated plots were treated with bromacil (240 g/L) (Hyvar-XL) applied at a rate of 4.0 mL per 5.0-cm stem diameter (2.4 kg/ha) using a spot gun (Drouin 1981, 1982) (July 1981 temperature 16°C, humidity 27%, and wind northwest at 3.2–10.0 km/h). Assessment carried out in late August at the end of the first growing season showed good control. Among the alders, balsam poplar, and trembling aspen there was no refoliation with green stems. Willows were more resistant, having sprouting from stems or root collars but no refoliation.

1981 Conifer Release with Hexazinone Granules and Fosamine Ammonium (Plots GP8 and GP9)

The trial site supported scattered aspen, balsam poplar, and birch regeneration (2.5–3.0 m in height), with willow and alder rapidly taking over the area. Crop trees were lodgepole pine and white spruce. Fall 1981 treatments were made of 20% hexazinone granules (Velpar) applied to plot GP8 with a cyclone seeder at a rate of 2.8 kg/ha and offosamine ammonium (Krenite L) applied to plot GP9 as a spray solution from a Solo backpack sprayer at a rate of 1.4 kg/ha (September 1981 temperature 15°C, humidity 48%, and wind northwest at 3.0–8.0 km/h). In these two 0.04-ha plots, fosamine ammonium provided no measureable control over the target weed complex. The hexazinone granular application at the end of the first growing season showed good control of grasses, forbs, balsam poplar, and birch but had little effect on willow and alder. The area is sloped to the west, and there was no evidence of off-site movement by the compound. No mortality was recorded in either crop species. Large populations of hares in the winter of 1981–82 caused severe clipping damage to the

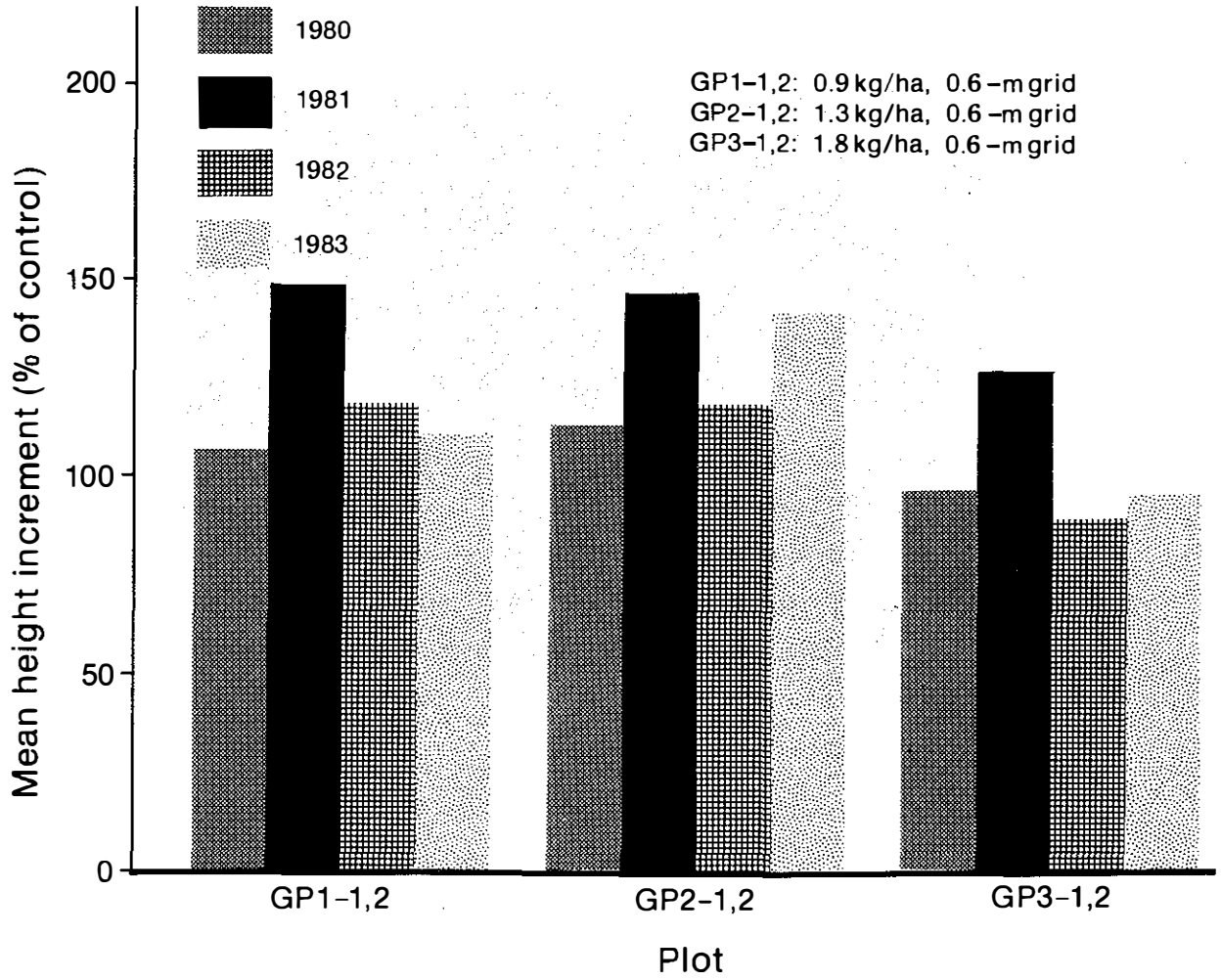

Figure 10. White spruce growth response to herbicide treatments near Grande Prairie, Alberta, showing 1980–83 mean height increment as a percentage of the control following fall 1980 application of hexazinone liquid on plots GP1–1,2, GP2–1,2, and GP3–1,2.

small pine and spruce and girdling to the larger pine. The plots were abandoned in 1982 because of this.

1981 Conifer Release with Hexazinone Liquid (Plots GP10 and GP11)

Aspen, balsam poplar, and birch regeneration (3 m in height) occupied the trial site along with scattered willow, alder, buffalo-berry, and raspberry canes spreading rapidly throughout. In the spring of 1981, replicated 0.04-ha plots were treated with undiluted (240 g/L) hexazinone liquid (Velpar L) at rates of 2.2 and 3.2 kg/ha (May 1981 temperature 15°C, humidity 48%, and a trace of wind). The chemical was applied with a Solo backpack sprayer at 240 kPa pressure over the top of 15 tagged white spruce in a 0.6-m radius circle. Both the 2.2- and the 3.2-kg/ha rates were effective in controlling grasses, rose, raspberry, buffalo-berry, poplar, birch, willow, and alder within the sprayed circles. Spraying over the white spruce at these rates caused chlorosis to varying degrees. Both rates showed medium to severe burn damage to the crop tree, reduced growth, and loss of foliage in the chlorotic areas of the trees. Epidemic hare populations as well as moose browsing further increased damage and caused loss of the 15 tagged trees, thus invalidating measurements. The plots were discontinued in 1983 (Fig. 11).

1981 Conifer Release with Hexazinone Granules (Plots GP12-1,2)

Aspen, balsam poplar, and birch regeneration characterize the trial site, with scattered willow, alder, buffalo-berry, currant, and raspberry spreading rapidly throughout. In the summer of 1981, 20% hexazinone granules (Velpar) were applied with a cyclone seeder at

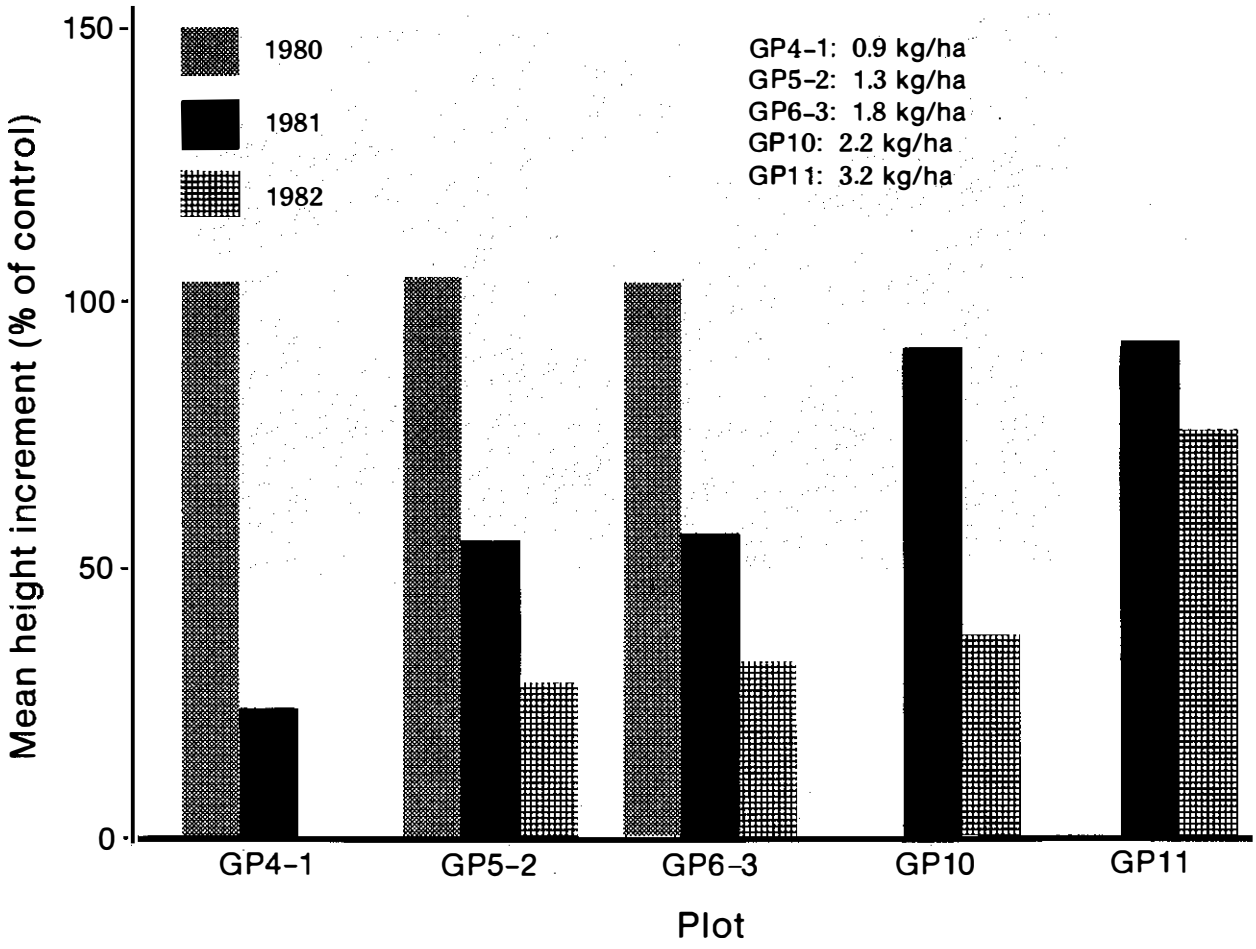

Figure 11. White spruce growth response to herbicide treatments near Grande Prairie, Alberta, showing 1980–82 mean height increment as a percentage of the control following spring 1981 application of hexazinone liquid on plots GP4–1, GP5–2, GP6–3, GP10, and GP11.

rates of 2.8 and 4.0 kg/ha on 0.04-ha plots (July 1981 temperature 22°C, humidity 68%, and wind west at 3.0-8.0 km/h). First- and second-year assessments revealed both rates controlled grasses, forbs, rose, raspberry, poplar, and birch and (to a much lesser degree) alder, willow, and buffalo-berry. No damage was observed on the 15 tagged white spruce in both plots. The plots were discontinued in 1984 due to epidemic hare populations (Fig. 12) and moose browsing in the area.

1985 Conifer Release with Hexazinone Liquid by Spot Gun Application (Plot GP13)

Aspen, balsam poplar, and birch regeneration (1.5–3.0 m in height) characterize the trial site, with scattered willow, alder, buffalo-berry, currant, and raspberry spreading throughout the area. Spot gun application of undiluted (240 g/L) hexazinone liquid (Velpar L) was replicated three times in the spring of 1985 at a rate of 4.3 kg/ha (4.0 mL per 5.0-cm stem diameter and 1.5-m grid spacing) (May 1985 temperature 14°C, humidity 51%, and wind northwest at 12.0 km/h). Assessment of percentage defoliation on 34 overstory tagged deciduous trees, 10 understory shrubs and trees, and 82 white spruce crop trees after the first growing season showed uniform defoliation of the overstory and understory (Table 12), including grasses. Alder and willow were more resistant than other species. Crop tree mortality or chlorosis was minimal.

No assessment was possible in 1986 due to pressure of work on Pronone 10G near Bald Mountain Creek in the Grande Prairie test site and due to retirement of the primary investigator.

Figure 12. Extensive hare damage on lodgepole pine in plots treated with 20% hexazinone granules in the Economy Tower Supplemental Area near Grande Prairie, Alberta, after 3 years.

Table 12. White spruce crop tolerance and weed control ratings in 1986 following spring 1985 spot gun application of hexazinone liquid at 4 mL per 5.0-cm stem diameter on plot GP13 near Grande Prairie, Alberta

				Control rating after 1 year[a]					
				Overstory		Understory			
Plot	Grid spacing (m)	Rate (kg/ha)	White spruce crop tolerance	Aspen	Balsam poplar	Aspen	Willow	Balsam poplar	Alder[b]
GP13	1.5	4.3	Good	8	9	9	8	9	7

[a] 0 = no control, 9 = complete control.

1984–85 Calling Lake, Alberta

The trial sites (Sect. 24–25, Tp. 72, Rng. 21, W4) (Fig. 13) experienced wildfire in 1968. Soils are generally Orthic Gray Luvisols of clay loam textures, with 5.0–8.0 cm of organic matter.

1984 Conifer Release with Hexazinone Liquid by Spot Gun Application (Plots CA-1a,b,c,d)

Forestry Canada personnel assisted Dupont Canada with undiluted (240 g/L) hexazinone liquid (Velpar L) spot gun trials. The trial site was left to self-regenerate and was supplemented in 1980 by hand seeding of white spruce. The site supported an overstory of 17-year-old aspen, balsam poplar, and a few stems of birch. The understory of aspen, balsam poplar, and willow ranged from 1.0 to 2.0 m in height, and the white spruce ranged from a few centimetres to 1.0 m in height. In the spring of 1984, four treatments were applied with a spot gun (May 1984 temperature 15°C, humidity 70%, and a trace of wind): a) 4.0 mL at a 2.0-m grid spacing (2.4 kg/ha); b) 4.0 mL at a 1.5-m grid spacing (4.3 kg/ha); c) 8.0 mL at a 2.0-m spacing (4.8 kg/ha); and d) 8.0 mL at a 1.5-m spacing (8.6 kg/ha). Each treatment area, unreplicated, was 0.09 ha (20 × 45 m) and was separated by a 10.0-m check strip.

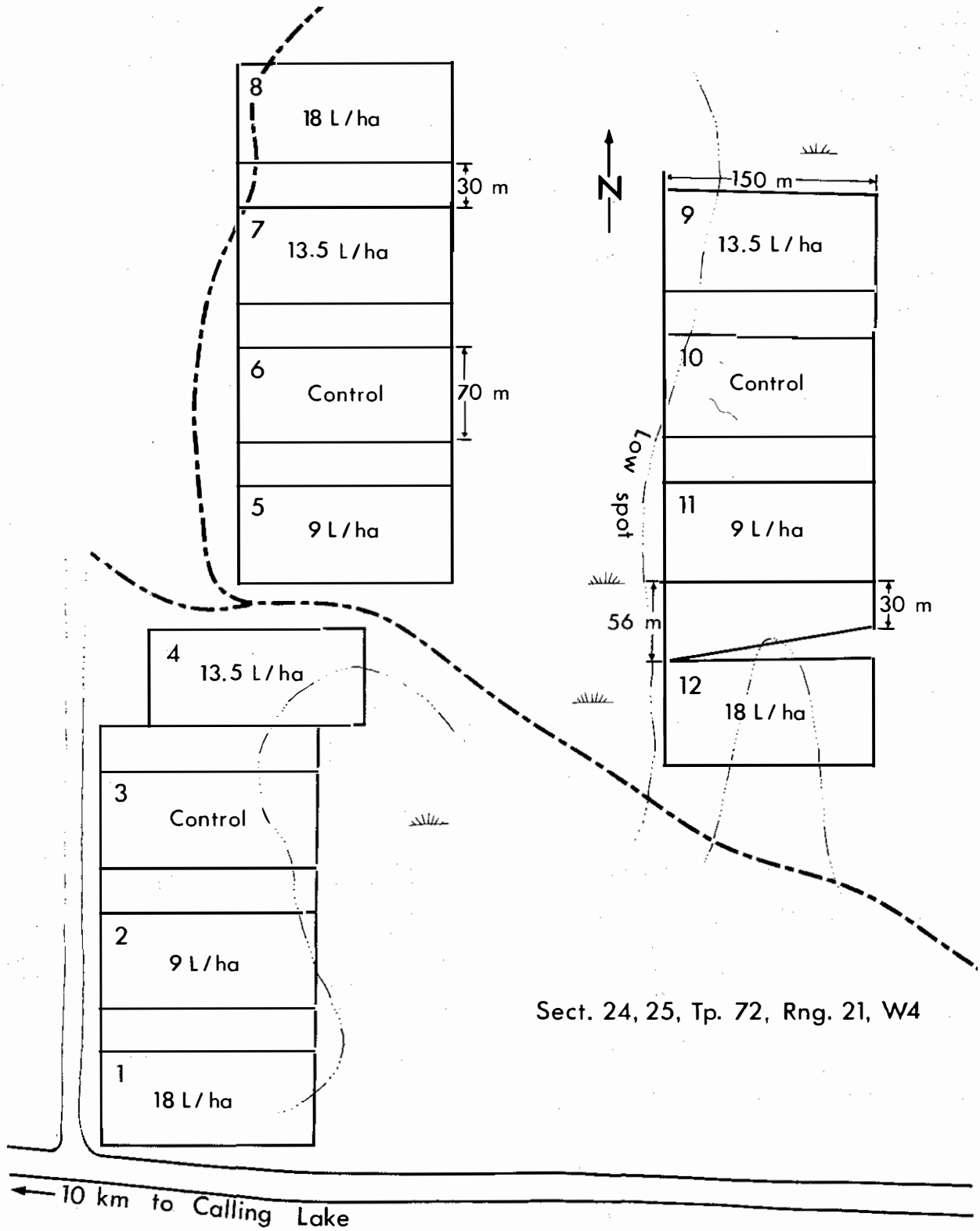

Figure 13. Aerial application plots for site preparation and conifer release near Calling Lake, Alberta, 1984.

Assessment of percentage defoliation on 20 overstory deciduous trees and 10 understory deciduous trees was carried out at the end of the first growing season. In addition, 10 white spruce were tagged, evaluated for percentage injury, and measured (heights and diameters) for two growing seasons. After 2 years there was no damage among the 10 tagged spruce. All overstory weed trees were controlled in the year following application. Balsam poplar and willow understory species were completely controlled at all rates. Plot measurements are to be completed in 1989 by the Alberta Forest Service.

1984 Site Preparation and Conifer Release by Aerial Application of Hexazinone Liquid (Plots CA-2a,b,c)

Forestry Canada and Alberta Forest Service personnel assisted Dupont Canada with aerial applications of undiluted (240 g/L) hexazinone liquid (Velpar L). The trial site was cut, piled, and burned in 1979–80, Bracke-scarified in 1981, and planted with 2–0 bare-root white spruce in 1982. The chemical was applied to 1.0-ha plots from a Bell T4A helicopter flying at a speed of 50 km/h 12–13 m above the ground applying a spray volume of 250 L/ha and pressure of 172 kPa using a 028 airfoil nozzle attached to a microfoil boom with a 14-m swath width. Three rates of application were used: 2.2, 3.2, and 4.3 kg/ha (May 1984 temperature 16°C, humidity 75%, and a trace of wind) (Drouin 1984). Treatments included one control plot and two replicates. In June 1984 the vegetation was assessed before and after application. Each 1.0-ha plot contained nine 4-m^2 subplots in which assessments were made of existing conifers and one lodgepole pine (2–0 container) and one white spruce (2–0 bare-root) that were planted into each subplot (Fig. 14).

At the end of the first and second growing seasons, grass control was good for all rates. Over 80% of the total brush component was killed at the 2.2- and 3.2-kg/ha rates (Fig. 15). With the 4.3-kg/ba rate, total kill of brush and grass was evident in the second season, and mortality of some crop trees resulted. There was a significant growth response by white spruce at the 2.2- and 3.2-kg/ha rates. The white spruce in scarified holes in the treated plots experienced some mortality due to the compounding effects of flooding and chemical stress.

1985 Conifer Release with Hexazinone Granules (Plots CA-3a,b,c)

Forestry Canada personnel assisted Pfizer C. & G. Inc., London, Ontario, with a ground application of 10% hexazinone granules (Pronone 10G). The trial site was cut, piled, and burned in 1979–80, Bracke scarified in 1981, and planted with white spruce in 1982. A Herd-92 applicator (skidder-mounted) was used in the spring of 1985 (June 1985 temperature 15°C, humidity 70%, and a trace of wind) to apply the chemical on 2.0-ha plots replicated three times at 1.0, 2.0, and 4.0 kg/ha over brush, aspen, balsam poplar, and willow (1.0–3.0 m in height) (Drouin 1985). Effective defoliation of grass species, aspen, and balsam poplar was noted at all rates (Fig. 14). Rose and willow showed a distinct tolerance. The white spruce showed tolerance at the 1.0-and 2.0-kg/ha rates and some chlorosis at the 4.0-kg/ha rate. There was no evidence of off-site movement by the product.

1980–83 Pine Falls, Manitoba

The trial site is located in a riparian zone 3.4 km from the main road east along the Bear River Road in Abitibi–Price operations, near Pine Falls, Manitoba (Sect. 31, Tp. 18, Rng. 11, EPM) (Fig. 16). Soils are generally Gleyed Dark Gray Wooded of sandy textures, with 2.0–5.0 cm of organic matter.

1981 Conifer Release with Hexazinone Grid Balls (Plots 13PF-1,2,3,4,5,6 and 15PF-1A)

The area was shear-bladed in February 1980 and planted with paper-pot black spruce in July 1980. The trial site was characterized by dense juvenile balsam poplar 1.5–2.0 m in height, willow, Manitoba maple, and black ash, with heavy grasses and forbs. In the spring of 1981, three 0.04-ha plots (13PF-1,2,3) were hand treated at rates of 1.7, 3.4, and 5.0 kg/ha using 0.5-cm^3 20% hexazinone grid balls (Velpar Gridballs) at spacings of 1.50, 1.05, 0.81 m, respectively (May 1981 temperature 15°C, humidity 60%, and a trace of wind) (Drouin 1981, 1982). A smaller (0.02 ha) plot (15PF-1A) was also hand treated at 1.7 kg/ha with 0.5-cm^3 20% hexazinone grid balls at a spacing of 1.5 m. Three more 0.04-ha plots (13PF-4,5,6) were hand treated at 3.4, 6.7, and 11.2 kg/ha with 0.5-cm^3 10% hexazinone grid balls at spacings of 1.05, 0.75, and 0.60 m, respectively (Fig. 16). There was no appreciable difference in defoliation of aspen and balsam poplar with differing dosages and grid spacings. Chlorosis of black spruce crop trees recorded after the first assessment gradually faded, and good growth occurred. The plots were abandoned after being accidentally oversprayed with glyphosate in the second year (Table 13).

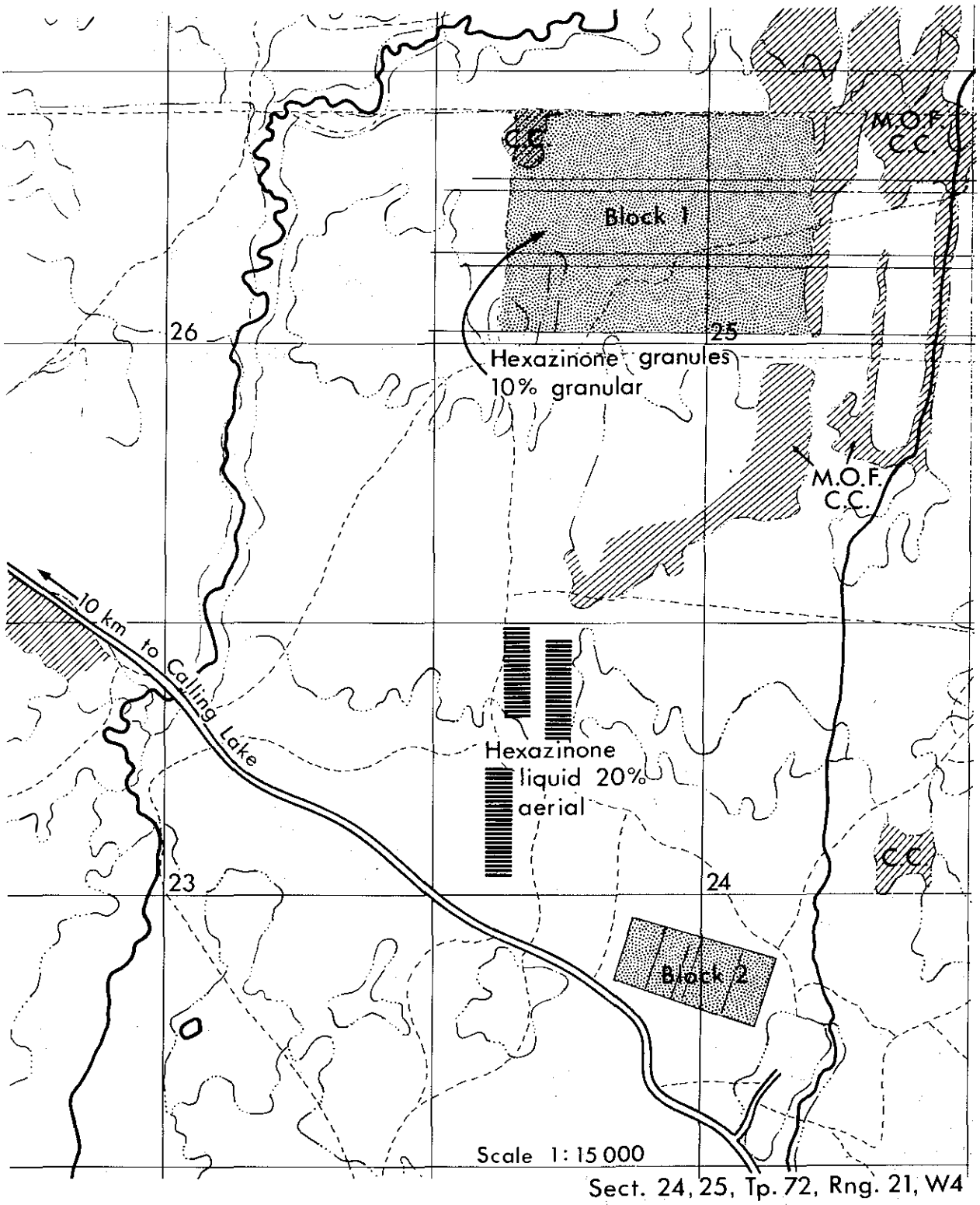

Figure 14. Conifer release plots near Calling Lake, Alberta, 1985.

Figure 15. One year after aerial application of hexazinone liquid (3.2 kg/ha) with a microfoil boom near Calling Lake, Alberta, showing significant control and growth response.

1981 Conifer Release with Hexazinone Granules (Plots 14PF-1,2,3,4)

A dense growth of balsam poplar, willow, Manitoba maple, black ash, herbaceous weeds, and grasses covered the trial site, which was shear-bladed in February 1980 and planted with paper-pot black spruce in July 1980. In the spring of 1981, two 58-m^2 replicated plots were treated with 20% hexazinone granules (Velpar) at rates of 1.1 and 2.2 kg/ha using a cyclone seeder (May 1981 temperature 17°C, humidity 65%, and a trace of wind). After the first growing season, little vegetation remained at both rates except for scattered cranberry and black ash (Drouin 1982), which had less than 30% defoliation. There was no black spruce seedling mortality at either dosage. The lower rate of 1.1 kg/ha would be sufficient for good conifer release. Crop tolerance was good in both treatments but best at the lower rate. Spruce showed good recovery from the chlorotic effect of hexazinone. Spray drift contamination from accidental aerial spray applications of glyphosate over much of this area reduced the reliability of the data, and the plots were abandoned in the second year.

1981-85 Agassiz Provincial Forest, Manitoba

The trial site is located in the Agassiz Provincial Forest on a sandy-clay ridge 80 km east of Winnipeg and 6.4 km north of Highway 44 on the central Agassiz Road (Sect. 18, Tp. 13, Rng. 10, EPM) (Fig. 17). Soils are generally Orthic Gray Wooded of sandy textures, with 2.0-4.0 cm of organic matter.

1981 Conifer Release with Hexazinone Grid Balls (Plots 8AG-1,2,3 and 9AG-4,5,6)

This white spruce-jack pine release area had a moderate to heavy cover of aspen, balsam poplar, birch, willow, pin cherry, hazel, rose, grasses, and herbaceous weeds. In the spring of 1981, three 0.04-ha plots (8AG-1,2,3) were hand treated at 1.7, 3.4, and 5.6 kg/ha with 0.5-cm^3 20% hexazinone grid balls (Velpar Gridballs) at spacings of 1.05, 0.75, and 0.60 m, respectively (May 1981 temperature 22°C, humidity 23%, and wind southeast to 8.0 km/h) (Drouin 1981). Three 0.04-ha plots (9AG-4,5,6) were hand treated at

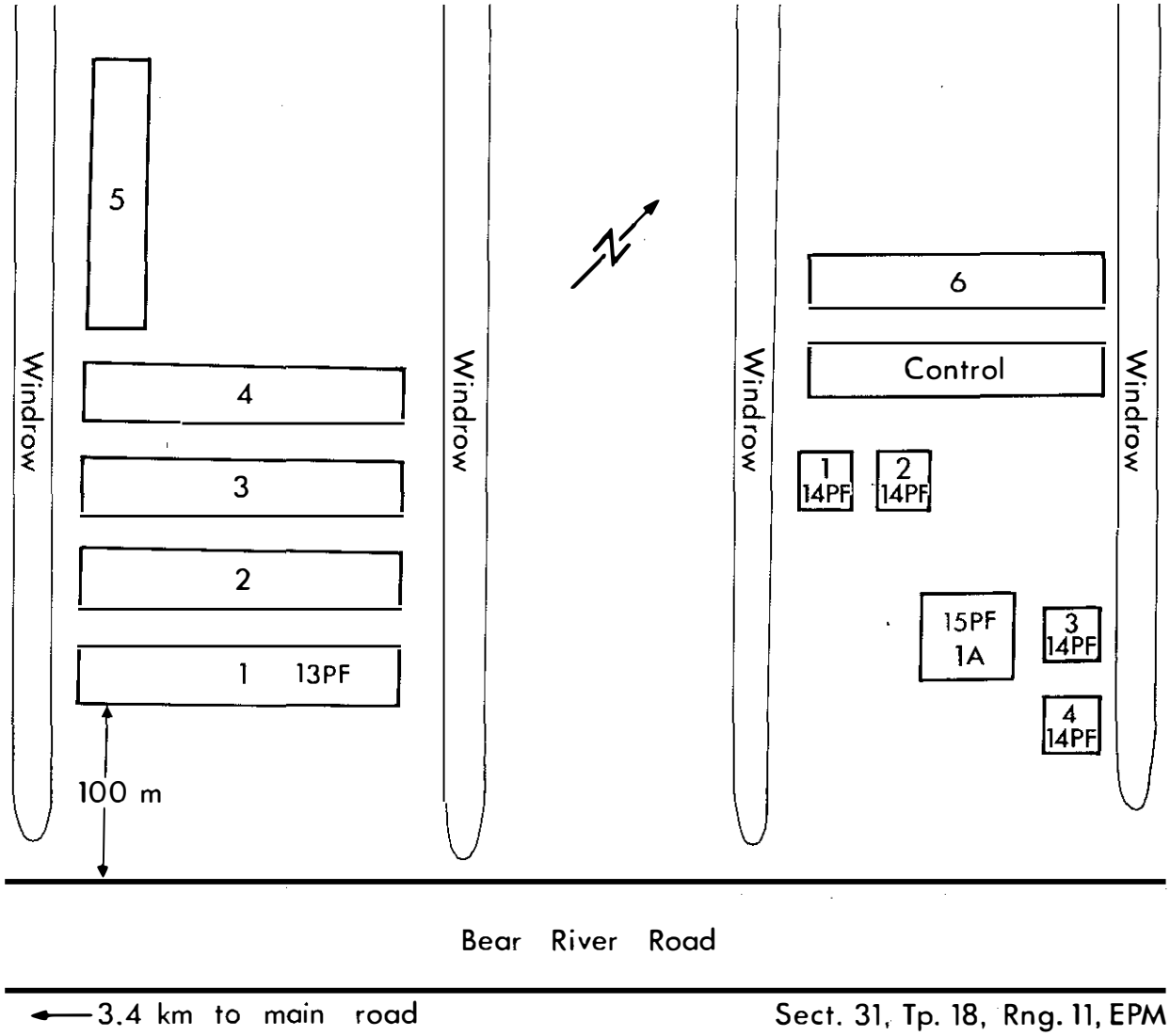

Figure 16. Conifer release plots along the Bear River Road near Pine Falls, Manitoba, 1980–82.

0.85, 1.70, and 2.80 kg/ha with 0.5-cm³ 10% hexazinone grid balls at spacings of 0.51, 0.36, and 0.30 m, respectively.

At the end of the first growing season, good to excellent control was evident on all weed trees, shrubs, grasses, and herbs. The grid balls were more effective in the sandier soils, opening the canopy by defoliating 80–100% of the aspen–poplar–birch overstory (up to 8.0 cm in diameter) with both the 0.5-cm³ 10% and 20% concentrations at all rates. Crop tree mortality increased with dosage, particularly with the 0.5-cm³ 20% grid balls. Chlorosis occurred on some spruce, but recovery was usually good. Due to its low hexazinone tolerance, jack pine mortality occurred at the various dosages. Temporary reflushing occurred in the second and third years on balsam poplar and willow. Hazel was spreading into the treated area by the third year. No off-site chemical movement was recorded in these plots. Rabbits were attracted to the grid balls, the grid pattern being visible by the feeding areas. Vegetation and organic matter had been eaten down to the mineral soil. No dead animals were found after close examination of the plot areas. After 4 years the 2.80-kg/h rate for the 10% grid balls and the 1.7-kg/ha rate for the 20% grid balls resulted in the best crop tree heights (Fig. 18, Table 14).

Table 13. Black spruce crop tolerance and weed control ratings in 1982 following spring 1981 application of 0.5-cm³ 20% and 10% hexazinone grid balls on plots 13PF-1,2,3,4,5,6 and 15PF-1A near Pine Falls, Manitoba

Plot	Grid spacing (m)	Plot size (ha)	Rate (kg/ha)	Black spruce crop tolerance	Control rating after 1 year[a]			
					Aspen/ balsam poplar	Black ash	Manitoba maple	Grasses
20% hexazinone								
13PF-1	1.50	0.04	1.7	Good	7	5	4	6
13PF-2	1.05	0.04	3.4	Good	5	4	5	7
13PF-3	0.81	0.04	5.0	Good	6	5	5	7
15PF-1A	1.50	0.02	1.7	Good	8	5	5	6
10% hexazinone								
13PF-4	1.05	0.04	3.4	Good	6	5	5	6
13PF-5	0.75	0.04	6.7	Good	7	7	6	8
13PF-6	0.60	0.04	11.2	Good	7	6	5	7

[a] 0 = no control, 9 = complete control.

1981 Conifer Release with Hexazinone Grid Balls (Plots 8AG-1A,2A,3A)

This white spruce and jack pine release area had a moderate cover of aspen, balsam poplar, birch, willow, pin cherry, choke cherry, hazel, rose, grasses, and forbs. In the spring of 1981, hexazinone was applied by hand at rates of 0.85, 1.70, and 2.80 kg/ha with 0.5-cm³ 10% grid balls (Velpar Gridballs) at 1.05-, 0.75- and 0.60-m grid spacings. Three 149-m² plots were treated (June 1981 temperature 16°C, humidity 72%, and a trace of wind to the south). Assessment after the first growing season indicated good to very good control on all aspen, balsam poplar (up to 7.6 cm diameter), birch, willow, and hazel and on most shrubs and grasses. Mortality and chlorosis occurred at the higher rates on both crop tree species. Jack pine in particular showed more damage due to its low hexazinone tolerance. Measurements the following years showed grid ball drop zones to be visible still. Flushing was recorded on some aspen and willow, but in most cases the condition was temporary. Chlorosis recovery as well as good growth took place quickly on the white spruce. After 4 years the best growth was at the 1.7-kg/ha rate on a 0.75-m grid (Fig. 19).

1981 Conifer Release with Hexazinone Granules (Plots 10AG-1,2,3,4)

A moderate to heavy cover of aspen, balsam poplar, birch, jack pine, willow, hazel, pin cherry, rose, grasses, and forbs is found in this white spruce release area. In the spring of 1981, two replicated 58-m² plots were treated with 20% hexazinone granules (Velpar) at rates of 1.1 and 2.2 kg/ha using a cyclone seeder (May 1981 temperature 22°C, humidity 23%, and wind southeast to 8.0 km/h) (Drouin 1981, 1982). At the end of the first growing season, the lower dosage showed good control, good canopy opening, and less than 30% refoliation in the aspen, balsam poplar, birch, and willow. With the exception of ferns, all remaining shrubs, grasses, and forbs were 100% defoliated. The 2.2 kg/ha rate showed very good control. There was excellent aspen-poplar canopy opening, with 100% defoliation (resprouting from some stems did occur later). All remaining broadleaf vegetation died, as did many of the pine. Temporary chlorosis occurred on the lower third of some white spruce. No off-site movement was noted in this light sandy soil. Slightly better growth occurred with the 1.1-kg/ha rate after 3 years (Fig. 20).

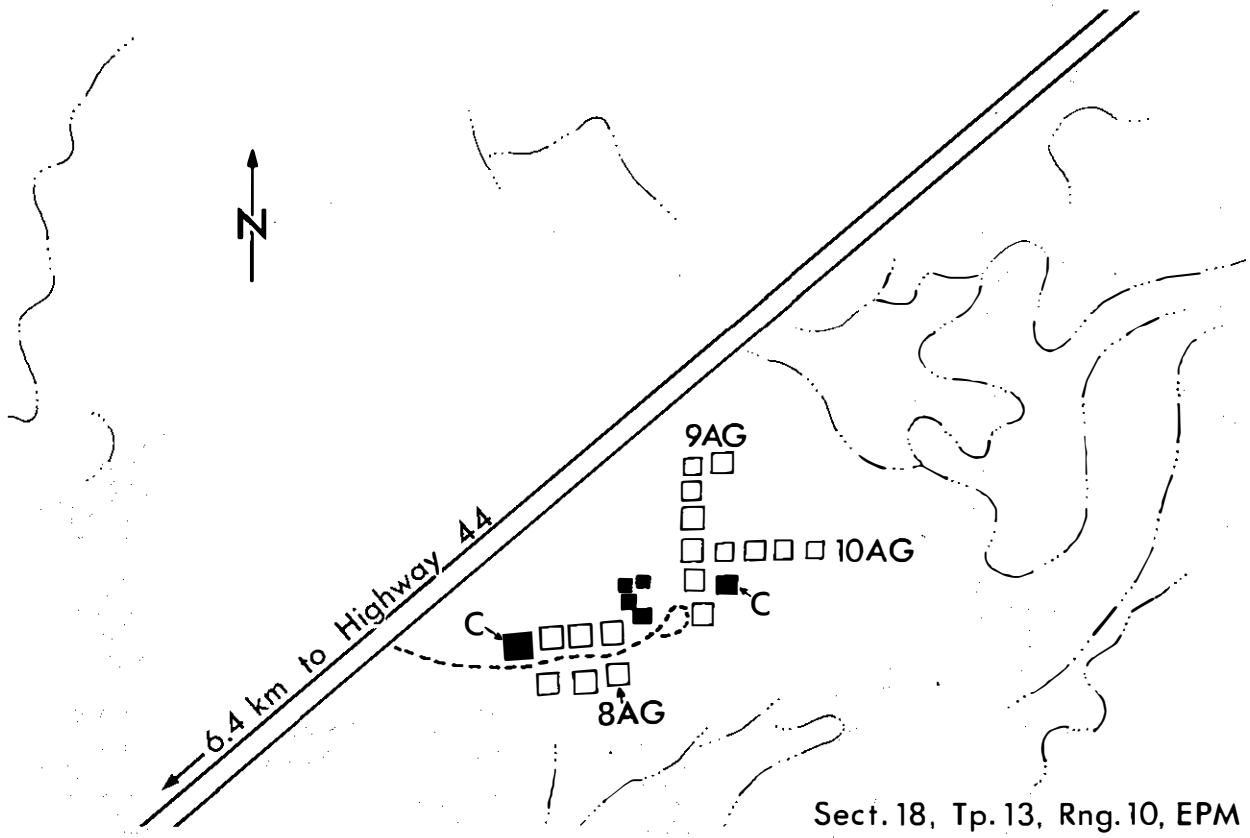

Figure 17. Conifer release plots in the Agassiz Provincial Forest in Manitoba, 1981–85.

1982 Conifer Release with Hexazinone Granules (Plots 10AG-5,6)

This white spruce release area had a moderate cover of aspen, balsam poplar, birch, willow, pin cherry, hazel, rose, grasses, and forbs. In the spring of 1982, 20% hexazinone granules (Velpar) were applied with a cyclone seeder on replicated 58-m^2 plots at a rate of 1.8 kg/ha (May 1982 temperature 16°C, humidity 72%, and a trace of wind). At the end of the first growing season, fair to good control was evident on the 6-m aspen and balsam poplar. There was variable control on dogwood and rose. The study was discontinued in 1983 due to interference by other treatments.

1981–85 Piney-Wampum, Manitoba

The trial site is located in Manitoba in the Piney-Wampum red pine release area (Sect. 11, Tp. 1, Rng. 12, EPM) (Figs. 21 and 22). Soils are generally a minimal Podzol and Orthic Gray Wooded of sandy textures, with 2.0–5.0 cm of organic matter. The crop tree is red pine.

1981 Conifer Release with Hexazinone Grid Balls (Plots 11P-1,2,3,4,5,6)

The trial site supports a moderate cover of aspen, balsam poplar, birch, willow, rose, raspberry, choke cherry, pin cherry, herbaceous weeds, ferns, and grasses. In the spring of 1981, three 0.04-ha plots (11P-4,5,6) were hand treated at 0.85, 1.70, and 2.80 kg/ha with 0.5-cm^3 10% hexazinone grid balls (Velpar Gridballs) at spacings of 2.1, 1.5, and 0.9 m, respectively. Three more 0.04-ha plots (11P-1,2,3) were hand treated at the same dosages and spacings with 2.0-cm^3 10% hexazinone grid balls (May 1981 temperature 27°C, humidity 22%, and wind east at 3.2–9.6 km/h). At the end of the first and second growing season, fair control was evident at the lower (0.85 kg/ha) rate, increasing to good at the

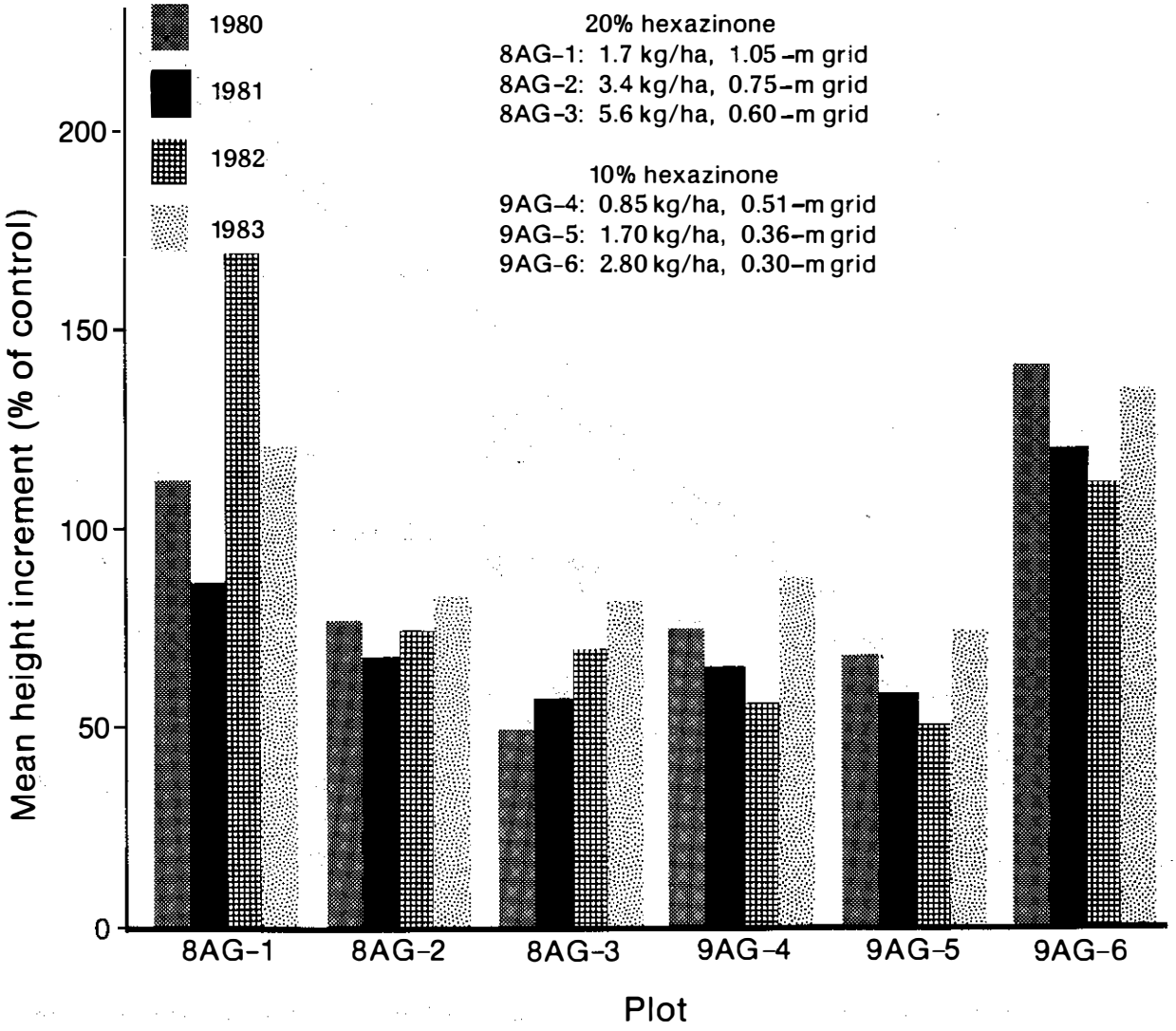

Figure 18. White spruce and jack pine growth response to herbicide treatments near Agassiz, Manitoba, showing 1980–83 mean height increment as a percentage of the control following spring 1981 application of 0.5-cm³ 20% hexazinone grid balls on plots 8AG-1,2,3 and 0.5-cm³ 10% hexazinone grid balls on plots 9AG-4,5,6.

1.70 and 2.80 kg/ha rates with both sizes of grid balls (Drouin 1981, 1982). Control on shrubs, grasses, and ferns was 80–100%. Some chlorosis and pine mortality was noted at the higher dosage for both sizes, the larger size causing slightly more harm. The grid pattern at all plots was visible by the hare digs or feeding areas. Vegetation and organic matter had been eaten to the mineral soil. There were no dead animals found in the area. Also, there was no chemical off-site movement. Good growth was recorded in all six plots after 4 years, with the 1.70-kg/ha rate at 1.5-m spacing being slightly better than the others (Fig. 23, Table 15).

1981 and 1982 Conifer Release with Hexazinone Granules (Plots 12P-1,2,3,4 and 13P-5,6)

The trial site supports a moderate cover of aspen, balsam poplar, birch, willow, rose, raspberry, choke cherry, pin cherry, and mullein, heavy fern growth, and scattered grasses. Spring 1981 (plots 12P-1,2,3,4) and 1982 (plots 13P-5,6) applications of 20% hexazinone granules (Velpar) using a cyclone seeder were replicated on six 58-m² red pine plots (Figs. 24–26) at 2.8, 5.6, and 1.8 kg/ha (May 1981 temperature 26°C, humidity 22%, and wind east at 3.2–10.0 km/h; June 1982

Table 14. White spruce and jack pine crop tolerances and weed control ratings in 1985 following spring 1981 application of 0.5-cm³ 20% and 10% hexazinone grid balls on plots 8AG-1,2,3 and 9AG-4,5,6 near Agassiz, Manitoba

Plot	Grid spacing (m)	Rate (kg/ha)	Crop tolerance		Control rating after 4 years[a]			
			White spruce	Jack pine	Aspen/ balsam poplar	Birch	Willow	Shrubs[b]
20% hexazinone								
8AG-1	1.05	1.70	Good	Poor	9	8	8	6
8AG-2	0.75	3.40	Fair	Poor	9	8	8	7
8AG-3	0.60	5.60	Fair	Poor	9	9	9	7
10% hexazinone								
9AG-4	0.51	0.85	Good	Fair	9	7	7	5
9AG-5	0.36	1.70	Good	Poor	9	8	9	6
9AG-6	0.30	2.80	Fair	Poor	9	9	9	7

[a] 0 = no control, 9 = complete control.
[b] Hazel, rose, choke cherry, and saskatoon.

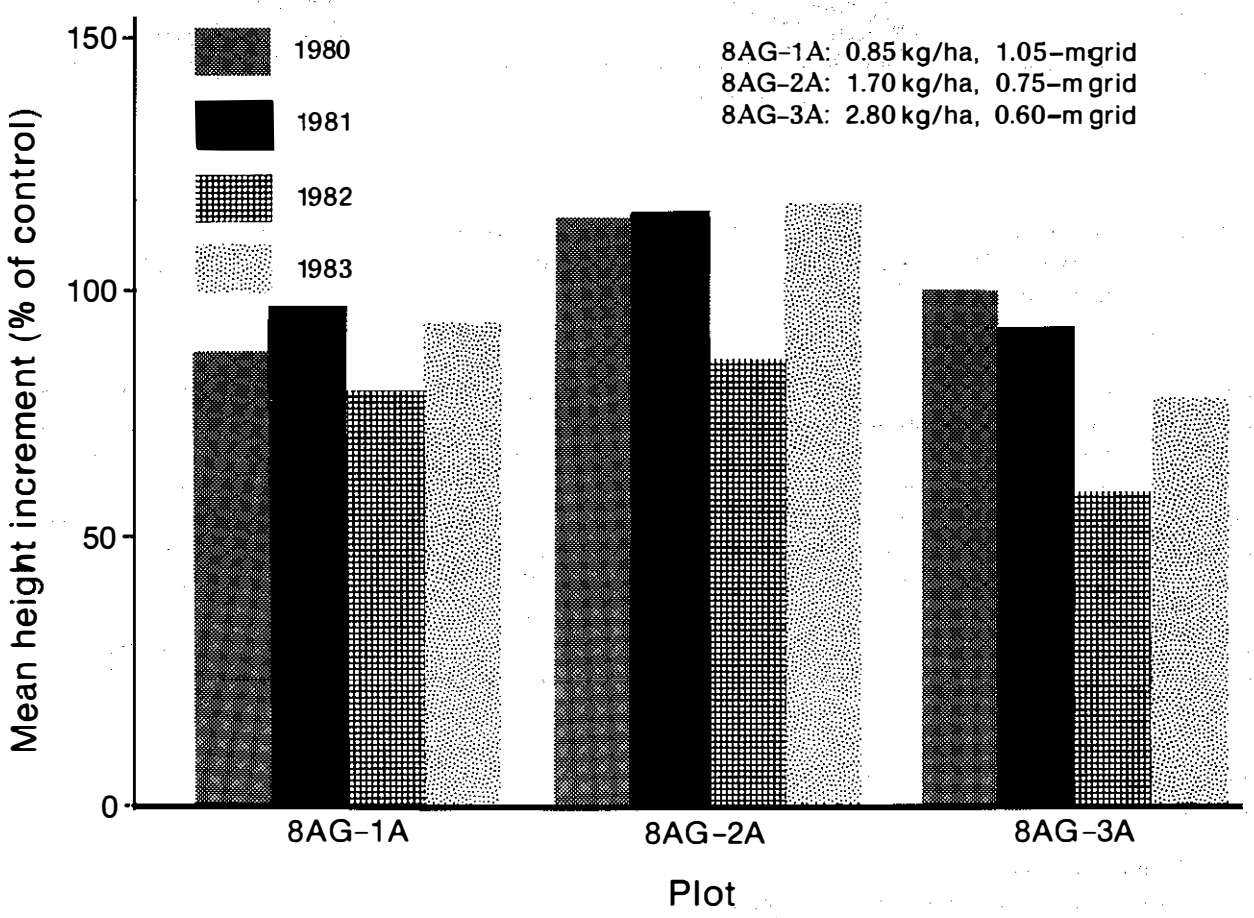

Figure 19. White spruce and jack pine growth response to herbicide treatments near Agassiz, Manitoba, showing 1980-85 mean height increment as a percentage of the control following spring 1981 application of 0.5-cm³ 10% hexazinone grid balls on plots 8AG-1A,2A,3A.

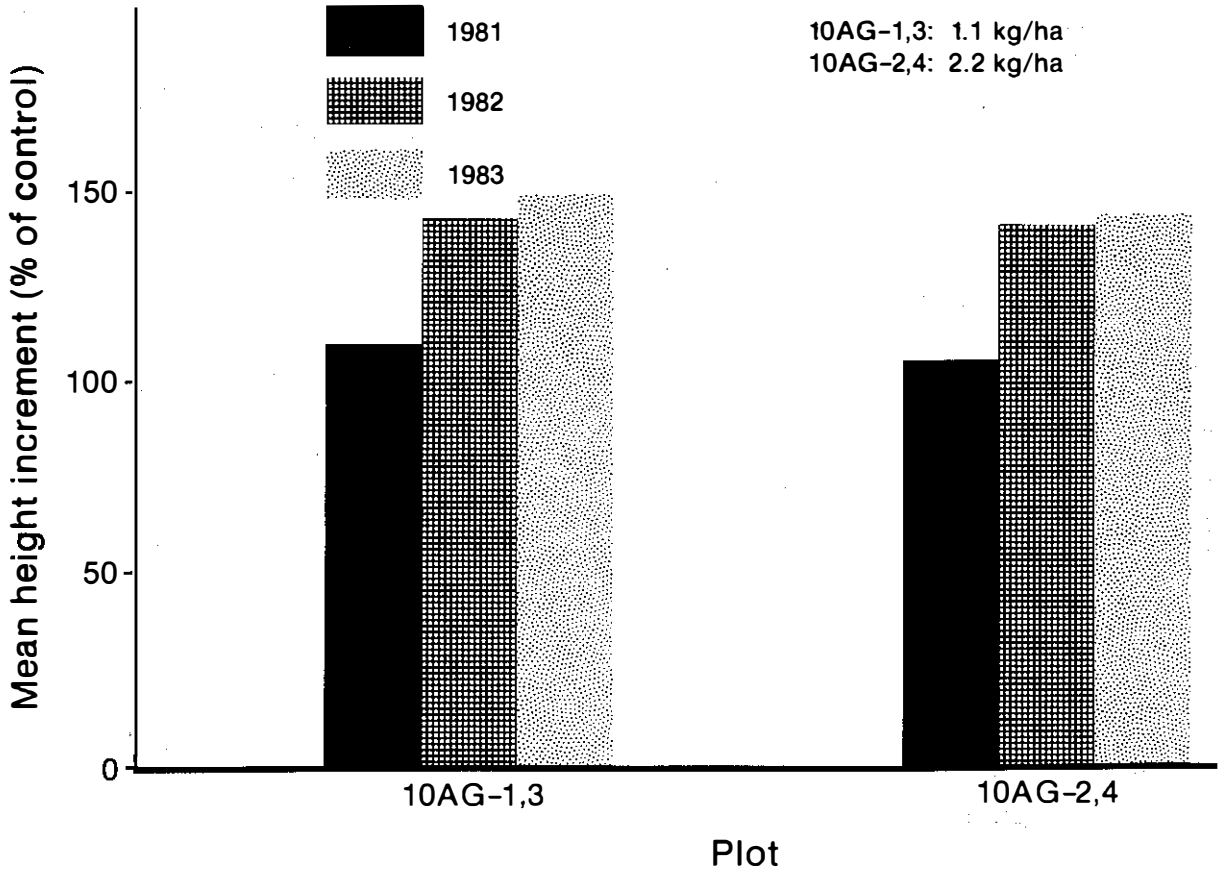

Figure 20. White spruce and jack pine growth response to herbicide treatments near Agassiz, Manitoba, showing 1981–83 mean height increment as a percentage of the control following spring 1981 application of 20% hexazinone granules on plots 10AG-1,2,3,4.

temperature 16°C, humidity 62%, and a trace of wind) (Drouin 1982). At the end of one growing season, crop tolerance at the three dosages was rated as good, fair, and good, respectively, while weed control varied from poor in the 1.8-kg/ha dosage to complete control in the 5.6-kg/ha dosage. All dosages resulted in very good canopy opening and conifer release, with minimal reflushing and regrowth. No off-site movement was recorded. Growth data indicates that an application of 1.8 kg/ha in sandy soil would be adequate.

1984 Conifer Release with Hexazinone Liquid (Plots 14P-1,2,3,4)

The trial site supports a moderate cover of birch, willow, alder, saskatoon, rose, raspberry, fern, and grasses. In the spring of 1984, undiluted (240 g/L) hexazinone liquid (Velpar L) was applied on two 0.04-ha replicated plots at 1.1 and 2.2 kg/ha using a pressurized backpack sprayer at 240 kPa pressure (May 1984 temperature 8°C, humidity 56%, and wind northwest at 11.0 km/h). At the end of the first growing season, crop tolerance on these sandy soils was good. Control of vegetation from both dosages was impossible to assess, because it was difficult to separate the effect of hexazinone from the effect of the severe drought conditions in southeast Manitoba in the year of application. No red pine mortality was recorded attributable to hexazinone, but growth response was poor after 3 years (Fig. 27).

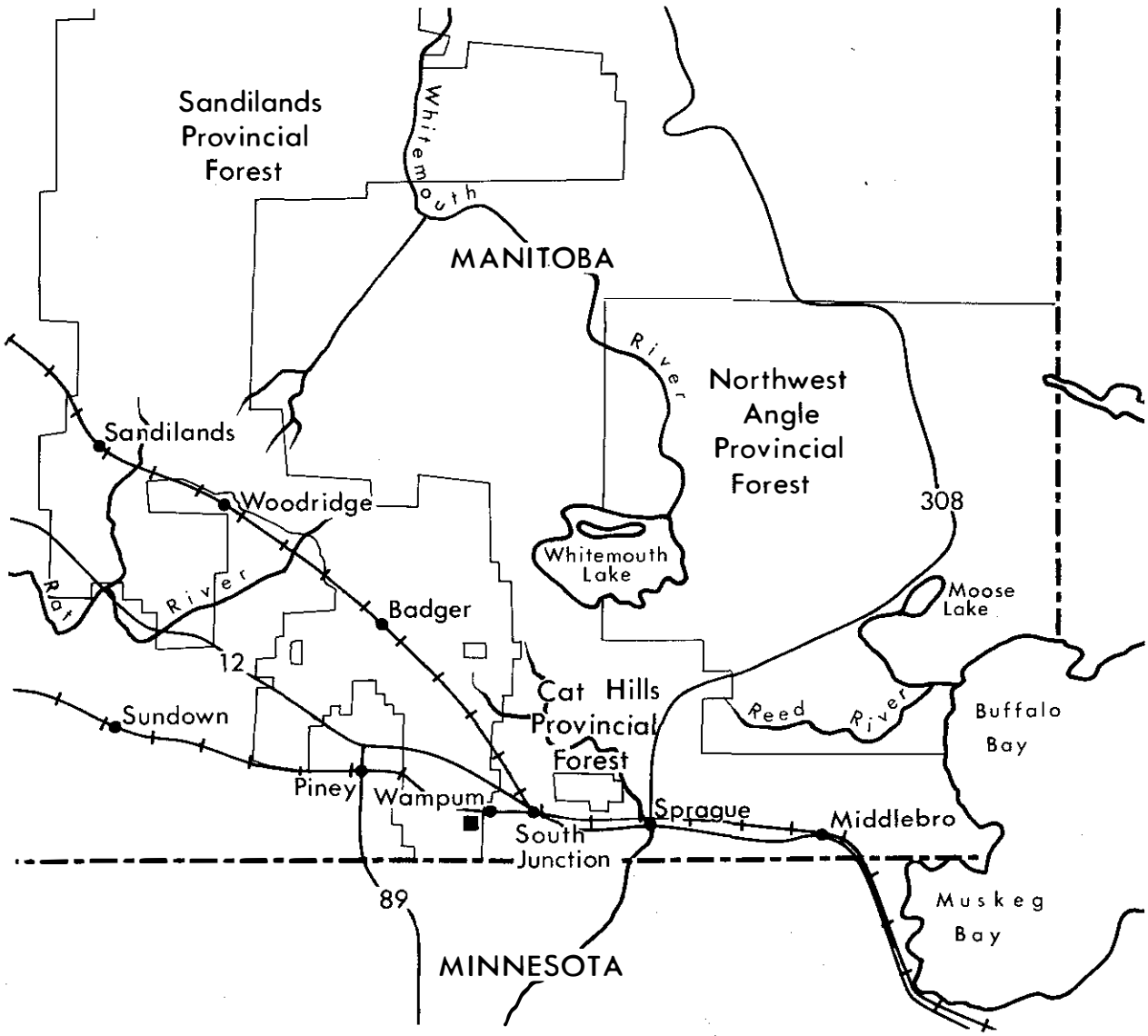

Figure 21. Conifer release plots location in the Piney-Wampum area of southeastern Manitoba, 1981-85.

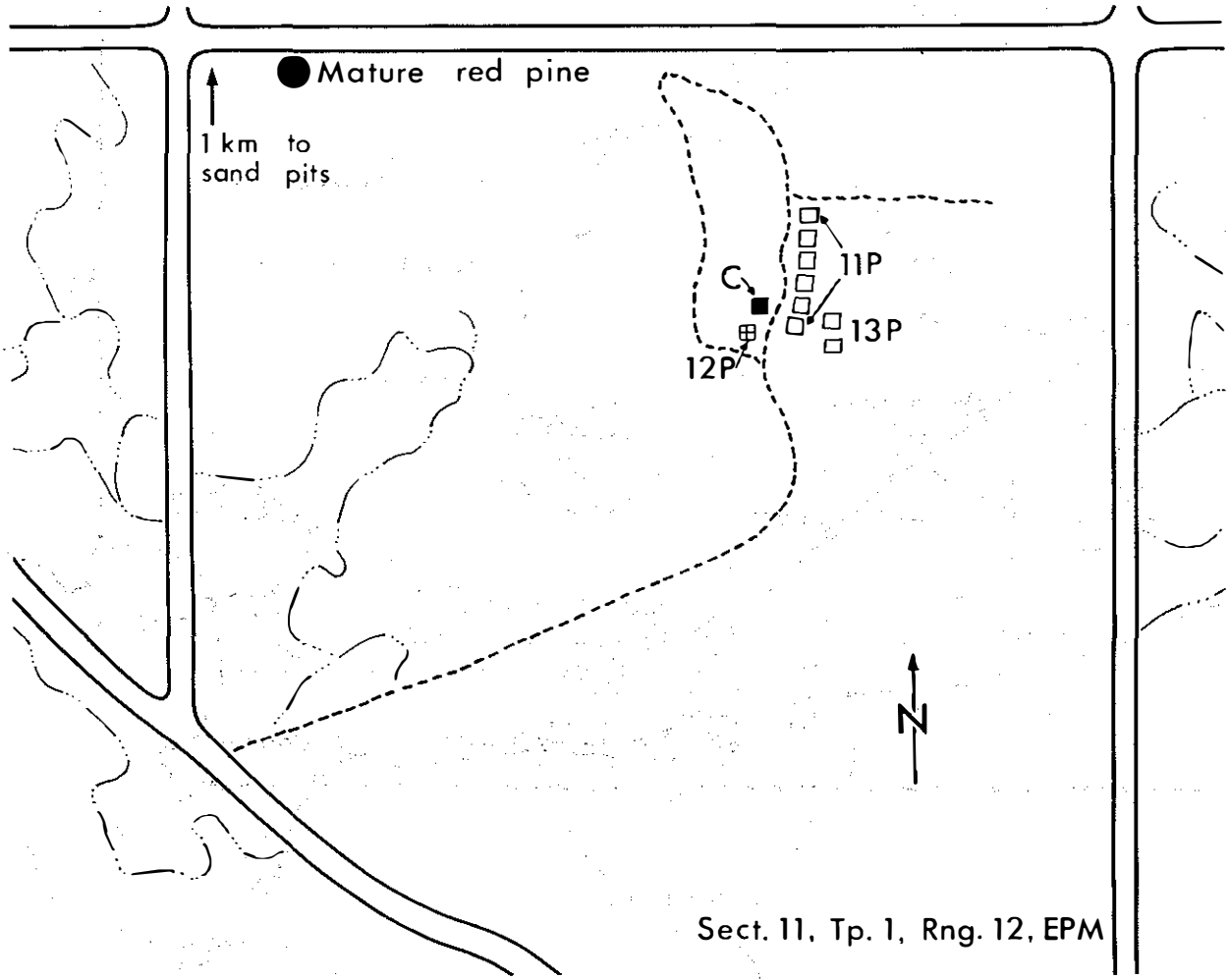

Figure 22. Conifer release plots in the Piney–Wampum red pine release area in Manitoba, 1981–85.

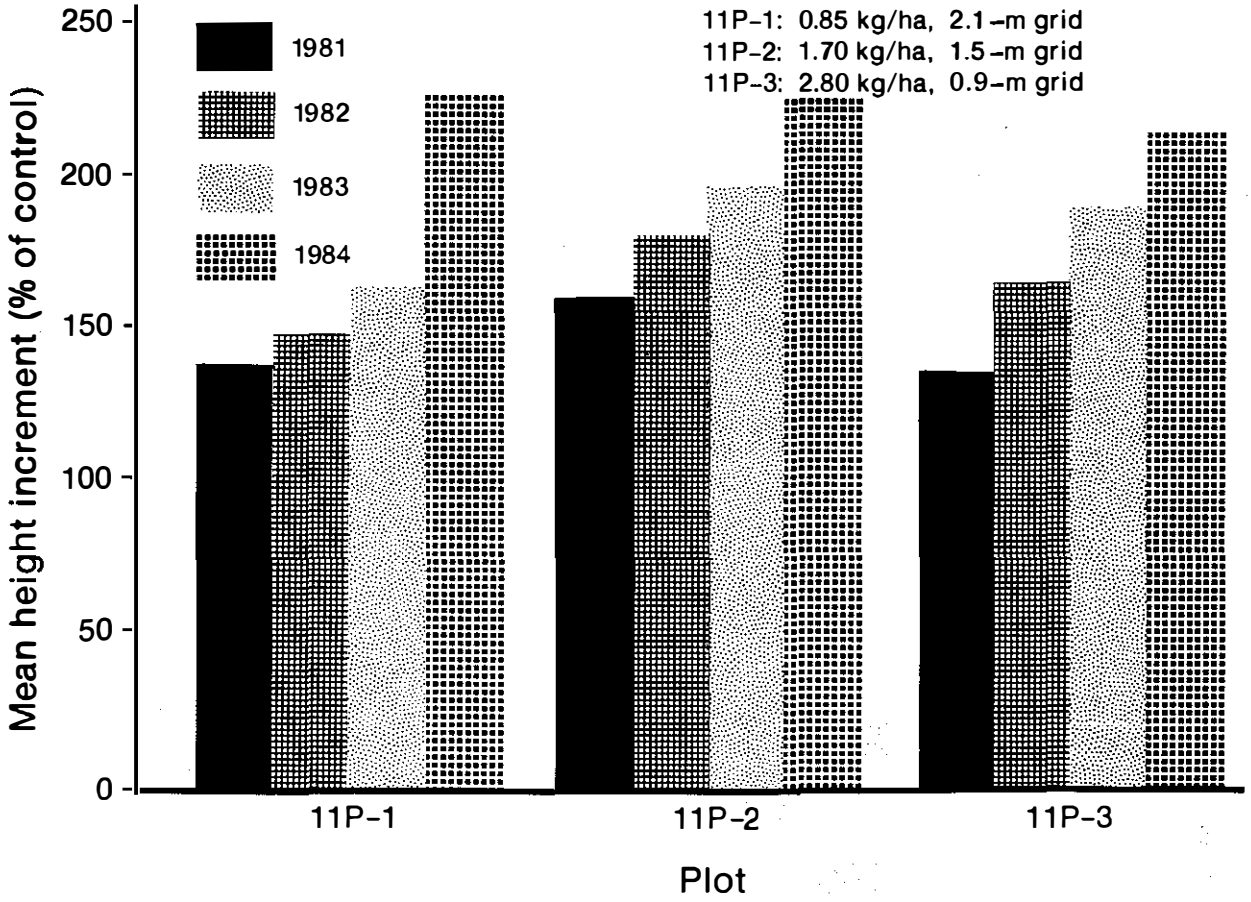

Figure 23. Red pine growth response to herbicide treatments near Piney, Manitoba, showing 1981–84 mean height increment as a percentage of the control following spring 1981 application of 2.0-cm³ 10% hexazinone grid balls on plots 11P-1,2,3.

Table 15. Red pine crop tolerance and weed control ratings in 1985 following spring 1981 application of 2.0- and 0.5-cm³ 10% hexazinone grid balls on plots 11P-1,2,3,4,5,6 near Piney, Manitoba

Plot	Grid spacing (m)	Rate (kg/ha)	Red pine crop tolerance	Control rating after 4 years[a]				
				Aspen/ balsam poplar	Birch	Willow	Raspberry	Others[b]
2.0-cm³ grid balls								
11P-1	2.1	0.85	Good	8	8.0	7.5	8	7
11P-2	1.5	1.70	Good	9	9.0	8.0	9	8
11P-3	0.9	2.80	Good	9	9.0	8.0	9	8
0.5-cm³ grid balls								
11P-4	2.1	0.85	Fair	7	8.5	7.0	8	6
11P-5	1.5	1.70	Good	9	9.0	9.0	9	9
11P-6	0.9	2.80	Good	9	9.0	9.0	9	9

[a] 0 = no control, 9 = complete control.
[b] Choke cherry, pin cherry, mullein, ferns, and alder.

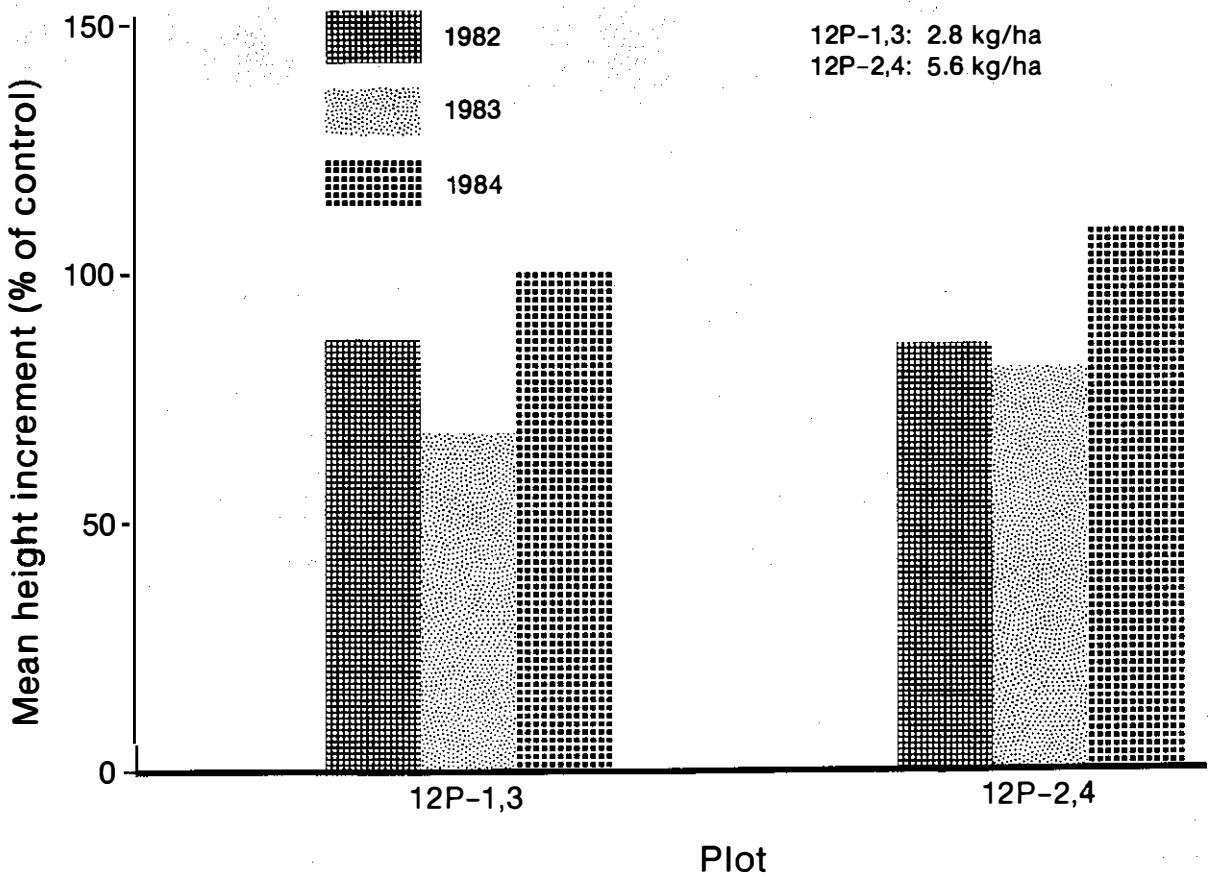

Figure 24. Red pine growth response to herbicide treatments near Piney, Manitoba, showing 1982-84 mean height increment as a percentage of the control following spring 1981 application of 20% hexazinone granules on plots 12P-1,2,3,4.

Figure 25. One year after conifer release with 20% hexazinone granules (2.8 kg/ha) in the Piney-Wampum red pine release area showing excellent canopy opening and chemical tolerance by red pine.

Figure 26. One year after conifer release with 20% hexazinone granules (5.6 kg/ha) in the Piney-Wampum red pine release area showing excellent canopy opening. No off-site movement by the chemical was recorded at this rate.

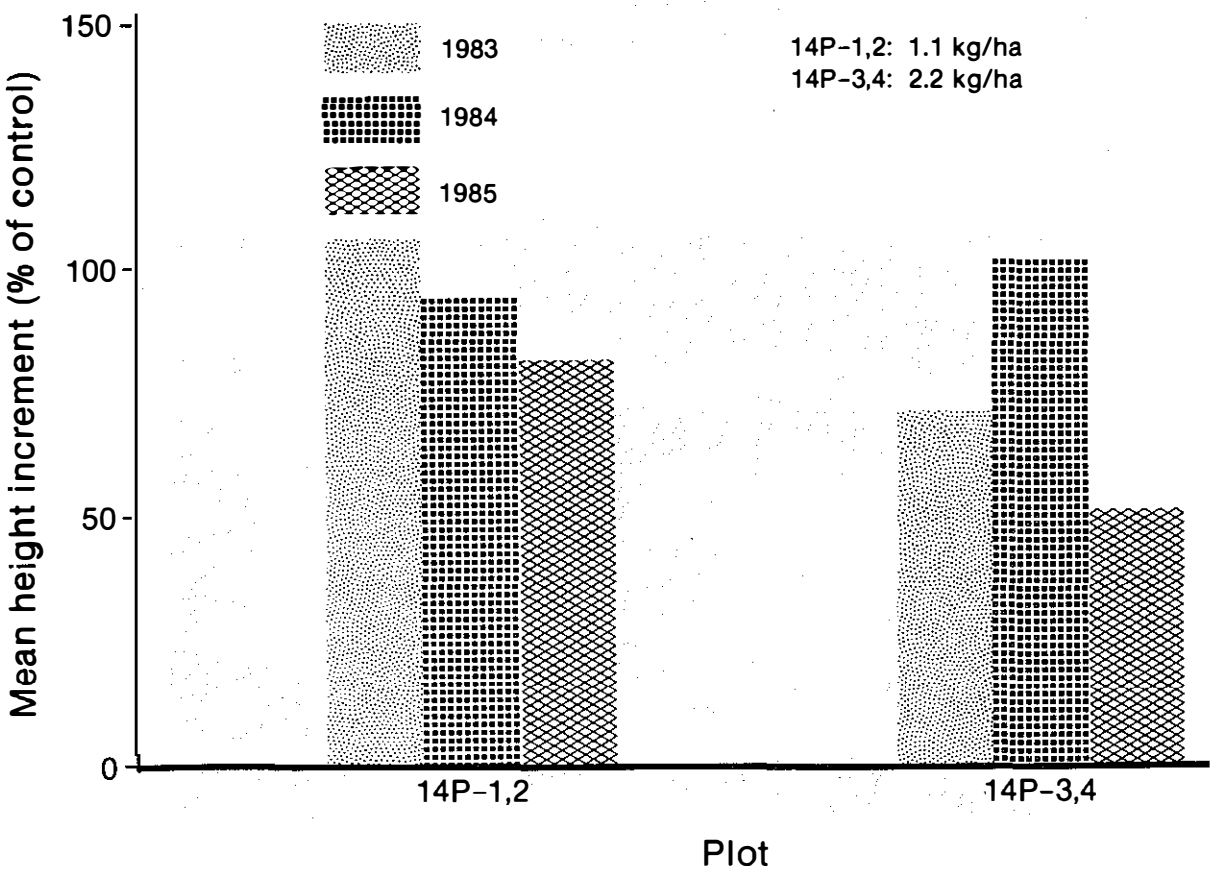

Figure 27. Red pine growth response to herbicide treatments near Piney, Manitoba, showing 1983–85 mean height increment as a percentage of the control following spring 1984 application of hexazinone liquid on plots 14P-1,2,3,4.

ACKNOWLEDGMENTS

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APPENDIX 1

SUMMARY OF 1980–85 FIELD TRIALS IN ALBERTA

Plot[a]	Location and year	Chemical[b]	Dosage (kg/ha)	Replication	Grid spacing (m)	Crop tree[c]	Type[d]	Time of application	Weed control[e]	Crop tree tolerance
1-4F	Faust 1980	Hexazinone GB, 2.0 cm³, 10%	1.1	Yes	1.80	wS	CR	Summer	8.0	Good
2-5F	Faust 1980	Hexazinone GB, 2.0 cm³, 10%	2.2	Yes	1.30	wS	CR	Summer	9.0	Good
3-6F	Faust 1980	Hexazinone GB, 2.0 cm³, 10%	3.3	Yes	1.05	wS	CR	Summer	9.0	Fair
4F-1	Faust 1981	Hexazinone GB, 0.5 cm³, 20%	1.7	No	1.05	wS	CR	Spring	7.0	Good
4F-2	Faust 1981	Hexazinone GB, 0.5 cm³, 20%	3.4	No	0.75	wS	CR	Spring	8.0	Good
4F-3	Faust 1981	Hexazinone GB, 0.5 cm³, 20%	5.6	No	0.60	wS	CR	Spring	7.0	Fair
5F-4	Faust 1981	Hexazinone GB, 0.5 cm³, 10%	1.7	No	0.51	wS	CR	Spring	7.0	Good
5F-5	Faust 1981	Hexazinone GB, 0.5 cm³, 10%	3.4	No	0.36	wS	CR	Spring	7.0	Good
5F-6	Faust 1981	Hexazinone GB, 0.5 cm³, 10%	5.6	No	0.30	wS	CR	Spring	9.0	Fair
6F-1,3	Faust 1981	Hexazinone G, 20%	2.8	Yes	—	wS	CR	Spring	7.0	Good
6F-2,4	Faust 1981	Hexazinone G, 20%	5.6	Yes	—	wS	CR	Spring	9.0	Fair
7F-11	Faust 1981	Hexazinone G, 20%	2.8	No	—	wS	CR	Fall	8.0	Good
7F-12	Faust 1981	Hexazinone G, 20%	5.6	No	—	wS	CR	Fall	9.0	Good
*8F-13a	Faust 1981	Hexazinone GB, 1.0 cm³, 20%	2.2	No	1.30	wS	CR	Summer	—[f]	Discontinued
*8F-13b	Faust 1981	Hexazinone GB, 1.0 cm³, 20%	4.4	No	0.90	wS	CR	Summer	—	Discontinued
*9F-14	Faust 1981	Hexazinone G, 20%	1.8	Yes	—	wS	CR	Spring	—	Discontinued
*10F-15a	Faust 1982	Metsulfuron methyl, 75%	53 g/ha	Yes	—	wS/lP	CR/SP	Spring	4.0	Fair/poor
*10F-15b	Faust 1982	Metsulfuron methyl, 75%	188 g/ha	Yes	—	wS/lP	CR/SP	Summer	6.0	Good/poor
*10F-15c	Faust 1982	Metsulfuron methyl, 75%	375 g/ha	Yes	—	wS/lP	CR/SP	Fall	7.0	Good/poor
11F-16	Faust 1983	Hexazinone G, 20%	2.8	Yes	—	wS	CR	Spring	8.0	Good
12F-17	Faust 1983	Hexazinone G, 20%	5.6	Yes	—	wS	CR	Spring	9.0	Good
13F-18	Faust 1983	Fluazifop-butyl	250 g/ha	No	—	wS	CR	Spring	2.5	Good
*14F-19	Faust 1983	Metsulfuron methyl, 75%	375 g/ha	No	—	wS	CR	Spring	7.0	Poor
15SL-20	Slave Lake 1983	Hexazinone G, 20%	5.6	No	—	wS	CR	Spring	9.0	Good
△25F-SCa	Faust 1984	Hexazinone L, spot gun	8.6	Yes	1.50	wS	CR	Spring	8.0	Poor
△25F-SCb	Faust 1984	Hexazinone L, spot gun	2.4	Yes	2.00	wS	CR	Spring	9.0	Good

1,2	Edson 1980	Bromacil, spot gun	5.9	Yes	1.80	lP	CT	Summer	8.0	Poor
4,5	Edson 1981	Bromacil, spot gun	3.0	Yes	1.80	lP	CT	Summer	6.0	Fair
GP1-1,2	Grande Prairie 1980	Hexazinone L, spray	0.9	Yes	0.60	wS	CR	Fall	3.0	Fair
GP2-1,2	Grande Prairie 1980	Hexazinone L, spray	1.3	Yes	0.60	wS	CR	Fall	3.0	Fair
GP3-1,2	Grande Prairie 1980	Hexazinone L, spray	1.8	Yes	0.60	wS	CR	Fall	6.0	Poor
GP4-1	Grande Prairie 1981	Hexazinone L, spray	0.9	Yes	—	wS	CR	Spring	3.0	Poor
GP5-2	Grande Prairie 1981	Hexazinone L, spray	1.3	Yes	—	wS	CR	Spring	3.0	Poor
GP6-3	Grande Prairie 1981	Hexazinone L, spray	1.8	Yes	—	wS	CR	Spring	6.0	Poor
*GP7	Grande Prairie 1981	Bromacil, spot gun	2.4	Yes	—	lP	CR	Spring	8.0	Good
*GP8	Grande Prairie 1981	Hexazinone G, 20%, CS	2.8	No	—	lP/wS	CR	Fall	8.0	Good
*GP9	Grande Prairie 1981	Fosamine ammonium, spray	1.4	No	—	wS	CR	Fall	2.0	Good
GP10	Grande Prairie 1981	Hexazinone L, spray	2.2	Yes	—	wS	CR	Spring	9.0	Fair
GP11	Grande Prairie 1981	Hexazinone L, spray	3.2	Yes	—	wS	CR	Spring	9.0	Poor
*GP12-1	Grande Prairie 1981	Hexazinone G, 20%, CS	2.8	No	—	wS	CR	Summer	7.0	Good
*GP12-2	Grande Prairie 1981	Hexazinone G, 20%, CS	4.0	No	—	wS	CR	Summer	7.0	Good
△GP-13	Grande Prairie 1985	Hexazinone L, spot gun	4.3	Yes	1.50	wS	CR	Spring	8.0	Good
△CA-1a	Calling Lake 1984	Hexazinone L, spot gun	2.4	No	2.00	wS	CR	Spring	9.0	Good
△CA-1b	Calling Lake 1984	Hexazinone L, spot gun	4.3	No	1.50	wS	CR	Spring	9.0	Good
△CA-1c	Calling Lake 1984	Hexazinone L, spot gun	4.8	No	2.00	wS	CR	Spring	9.0	Good
△CA-1d	Calling Lake 1984	Hexazinone L, spot gun	8.6	No	1.50	wS	CR	Spring	9.0	Good
△CA-2a	Calling Lake 1984	Hexazinone L, aerial	2.2	Yes	—	lP/wS	CR/SP	Spring	7.0	Good
△CA-2b	Calling Lake 1984	Hexazinone L, aerial	3.2	Yes	—	lP/wS	CR/SP	Spring	7.0	Good
△CA-2c	Calling Lake 1984	Hexazinone L, aerial	4.3	Yes	—	lP/wS	CR/SP	Spring	9.0	Fair
△CA-3a	Calling Lake 1985	Hexazinone G, 10%, ground	1.0	Yes	—	wS	CR	Spring	9.0	Good
△CA-3b	Calling Lake 1985	Hexazinone G, 10%, ground	2.0	Yes	—	wS	CR	Spring	9.0	Good
△CA-3c	Calling Lake 1985	Hexazinone G, 10%, ground	4.0	Yes	—	wS	CR	Spring	9.0	Fair

a * = plot discontinued due to interference; △ = plot data incomplete.

b GB = grid ball; G = granular; L = liquid; CS = cyclone seeder.

c wS = white spruce; lP = lodgepole pine.

d CR = conifer release; SP = site preparation; CT = chemical thinning.

e 0 = no control; 9 = complete control.

f No results; trial discontinued.

APPENDIX 2

SUMMARY OF 1980–85 FIELD TRIALS IN MANITOBA

Plot[a]	Location and year	Chemical[b]	Dosage (kg/ha)	Replication	Grid spacing (m)	Crop tree[c]	Type[d]	Time of application	Weed control[e]	Crop tree tolerance
*13PF-1	Pine Falls 1981	Hexazinone GB, 0.5 cm³, 20%	1.70	No	1.50	bS	CR	Spring	5.0	Good
*13PF-2	Pine Falls 1981	Hexazinone GB, 0.5 cm³, 20%	3.40	No	1.05	bS	CR	Spring	5.0	Good
*13PF-3	Pine Falls 1981	Hexazinone GB, 0.5 cm³, 20%	5.00	No	0.81	bS	CR	Spring	6.0	Good
*13PF-4	Pine Falls 1981	Hexazinone GB, 0.5 cm³, 10%	3.40	No	1.05	bS	CR	Spring	5.0	Good
*13PF-5	Pine Falls 1981	Hexazinone GB, 0.5 cm³, 10%	6.70	No	0.75	bS	CR	Spring	7.0	Good
*13PF-6	Pine Falls 1981	Hexazinone GB, 0.5 cm³, 10%	11.20	No	0.60	bS	CR	Spring	6.0	Good
*14PF-1,2	Pine Falls 1981	Hexazinone G, 20%, CS	1.10	Yes	—	bS	CR	Spring	8.0	Fair
*14PF-3,4	Pine Falls 1981	Hexazinone G, 20%, CS	2.20	Yes	—	bS	CR	Spring	9.0	Good
*15PF-1A	Pine Falls 1981	Hexazinone GB, 0.5 cm³, 20%	1.70	No	1.50	bS	CR	Spring	6.0	Good
8AG-1	Agassiz 1981	Hexazinone GB, 0.5 cm³, 20%	1.70	No	1.05	wS/jP	CR	Spring	8.0	Good/poor
8AG-2	Agassiz 1981	Hexazinone GB, 0.5 cm³, 20%	3.40	No	0.75	wS/jP	CR	Spring	8.0	Fair/poor
8AG-3	Agassiz 1981	Hexazinone GB, 0.5 cm³, 20%	5.60	No	0.60	wS/jP	CR	Spring	9.0	Fair/poor
9AG-4	Agassiz 1981	Hexazinone GB, 0.5 cm³, 10%	0.85	No	0.51	wS/jP	CR	Spring	7.5	Good/Fair
9AG-5	Agassiz 1981	Hexazinone GB, 0.5 cm³, 10%	1.70	No	0.36	wS/jP	CR	Spring	8.0	Good/poor
9AG-6	Agassiz 1981	Hexazinone GB, 0.5 cm³, 10%	2.80	No	0.30	wS/jP	CR	Spring	9.0	Fair/poor
8AG-1A	Agassiz 1981	Hexazinone GB, 0.5 cm³, 10%	0.85	No	1.05	wS/jP	CR	Spring	7.0	Good/poor
8AG-2A	Agassiz 1981	Hexazinone GB, 0.5 cm³, 10%	1.70	No	0.75	wS/jP	CR	Spring	8.0	Fair/poor
8AG-3A	Agassiz 1981	Hexazinone GB, 0.5 cm³, 10%	2.80	No	0.60	wS/jP	CR	Spring	9.0	Fair/poor
10AG-1,3	Agassiz 1981	Hexazinone G, 20%, CS	1.10	Yes	—	wS	CR	Spring	8.0	Good
10AG-2,4	Agassiz 1981	Hexazinone G, 20%, CS	2.20	Yes	—	wS	CR	Spring	9.0	Fair
*10AG-5,6	Agassiz 1982	Hexazinone G, 20%, CS	1.80	Yes	—	wS	CR	Spring	7.0	Good
11P-1	Piney 1981	Hexazinone GB, 0.5 cm³, 10%	0.85	No	2.10	rP	CR	Spring	8.0	Good
11P-2	Piney 1981	Hexazinone GB, 0.5 cm³, 10%	1.70	No	1.50	rP	CR	Spring	9.0	Good
11P-3	Piney 1981	Hexazinone GB, 0.5 cm³, 10%	2.80	No	0.90	rP	CR	Spring	9.0	Fair
11P-4	Piney 1981	Hexazinone GB, 2.0 cm³, 10%	0.85	No	2.10	rP	CR	Spring	7.0	Good
11P-5	Piney 1981	Hexazinone GB, 2.0 cm³, 10%	1.70	No	1.50	rP	CR	Spring	9.0	Good
11P-6	Piney 1981	Hexazinone GB, 2.0 cm³, 10%	2.80	No	0.90	rP	CR	Spring	9.0	Fair

12P-1,3	Piney 1981	Hexazinone G, 20%, CS	2.80	Yes	—	rP	CR	Spring	7.5	Good
12P-2,4	Piney 1981	Hexazinone G, 20%, CS	5.60	Yes	—	rP	CR	Spring	9.0	Fair
13P-5,6	Piney 1982	Hexazinone G, 20%, CS	1.80	Yes	—	rP	CR	Spring	5.0	Good
△14P-1,2	Piney 1984	Hexazinone L, spray	1.10	Yes	—	rP	CR	Spring	—[f]	Good
△14P-3,4	Piney 1984	Hexazinone L, spray	2.20	Yes	—	rP	CR	Spring	—	Good

[a] * = plot discontinued due to interference; △ = plot data incomplete.

[b] GB = grid ball; G = granular; CS = cyclone seeder; L = liquid.

[c] bS = black spruce, wS = white spruce; jP = jack pine; rP = red pine.

[d] CR = conifer release.

[e] 0 = no control; 9 = complete control.

[f] No results; trial discontinued.