F. R. D. A. PROJECT 2.6 - E.P. 991.02

PROGRESS REPORT

THE CONVERSION OF MULTISTORIED BRUSH FIELDS TO CONIFEROUS PLANTATIONS - SECONDARY PLANT SUCCESSION

Results of Third Year Post-Treatment Sampling

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ABSTRACT

Bareroot Sitka spruce (*Picea sitchensis*) were planted on the high bench floodplain of the Skeena River at Salvus in spring 1972, following blade-scarification in 1971/72. Scattered 18 year old 1-3 metre tall Sitka spruce of low vigour can be found throughout Salvus beneath the 10-12 metre canopy of red alder (*Alnus rubra*).

With the intention of finding a successful silvicultural procedure for conversion of robust deciduous forest into a Sitka spruce and western redcedar (*Thuja plicata*) plantation, ten treatments including a control were selected. Pre-treatment vegetation sampling took place in August 1986. Treatments were applied in 1987, followed by post-treatment vegetation sampling in 1988, 1989 and 1990.

In GIRDLE, removal of the red alder overstory released the understory, mainly red elderberry (*Sambucus racemosa*), salmonberry (*Rubus spectabilis*) and thimbleberry (*Rubus parviflorus*). Existing plants increased rapidly in height and vigour, preventing re-establishment of red alder or, indeed, anything else. Apart from the lack of the alder canopy, vegetation composition and structure was very similar to CONTROL.

In BURN and HSQ/SPRAY, all of the existing vegetation was removed but the forest floor was not severely disturbed. Seed-banking species, especially red elderberry, quickly re-established as did a variety of other shrubs and herbs. Red alder cover has remained low, and structural and species diversity is highest on these plots.

BL/GRASS controlled the vegetation height and greatly slowed recolonization by shrub species; however, the extremely dense grass cover could have negative impacts on planted conifer seedlings and certainly has short-term negative impacts on biodiversity. The other two bladed treatments (BLADE and SP/BLADE) have resulted in very dense regrowth of young alders from seed. This might be partially avoidable by scarifying in spring before the arrival of wind-borne alder seeds in late summer. As performed at Salvus, these treatments seem to be most useful for enhancing vole populations.

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INTRODUCTION

Biogeoclimatic ecosystem classification (Pojar et al, 1987) in British Columbia has concentrated primarily on the description and interpretation of climax ecosystems. Resource managers (range, wildlife and silviculture) are increasingly concerned with the managing of seral ecosystems (Banner et al, 1986) as the surface area of logged or otherwise disturbed area expands. Concerns about forest regeneration in British Columbia have led to the development of criteria and guides for allocationg tree species on a site-specific basis (Bernardy et al, 1990; Pojar et al, 1987).

Old-growth coniferous stands on the extensive fluvial deposits at Salvus were logged between 1962 and 1965, blade scarified in 1971/1972 and planted with bareroot Sitka spruce in the spring of 1972 (Pollack 1987). However, the plantation failed, due to competition from red alder and shrubs such as salmonberry, thimbleberry, red elderberry and red-osier dogwood. Beneath the lush 10-12 metre canopy of red alder, the stunted 18-year-old shade-intolerant (Krajina et al, 1982) Sitka spruce are frequently less than 2 metres tall.

Salvus is located in the heart of the Coast Mountains, 60 km west of Terrace along the Skeena River, between the mouths of the Exchamsiks and Kasiks Rivers, within the Submontane Very Wet Maritime CWH (CWHvm1) biogeoclimatic variant. Predominantly the vegetation represents and early seral stage of the CWHvm1/Ss-Salmonberry site series of the high bench floodplain (Banner et al, 1990). Vermimull humus forms (Klinka et al, 1981) are predominant. Surrounded by flood channels, the soils of Salvus have developed through a continuous history of fluvial flooding events. the 54,000 km^2 Skeena River watershed is the fifth largest in B.C., after the Fraser, Liard, Peace and Columbia Rivers (Kerby 1984).

Yole (1986) divided the soils at the Salvus site into three main groups. The first group included those developed on elevated hummocks, which frequently contain decaying logs and organic debris accumulated during flooding. These well-drained coarse loamy and sandy soils have weak structure and minimal Ah development. Although these soils occupy less than 10% of the study area, they are important since many of the large Sitka spruce stumps appear concentrated on these hummocks. The second group of soils, which cover 70-80% of the area, are gleyed subgroups of Brunisols on level to gently undulating terrain. These Brunisols have granular, highly porous Ah horizon overlying a high bulk density silt horizon of varying thickness with plentiful fine and medium pores. The third group are Gleysols, occupying depressional sites including old stream channels and back eddies. These sites have surface water in winter and spring months, and cover 5-10% of the area.

Ten treatments were selected and replicated 3 times for a total of 30 study plots (Table 1). One permanent vegetation transect was established in each study plot in 1986, prior to stand conversion treatments in 1987. The transects lie outside the portion of the treatment plots planted with Cw, Hw and Ss seedlings.

METHODS

Thirty treatment plots of 0.5 to 1.0 ha. in area were established. Each plot had a permanent belt transect consisting of five $5m^2$ subplots (Figure 1). Within each subplot the vegetation layers A1-3, A-total, B1-2, B-total, C and D (Walmsley et al, 1980), as well as all layers combined, were assigned a visually estimated cover value. Species comprising the A1-3, B1-2, C and D layers were assigned percent cover, vigour and sociability values (Walmsley et al, 1980). Furthermore, mean height was measured for all species excluding the moss (D) layer species. See Banner et al (1986) for a more detailed description of the sampling scheme.

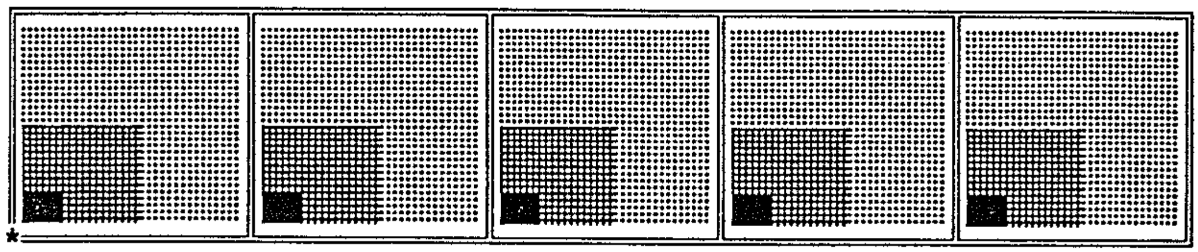


Figure 1. Each treatment plot has a permanent belt transect consisting of five $5m^2$ subplots within which tree-layer (A1-3) species are described. Nested within each subplot is a $3m^2$ area for characterizing shrub-layer (B1-2) species and a $1m^2$ area for herb- (C) and moss-layer (D) species. The asterisk marks the bottom left hand corner, or starting point, of the transect.

Western redcedar, western hemlock and Sitka spruce seedlings were planted after treatments in 1987. The conifer seedlings were planted elsewhere in the plot, not within the area of the vegetation transect. Of the ten treatments (Table 1) selected to control secondary succession, nine including a control have been evaluated (two somewhat cursorily but that's only temporary) in this report. Vegetation data were collected along each transect at the same time in August 1986 (pre-treatment) and in 1988, 1989 and 1990 (one, two and three years post-treatment).

Table 1 Description of stand conversion treatments.

No.	Treatment description	Replicate plot no.
1	Control, underplant	19, 30, 31
2	Blade, plant	2, 12, 20
3	Blade, plant, brush & weed with glyphosate	4, 17, 26
4 (2)*	Blade, plant, brush & weed manually	15, 24, 27
5	Blade, grass- and clover-seed, plant	3, 8, 13
6	Fell, burn, plant	1, 14, 28
7	Fell, burn, plant, brush & weed with glyphosate	9, 22, 25
8	Girdle alder, underplant	10, 18, 32
9	Site preparion with glyphosate, blade, plant	5, 21, 23
10	Hack & squirt alder, ground spray with glyphosate, plant	11, 29, 33

* *Manual brushing had not been completed at the time of sampling in August 1990. At this point, the affected plots were comparable to treatment 2 (BLADE). Treatment 4 was not evaluated in this report.*

To better understand the larger picture of vegetation succession, the three replicate transects per treatment have been grouped. Thus, in the figures that follow, each treatment is comprised of the vegetation data from three transect replicates, or 15 subplots.

DECORANA (DEtrended CORrespondence ANAlysis; Hill, 1979) was used on mean percent cover data to produce Figure 2, and graphs were produced using 3-D Perspectives.

RESULTS AND DISCUSSION

1. DECORANA analysis

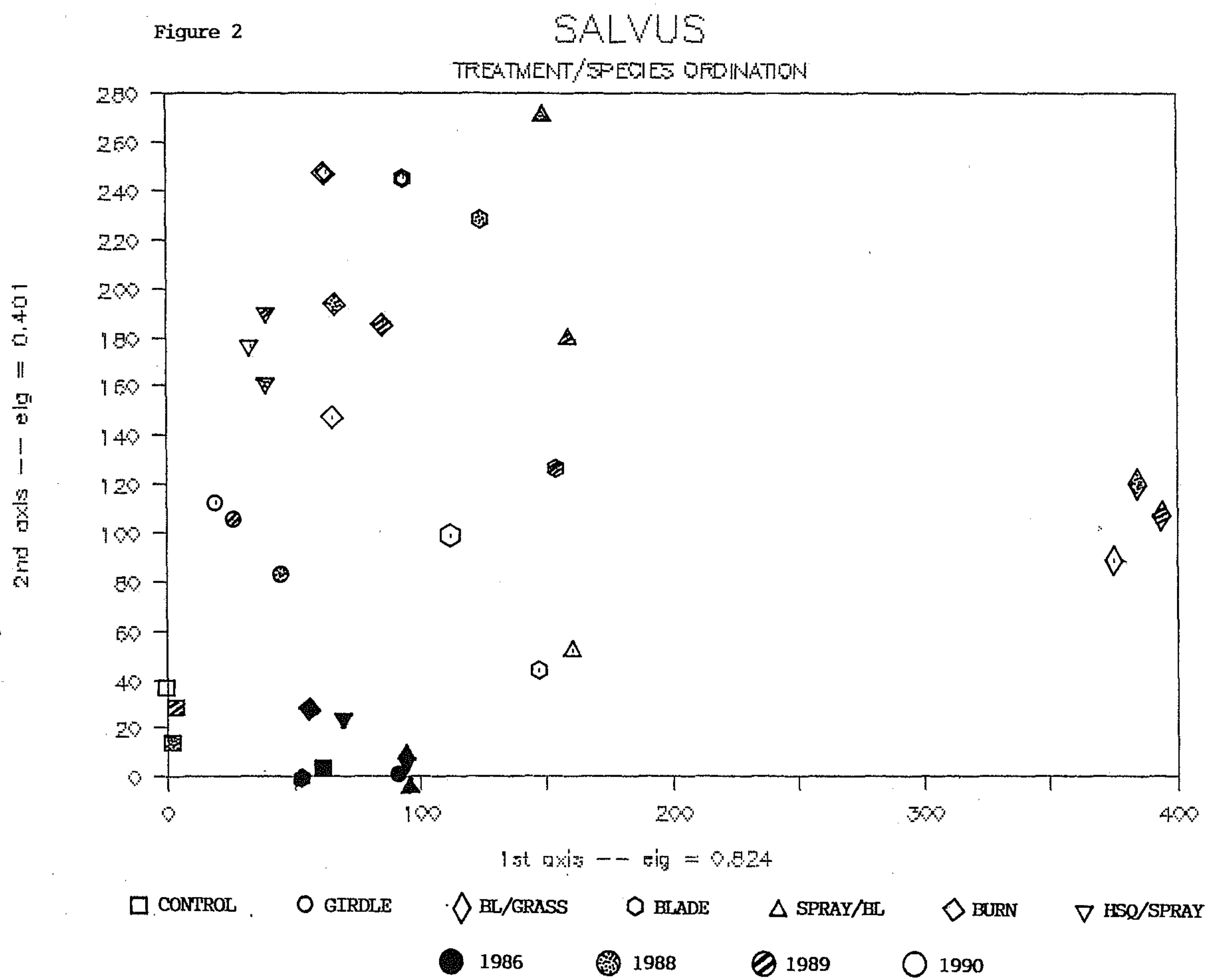
The computer ordination program DECORANA was used to illustrate the relationships between treated and untreated plots before and after treatment. DECORANA groups samples -- mean % cover of all species for each treatment in each year -- according to their relative similarities and differences. The resulting scatter diagram is shown in Figure 2.

The clearest grouping comprises the post-treatment BL/GRASS samples, which are isolated on the far right of the scatter diagram, reflecting their exotic species composition. Of the remaining samples, the pre-treatmnet samples are shown to be similar to each other and slightly less similar to the control. This is probably because red alder in CONTROL was assigned to the tree layer rather than to the tall shrub layer.

The post-treatment GIRDLE samples are shown to be fairly similar to both pre-treatment and control, whereas HSQ/SPRAY and BURN are shown to be similar to each other and less similar to other treatment plots. The BLADE and SPRAY/BL samples show the loosest grouping with little variation on the first axis but considerable variation on the second. They are probably fairly similar to each other, but the vegetation appears to be evolving more rapidly on these plots than on others.

BL/SPRAY and BURN/SPRAY in 1990 in 1990 (one year after the herbicide treatment) are grouped with BLADE and SPRAY/BL in 1988 (one year post-treatment), reflecting the pioneer seral vegetation complex in all four samples.

Figure 2



SALVUS
TREATMENT/SPECIES ORDINATION
2nd axis -- eig = 0.401
1st axis -- eig = 0.824
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
0
100
200
300
400
CONTROL
GIRDLE
BL/GRASS
BLADE
SPRAY/BL
BURN
HSQ/SPRAY
1986
1988
1989
1990

2. Treatment effects on the cover of major vegetation layers

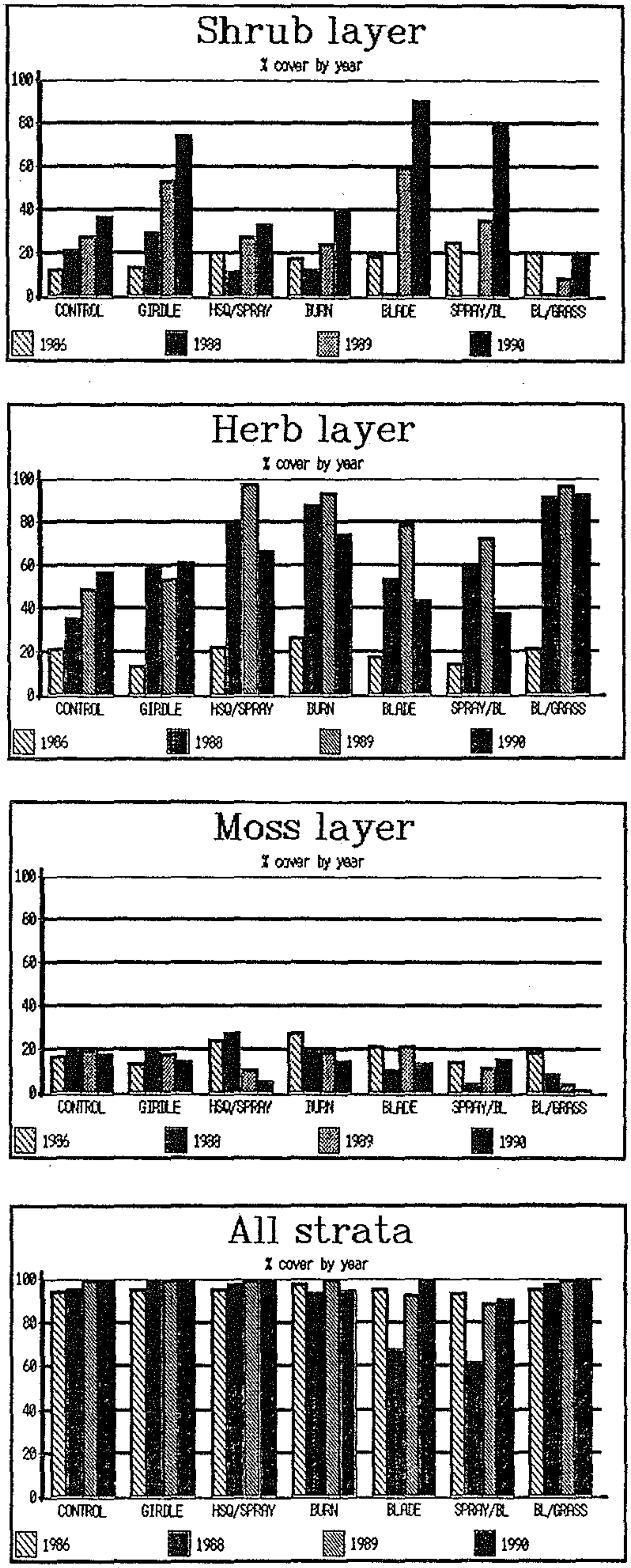
Before treatment, in 1986, cover was similar for all vegetation types. One year after treatment, in 1988, tree and shrub cover was reduced in all treatments except GIRDLE. However, shrub cover increased in the second and third years after treatment and by 1990 it had surpassed pre-treatment levels in all treatments except BL/GRASS. In GIRDLE, BLADE and SPRAY/BL, shrub cover was increased by 200 - 450% between 1986 and 1990. It should be noted that shrub cover in the control also increased by 200%.

With the opening of the canopy, the herb layer increased in all treatments, especially BL/GRASS, which had been given a head start by seeding with grasses and clover. However, in all treatments except GIRDLE, % cover in the herb layer peaked in 1989 and had started to decline in 1990. This was especially noticeable in BLADE and SPRAY/BL, where it was due to the dense shrub cover of young alders. However, a decrease was also marked in BURN and HSQ/SPRAY, where total shrub cover was much less.

BL/GRASS and HSQ/SPRAY showed particularly drastic declines in the moss layer. In both cases, this was probably due to an increasingly thick soil litter layer, composed of dead grasses in BL/GRASS and of many small pieces of broken dead twigs in HSQ/SPRAY.

Total % cover for each vegetation layer is shown in Figures 3a - d.

Figure 3 Total percent cover by strata, 1986 - 1990



3. Treatment effects on the cover of selected species

Treatments are generally arranged for discussion following the order of similarity indicated by DECORANA: CONTROL, GIRDLE, HSQ/SPRAY, BURN; then BLADE and SPRAY/BLADE; then BL/GRASS which is dissimilar to all others. This order is also used on the bar graphs in Figures 4 - 7.

3.1. Trees and shrubs

GIRDLE and HSQ/SPRAY have both virtually eliminated red alder by killing the original plants without producing a substrate suitable for germination of alder seed. However, both of these treatments caused a large increase in red elderberry (*Sambucus racemosa*) and (in GIRDLE) also in salmonberry (*Rubus spectabilis*) and thimbleberry (*Rubus parviflorus*), probably from increased growth of existing plants. In HSQ/SPRAY, existing plants were killed by the herbicide, but red elderberry has quickly re-established. BURN also greatly reduced red alder (to around 10% cover in 1990) and has slowed but not prevented the increase of salmonberry and thimbleberry.

The BLADE treatments, except for BL/GRASS, were immediately invaded by extremely dense red alder growth which reached 2m high and 80-90% cover by 1990. This suppressed most other shrub and herb species. In BL/GRASS, grass seeding slowed the rate of shrub establishment so that cover values for red alder, salmonberry and thimbleberry were still well below pre-treatment levels, although red alder was starting to increase quite rapidly in 1990.

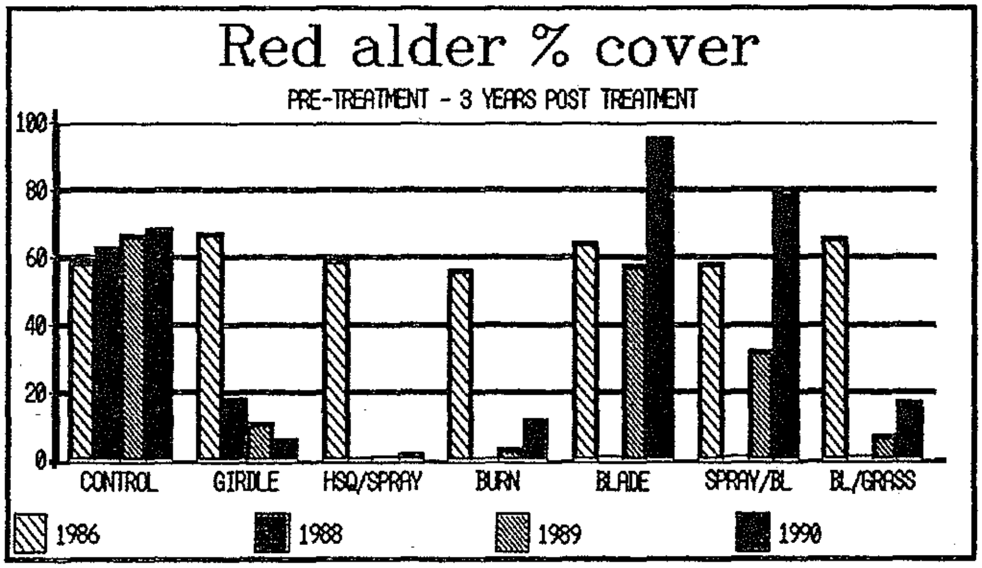
Cover values for red alder, red elderberry, salmonberry and thimbleberry are shown in Figures 4a - d.

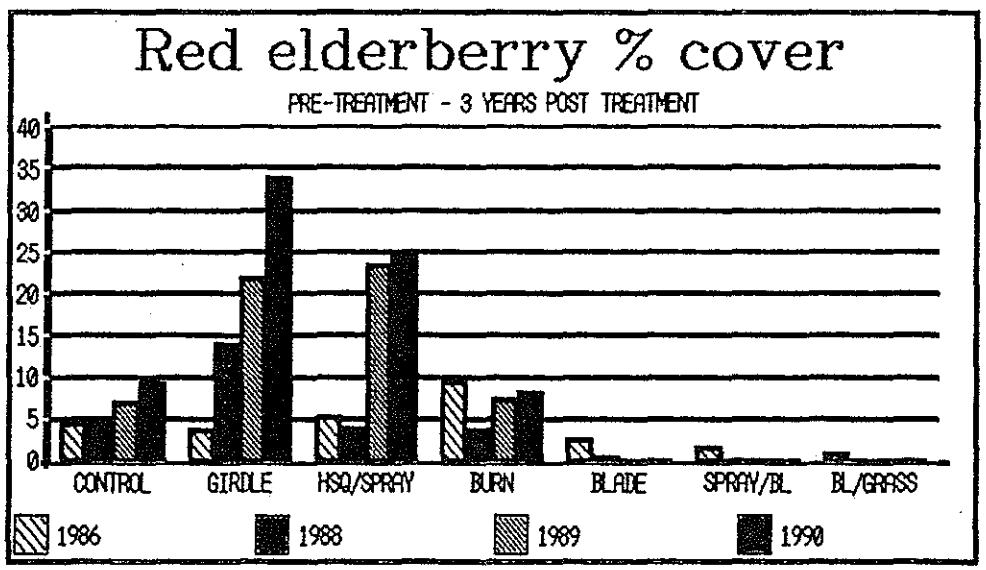
3.2. Herbs

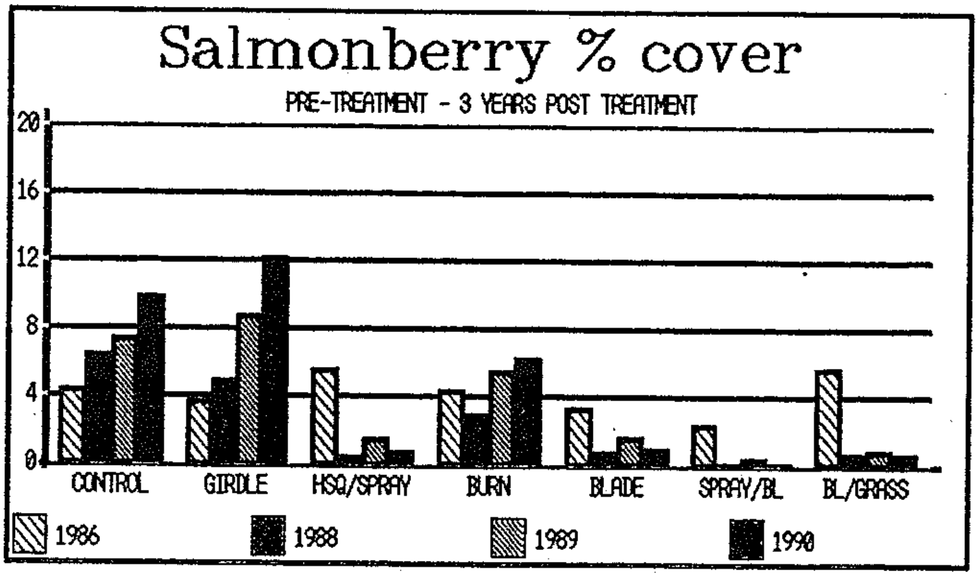
Cover values for representative herb species are shown in Figures 5a - f.

Both CONTROL and GIRDLE had well-developed herb layers, including large, robust species such as lady fern (*Athyrium felix-femina*), goatsbeard (*Aruncus dioicus*), tall fringecup (*Tellima grandiflora*) and kneeling angelica (*Angelica genuflexa*) which are considerably increased from 1986 levels. These species were much less abundant on the more severely disturbed bladed plots. In addition, GIRDLE showed increasing cover of Mexican hedge-

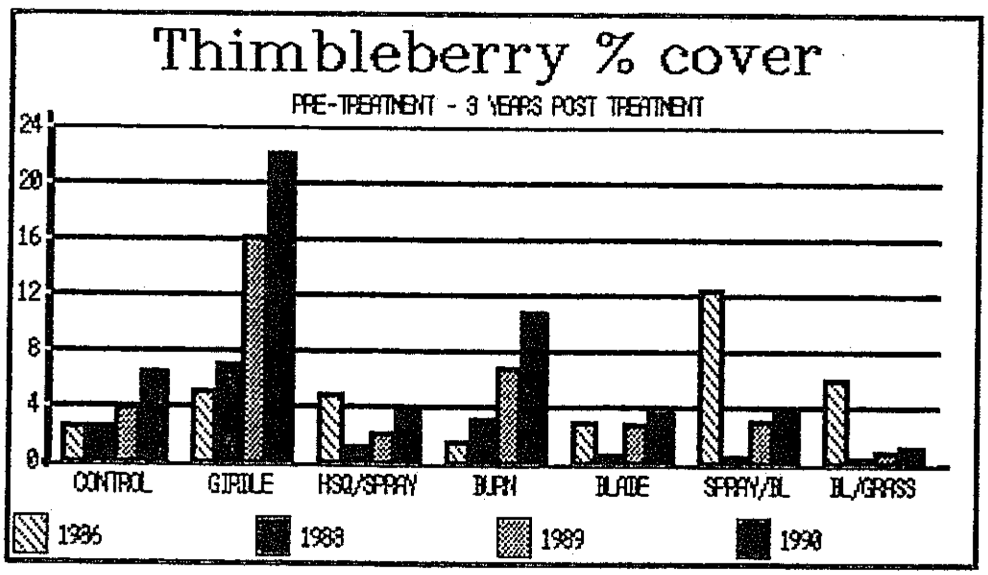
Figure 4 Mean percent cover for selected shrub species, 1986 - 1990







Salmonberry % cover
PRE-TREATMENT - 3 YEARS POST TREATMENT
20
16
12
8
4
0
CONTROL
GIRDLE
HSQ/SPRAY
BURN
BLADE
SPRAY/BL
BL/GRASS
1986
1988
1989
1990



Thimbleberry % cover
PRE-TREATMENT - 3 YEARS POST TREATMENT
24
20
16
12
8
4
0
CONTROL
GIRDLE
HSQ/SPRAY
BURN
BLADE
SPRAY/BL
BL/GRASS
1986
1988
1989
1990

nettle (*Stachys mexicana*) and stinging nettle (*Urtica dioica*).

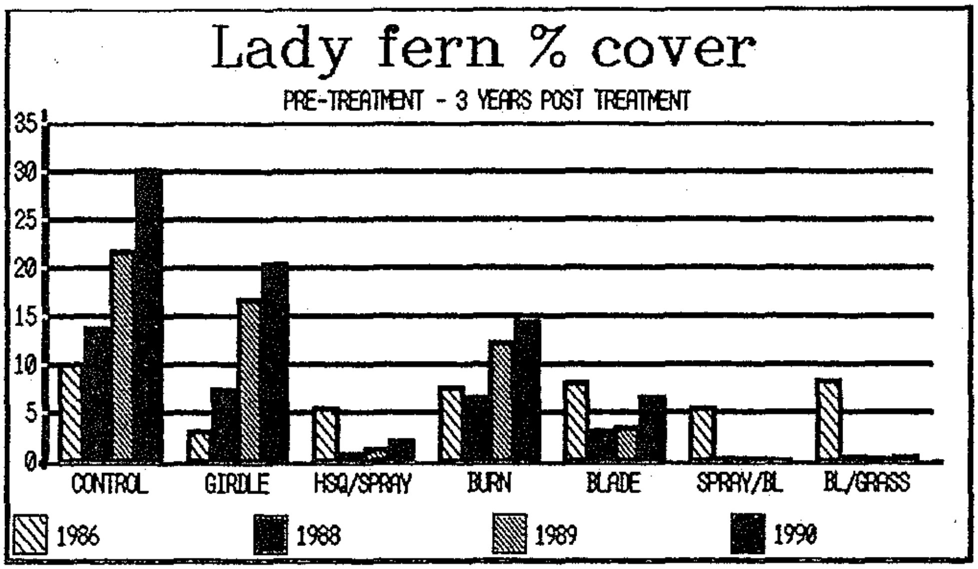
In BURN, HSQ/SPRAY, BLADE and SPRAY/BL, the herb layer decreased in 1990 with the increasing shrub layer. Early successional species such as purple-leaved willowherb (*Epilobium ciliatum*), large-leaved avens (*Geum macrophyllum*), common horsetail (*Equisetum arvense*) and, in particular, most grasses reached a peak in 1989 and started to decline in 1990. Mexican hedge-nettle, another early seral species, continued to increase especially in HSQ/SPRAY and BURN. This could be due at least partly to disturbance by humans and wildlife. The belt transect baseline had sometimes been used as a game trail, probably following trampling by human visitors, and this impacts mostly on the 1 x 1 metre subplot. In three cases, an entire subplot had been used as a moose bed and little vegetation other than hedge-nettle remained.

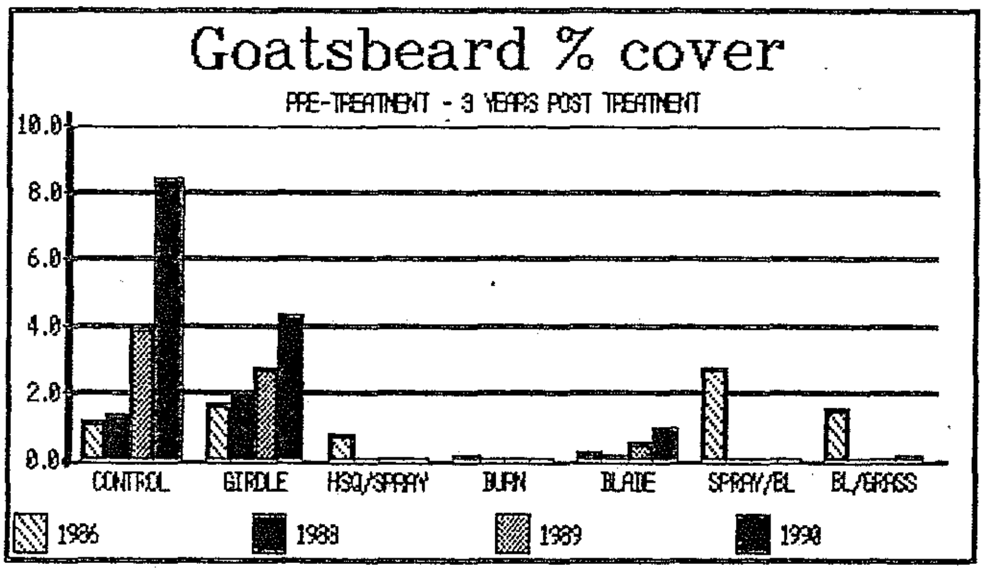
In BL/GRASS, the herb layer was completely dominated by creeping red fescue (*Festuca rubra*). Alsike clover (*Trifolium hybridum*) and orchardgrass (*Dactylis glomerata*) averaged 4% and 2% cover respectively, and no other herb species exceeded 2%. The evolution of the grass-clover mix is shown in Figure 6.

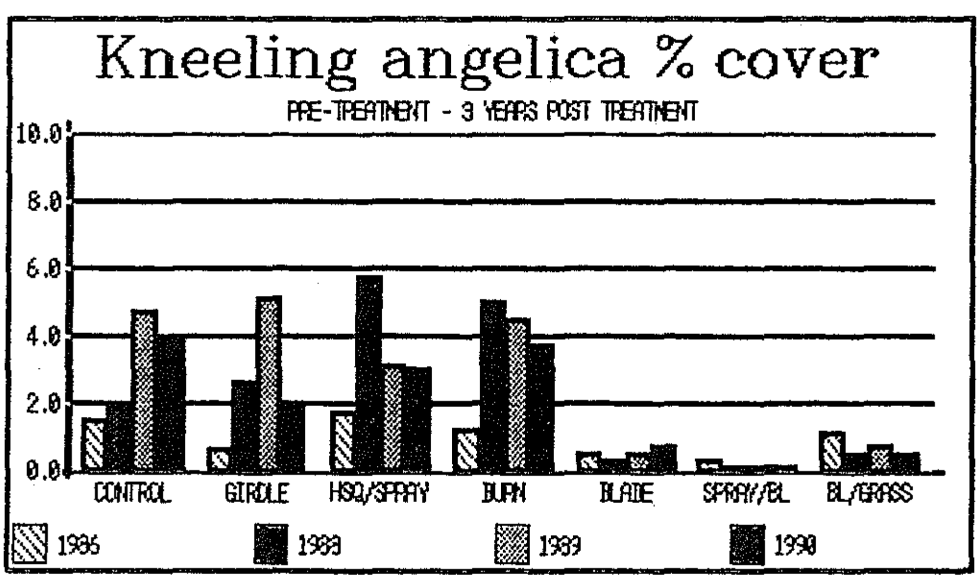
3.3. Moss

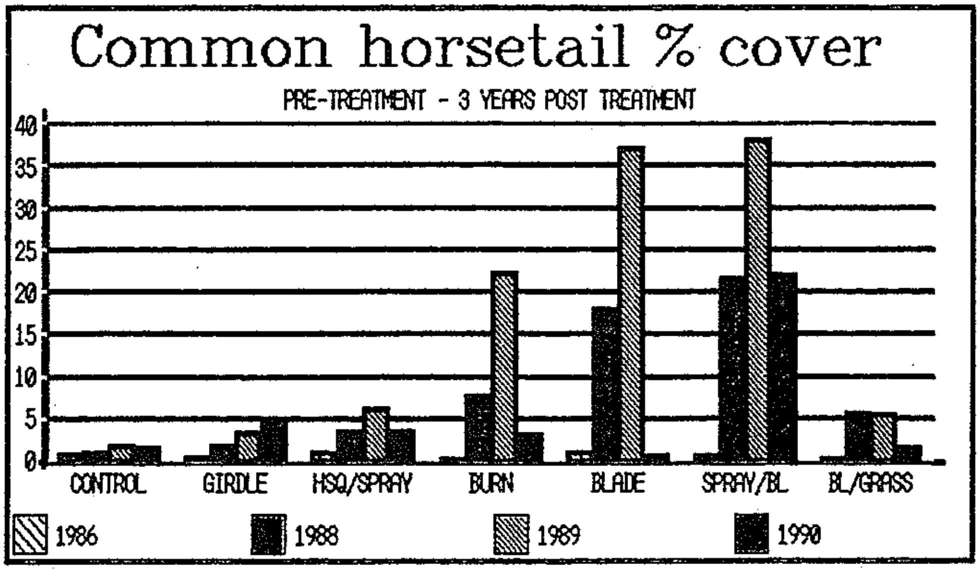
In most plots, the dominant mosses in 1986 were *Plagiomnium insigne* and *Brachythecium* spp. *P. insigne* showed a marked decline after all treatments ecept GIRDLE. This could be caused by increased litterfall or by increased solar radiation reaching and drying the soil surface.

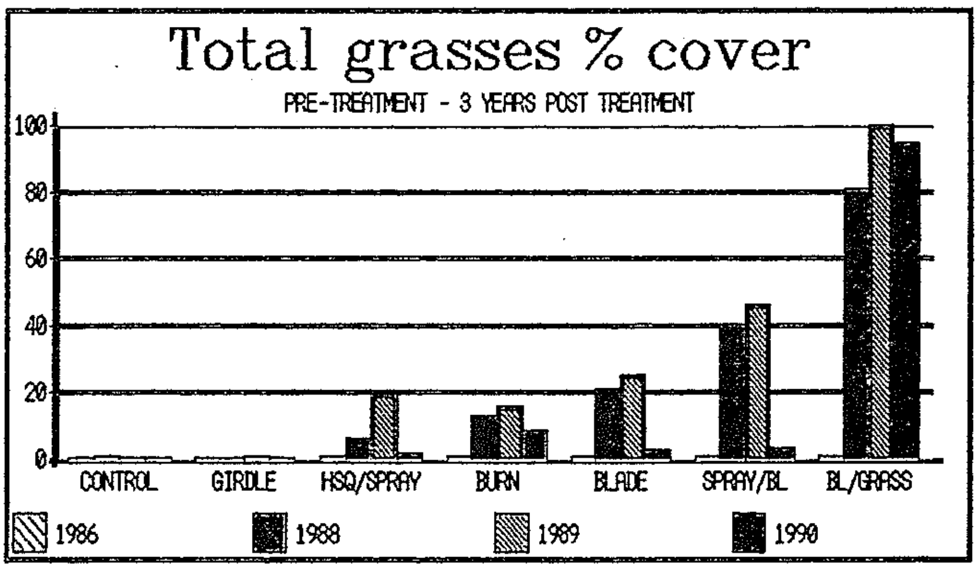
Figure 5   Mean percent cover for selected herb species, 1986 - 1990








Common horsetail % cover
PRE-TREATMENT - 3 YEARS POST TREATMENT
40
35
30
25
20
15
10
5
0
CONTROL
GIRDLE
HSQ/SPRAY
BURN
BLADE
SPRAY/BL
BL/GRASS
1986
1988
1989
1990


Total grasses % cover
PRE-TREATMENT - 3 YEARS POST TREATMENT
100
80
60
40
20
0
CONTROL
GIRDLE
HSQ/SPRAY
BURN
BLADE
SPRAY/BL
BL/GRASS
1986
1988
1989
1990

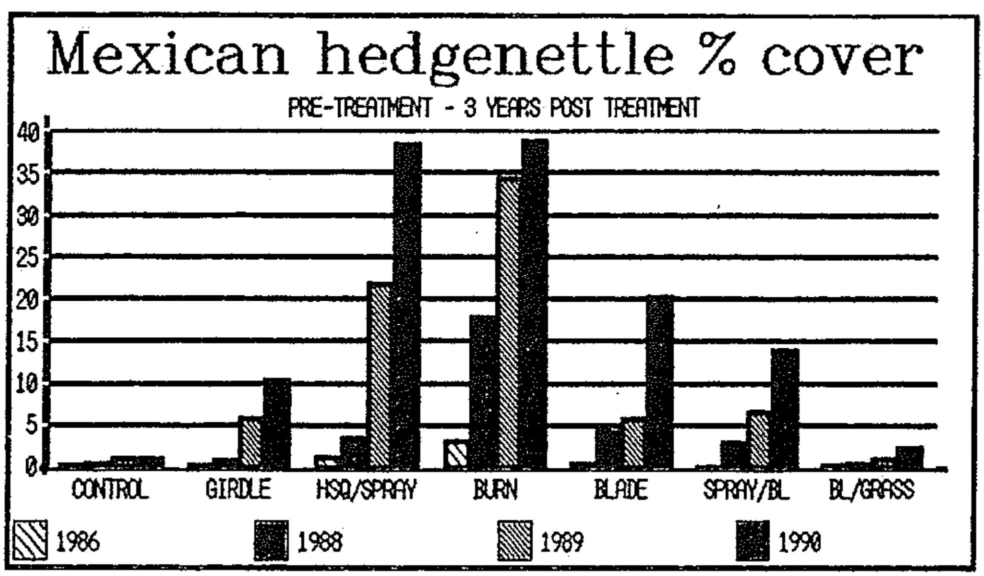
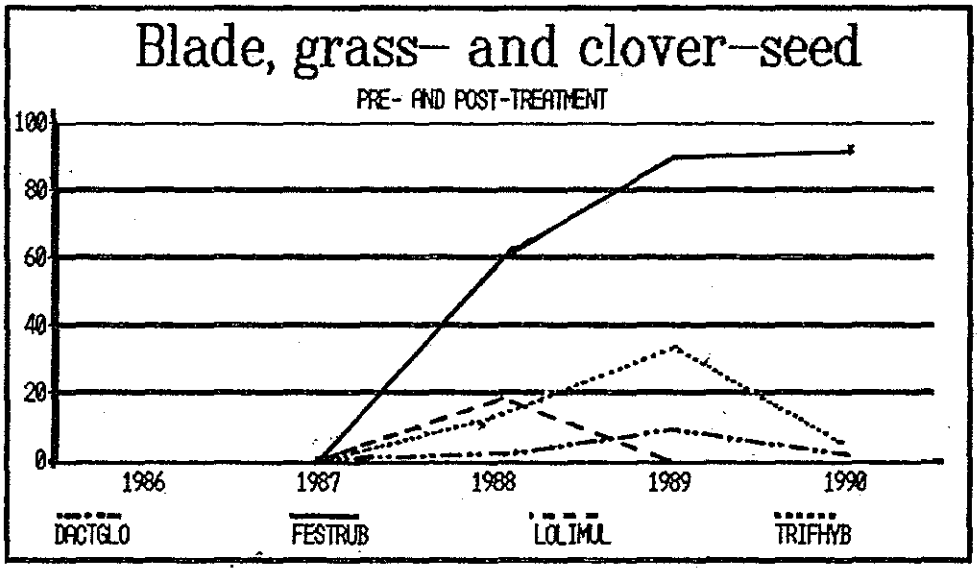

Mexican hedgenettle % cover
PRE-TREATMENT - 3 YEARS POST TREATMENT
40
35
30
25
20
15
10
5
0
CONTROL
GIRDLE
HSQ/SPRAY
BURN
BLADE
SPRAY/BL
BL/GRASS
1986
1988
1989
1990

Figure 6 Mean percent cover for grasses and clover seeded in treatment no. 5, 1986 - 1990



4. Biodiversity and wildlife considerations

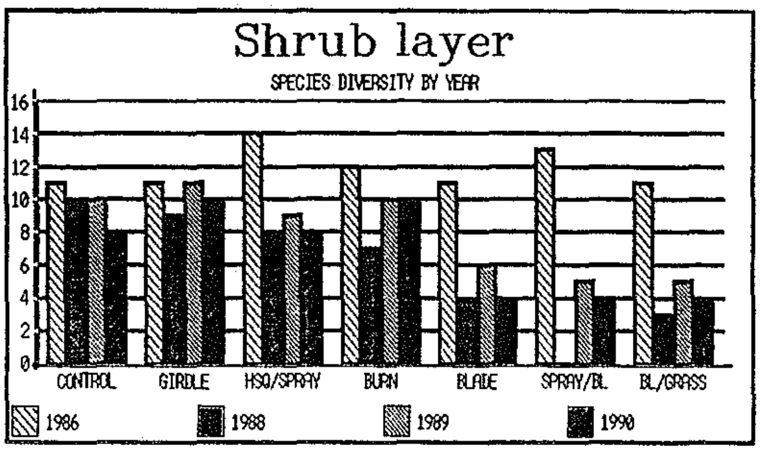
The object of the Salvus project is to suppress the existing vegetation to allow the establishment of seedling conifers. One inevitable consequence of this is a reduction of species and structural diversity at least in the short term and especially in the tree and shrub layers. Species diversity is shown as a series of bar graphs in Figure 7a - d.

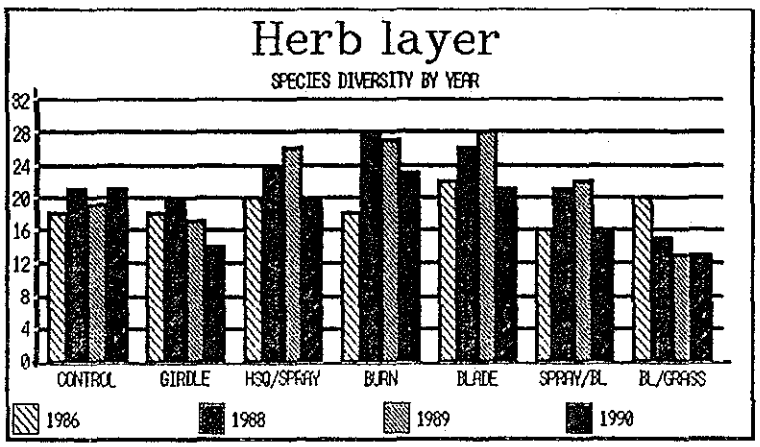
This reduction is most marked in the bladed treatments, where the 11 - 13 species originally present have been reduced to 4. Structural diversity is almost non-existant and the plots are dominated by one species -- red alder in BLADE and SPRAY/BL, creeping red fescue in BL/GRASS. The latter seems likely to become dominated by red alder in future years. Vole activity was noticeable in the bladed treatments as runways in BL/GRASS and as girdling of young alder stems in BLADE and SPRAY/BL. This corresponds with Coates et al (1990), who found very high incidence of vole damage to conifer seedlings in bladed plots. Vole populations could have been increased by windrowing the original vegetation around the edges of the plots, which provided excellent vole habitat.

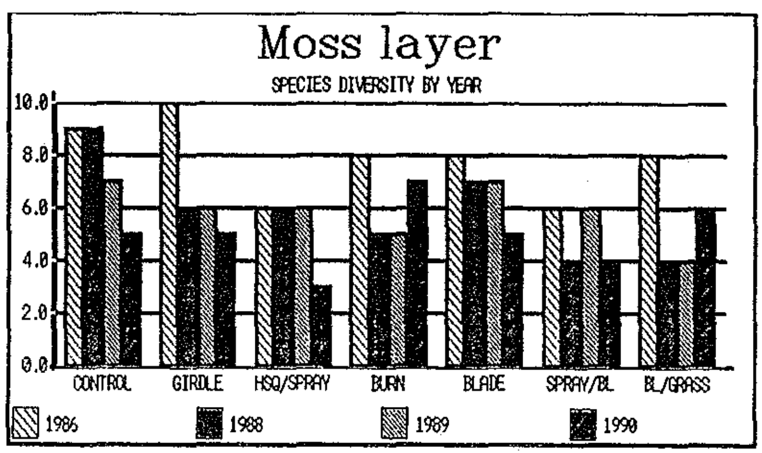
GIRDLE, HSQ/SPRAY and BURN have retained much of their species diversity in the shrub layer, although shrub cover in HSQ/SPRAY and BURN has increased less quickly than in the control. These plots have also retained some structural diversity, as green trees and alder snags in GIRDLE and HSQ/SPRAY and as scattered coarse woody debris in BURN. Berry-bearing shrubs (elderberry, thimbleberry and salmonberry) rather than red alder dominated these plots and wildlife use was noticeably higher, especially birds in HSQ/SPRAY and moose and bears in BURN. Vole activity was much less noticeable and rodent damage to conifer seedlings was much less than in bladed plots (Coates et al 1990).

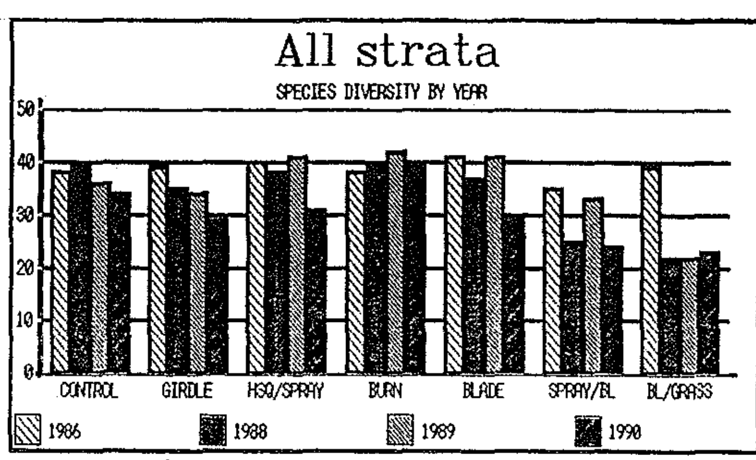
All treatments except BL/GRASS showed a temporary increase in species diversity in the herb layer in 1988-89; however, this declined to pre-treatment levels in 1990, either with shrub canopy closure or possibly with the end of the soil nutrient flush in BURN. With the general decrease in shrub and moss species, overall species diversity declined considerably in every treatment except BURN.

Figure 7 Species diversity by strata, 1986 - 1990









CONCLUSIONS

The wide selection of treatments at Salvus has provided an opportunity to gather considerable information on the difficulty of etablishing conifer plantations on some of the most productive soils in the Skeena River valley. Competition for space and light after removal of the tree canopy is fierce, regardless of the kind or severity of silvicultural treatments. Different treatments are effective at controlling different species. Nevertheless, none of the treatments have successfully blocked all of the serious competitors (Table 2).

Table 2 Common species competing against conifers in 1990

SPECIES	CONTROL	GIRDLE	BURN	HSQ/SPR	BLADE	SPRAY/BL	BL/GRASS
Red alder	+		+		*	*	*
Salmonberry	+	*	+	+	+		
Red elderberry	+	*	+	*			
Thimbleberry	+	*	*	+	+	+	
Lady fern	*	*	+				
Common horsetail		+					
Mex. hedge-nettle		+	*	*	*	*	
Tall fringecup	+	+	+	*	+		

In GIRDLE, removal of the alder canopy has released the understory, promoting the growth and vigour of existing plants but precluding the establishment of new ones. Pioneer species were uncommon on this site and it seems unlikely that conifer seedlings could survive.

Both BURN and HSQ/SPRAY removed the existing vegetation without severe disturbance to the forest floor. In 1990, the shrub layer was diverse but not dense, and comprised mainly seed-banking species such as red elderberry and pioneer herbs, especially Mexican hedge-nettle. Structural and species diversity were highest on these plots; however, the vigorous herb layer could still preclude seedling conifer establishment.

Vegetation in BLADE and SPRAY/BL were very similar -- the chemical treatment before blading seemed to have little effect. Blading provided an excellent substrate for germination of many types of seed, notably alder, grasses and common horsetail. However, in 1990 the alder dominated the plots and all other species were declining. Structural and species diversity were very low at these sites and they showed considerable evidence of vole presence. Between the alder and the voles, conifer establishment seems unlikely.

In BL/GRASS, grass-clover seeding largely prevented colonization of the site by native species. One of the seeded species (*Festuca rubra*) outcompeted the others and in 1990 dominated the site with over 90% cover. Red alder establishment had been slowed but not prevented and it seems likely that alder will dominate at least some of the subplots within two years. If conifer seedlings escape being choked by grass, they still have to face the alder. BL/GRASS showed the least species diversity, has no structural diversity and is a desert for any animal except cows and sheep.