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THE EFFECT

OF THINNING AND BURNING

ON PPdh2 UNDERSTORY

PLANT COVER

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Abstract

This study is designed to investigate the efficacy of stand-tending systems to rehabilitate over-stocked forests in the Ponderosa Pine biogeoclimatic zone. To determine the effect of different spacing/burning treatments on forage and wildlife resources, several treatment types were monitored within openings made between 15 and 20 years ago. Available light was taken as a more direct measure of the influence of canopy cover. Together with standard techniques for examining the composition of the understory vegetation, a number of stand tending sites were evaluated 15 to 20 years post-harvest. Techniques employed on these sites were examined for their efficacy in promoting the release of the understory vegetation. A number of preliminary conclusions are possible from this pilot study:

1) an average of 30% of the variability in the plant community was explained by the amount of available light,
2) a larger sample size would better accommodate the amount of variability in the plant communities found in the different treatments, especially below 30% and above 60% available light,
3) understory plant cover increases linearly with the amount of available light,
4) cover was approximately 15% higher on the burned sites than on the unburned sites,
5) available light averaged 41% at the 700 sph sites and 50% at the 400 sph sites,
6) there was no significant difference in the amount of understory plant cover between sites,
7) pinegrass frequency was highest when available light averaged 24% or less, from that point it declined to 0% at approximately 85% available light, and
8) rough fescue was absent at 5% available light and frequency was less than 25% up to 75% available light, from which point its frequency increased by 20% for each 5% increase in available light.

Forage release, in the 15 to 20 year span since these treatments, is mainly dependant on the nature of the herbaceous and shrub layer pre-treatment. While the composition of the pre-treatment understory plant cover was not available, we have shown that populations of rough fescue and pinegrass are light dependant. It appears as though burning speeds recovery, but again, pre-treatment data was not available with which to make comparisons.

This information will promote integrated resource management and improved ecological health in the Ponderosa Pine zone through integrated silviculture activities. This information will also refine methodology for investigation of the problem in the Interior Douglas-fir zone.

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1.0 Introduction

Dry forest types in the East Kootenay region of British Columbia suffer from excessive forest ingrowth. In the Rocky Mountain Trench and adjoining side-valleys, between the U.S. border and the Golden area, there are approximately 250,000 hectares of land in the Ponderosa Pine (PP) and the Interior Douglas-fir (IDF) biogeoclimatic zones (Gayton 1997). Both zones form part of Natural Disturbance Type 4 and are characterized by "frequent stand maintaining fires" (B€ Ministry of Forests/BC Environment 1995). Historically, fire returned to these sites every 5 to 50 years. Since the early 1930's, however, fire suppression and insufficient stand-tending activities have resulted in a serious forest ingrowth problem in these dry forest types.

These dry forest zones also include the grasslands and open forest types which support the livestock industry, and provide important winter and spring range for ungulate populations; which in turn support the hunting, guiding and tourism industries. Additionally, these forest types provide year-round habitat for a whole range of wildlife species and other natural values.

Various stand-tending systems have been used to remove excessive canopy cover and basal diameter from over-stocked sites. Timber resources, as well as forage and wildlife resources are expected to benefit from these treatments. These systems have focussed on reducing stem density to a pre-determined target number, usually by means of equidistant between-tree spacings. Spacing treatments are sometimes followed by a prescribed burn.

This study was designed to investigate the efficacy of stand-tending systems to rehabilitate over-stocked forests in the Ponderosa Pine biogeoclimatic zone. To determine the effect of different spacing/burning treatments on forage and wildlife resources, several treatment types were monitored within openings made between 15 and 20 years ago. In this way, the effectiveness of ecosystem rehabilitation practices can be monitored 15 to 20 years post-treatment. Light-penetration into the forest canopy and the composition of the understory herbaceous and shrub vegetation were taken as the primary measurements. Light penetration was taken as a more direct measurement of the influence of canopy cover. This information will promote integrated resource management and improved ecological health in the Ponderosa Pine zone through integrated silviculture activities. This information will also refine methodology for investigation of the problem in the Interior Douglas-fir zone.

The objectives of this project were:

1) Examine the post-harvest relationship between canopy closure and light penetration to the herbaceous and shrub layer following different spacing/burning treatments 15 to 20 years post-harvest.
2) Examine the composition of the herbaceous and shrub layer following different spacing/burning treatments.

3) Examine the effectiveness of various spacing/burning treatments in promoting the "release" of forage and browse production as a component of ecosystem restoration.

1.1 Site Description

The study took place in the St. Mary's Prairie, Cherry-TaTa and TaTa/Skookumchuck Range Units, all of which are located within the Cranbrook and Invermere Forest Districts in the East Kootenay region of British Columbia. These units represent a contiguous land area situated on the boundary between the 2 districts (Latitude 045° - 45', Longitude 115° - 43').

1.2 Soils and Landforms

The study area is located entirely within the Rocky Mountain Trench physiographic region (Holland 1976). Topography is described as moderately rolling, with prominent esker landforms (Lacelle 1990). The eskers are generally flat topped. Elevation ranges between 850 and 900 meters.

The Wycliffe soil association is the most common type in the study area. These soils developed on limestone-derived morainal parent material on valley floors and lower valley sides. These soils are mostly well-drained silt loams characterized by a clay accumulation layer (B_t), and a 'C' horizon with white carbonates on the underside of coarse fragments (Lacelle 1990). Wycliffe soils are well-drained, gravelly silt loams and are generally shallow solum soils classified as Orthic Eutric Brunisols. Wycliffe soil associations have developed in the Ponderosa Pine subzone of the Interior Douglas-fir zone (Lacelle 1990).

Elko, Fishertown and Hyak soils have developed on fluvioglacial parent material. These soils are silt loams or fine sandy loams in the upper soil horizon. Elko and Fishertown vary from very gravelly loam to very gravelly loamy sand in the lower fluvioglacial subsoil and may have substantial amounts of coarse fragments. These soils have developed in silty or sandy fluvial or aeolian veneers overlying gravelly fluvioglacial outwash plains, terraces and fans and are classified as Orthic Eutric Brunisols. Hyak soils are classified as Orthic Dark Brown Chernozems. These soil associations have developed within the Ponderosa Pine subzone of the Interior Douglas-fir zone (Lacelle 1990).

1.3 General Forest and Range Types

The Cherry/TaTa Range Unit is contained primarily within the Ponderosa Pine zone (Braumdahl and Curran 1992). Ponderosa pine [1] is the dominant tree species, however, douglas-fir, trembling aspen, lodgepole pine, western larch, black cottonwood and spruce are also present (Appendix 1).

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[1] Plant species names follow Hitchcock and Cronquist (1973).

Common shrubs within the area are bitterbrush, snowberry, rose, saskatoon, juniper, bearberry, chokecherry, soopolallie, bog-birch and low Oregongrape (Appendix 1).

Grass and grasslike species present on open range and treed grassland areas include; bluebunch wheatgrass, prairie Junegrass, Kentucky bluegrass, Canada bluegrass, rough fescue, Idaho fescue, western needlegrass and Columbia needlegrass (Appendix 1). Western yarrow, wild bergamo, nodding onion, balsamroot and Scottish bells are common forbs (Appendix 1).

Herbaceous vegetation found in open forest and closed forest areas includes pinegrass, rough fescue, Idaho fescue, bearded wheatgrass, asters and twinflower (Appendix 1).

Riparian areas are characterized by sedges, rushes, redtop, hair bentgrass and blue wildrye (Appendix 1). Domestic species commonly found in seeded areas such as roadsides, landings and utilities corridors include; orchardgrass, smooth bromegrass, slender wheatgrass, crested wheatgrass, timothy, red clover, alsike clover, sweet clover and alfalfa.

1.4 Treatment Prescriptions

Objectives for the block openings in the Cranbrook Forest District include general recommendations from the Trench Plan (TIRMP 1993):
1) selective harvesting, uneven-aged stand management, juvenile spacing,
2) native forage species desired,
3) spring and fall livestock range,
4) elk and white-tail winter, spring, summer and fall range, and migration routes,
5) snow interception and thermal cover, and
6) prescribed fire for stocking control, forage production or forage enhancement.

A summary of harvest dates, pre- and post-harvest stocking levels and soil associations can be found in Table 1.

Other specific objectives in the Cranbrook stand-tending reports include:
1) to reduce stocking for the release of leave trees, and
2) range enhancement.

Treatment prescriptions for juvenile spacing in the Invermere Forest District recognized thinning stagnating ponderosa pine as a principal objective. General objectives for block openings in the Invermere Forest District include:
1) juvenile space the area to approximately 330 to 400 stems per hectare,
2) improve grazing and make the area more accessible to cattle
2) enhance wildlife capability,
3) timber and forage production, and
4) improve timber quality.

Table 1. Harvest dates, pre-harvest and post-harvest stocking levels, and soil associations on stand-tending sites in the Cranbrook and Invermere Forest Districts.

Block	Treatment (sph)[1]	Year of Harvest	Year of Burn/Space	Pre-treatment (sph)	Post-treatment (sph)	Soil Association
Cranbrook						
18	400	1980	1980	3500	237	Wycliffe
10	700	1976	1980	1200	650	Wycliffe
22	400B[2]	1982	1982	1080	320	Hyak
26	700B	1977	1977	3139	750	Elko
Control				1290		Wycliffe
Invermere						
52	400	1981	1982	6025	330	Fishertown
52	700	1982	1982	8350	578	Fishertown
55	400B	1981	1982	6025	330	Fishertown
56	700B	1982	1983	8350	578	Fishertown
Control				2400		Fishertown

[1] sph = stems per hectare
[2] B = prescribed burn included in stand-tending operations

Slash management problems were noted in the Invermere proposals. It was recommended that slash be piled and burned the following spring to reduce fire hazard and insect susceptibility, and for range enhancement.

Forest harvest took place between 1976 and 1982. One project, block opening #10 in the Cranbrook FD, was harvested in 1976 and spaced in 1980. All other block openings were designed as stand-tending projects where specific objectives in terms of the number of stems per hectare (sph) were set. Prescribed burning, if applicable, took place the year following stand tending operations.

2.0 Methods

Baseline measurements were taken in late September and early October, 1997.

2.1 Stratification

Stratification by forest rehabilitation treatment was undertaken by selecting openings in ponderosa pine-leading timber types which had been treated 15 to 20 years previous. The following treatments were selected:
1) spaced to approximately 400 sph,
2) spaced to approximately 700 sph,
3) spaced to approximately 400 sph and burned,
4) spaced to approximately 700 sph and burned, and
5) a control selected from an adjacent unharvested stand which had similar stand density and composition to that of the openings pre-harvest.

The measurements were replicated by having one full set of each treatment in each of the 2 Forest Districts.

2.2 Range Reconnaissance

Following site stratification, a range reconnaissance survey was undertaken in order to delineate plant community types/canopy cover classes within treatments. Polygon boundaries were checked by means of field vegetation surveys. The reconnaissance level survey consisted of site visits for all treatment areas. The existing plant community was determined by occular estimate of percent foliar cover for each vegetation layer; trees - overstory, -understory, -regen, shrubs, forbs and grasses. The estimated tree stocking level was determined at this time with a 5.64 m. plot cord (if r=5.64 m. $\pi * r^2 = 0.01$ ha. #stems*100=sph). Total bryophyte cover and estimates of percent bare soil were recorded. Other plants, such as indicator species, noxious weeds and poisonous plants, were noted during the reconnaissance survey.

The primary purpose of the survey was to ground-truth the polygon borders within the initial block stratification, particularly those between open forest and closed forest. Harvest block boundaries tend to follow topographical borders, which do not always indicate ecological borders. As a result, areas of open grassland, treed grassland and open forest within logging block borders may be obscured.

2.3 Understory Plant Cover

A permanent 50 meter transect were established within each treatment using the following methodology (see Appendix 2). Herbaceous vegetation was sampled in ten 20 cm. X 50 cm. Daubenmire frames which were randomly located along the transects (Daubenmire 1959). These plots were nested within 1 m. X 2 m. plots. Tree and shrub cover was determined in these larger plots according to cover classes listed in Appendix 2. Transect ends were permanently marked with 1/2" rebar stakes, aluminum tags, and pink flagging tape. A tie-point consisting of a 7 cm. X 10 cm. aluminum tag was located on a prominent, nearby tree. Plot name, number and bearing and distance to the baseline were recorded on this tag. Plant species cover and frequency are presented in tabular form. Bare soil, bryophytes, litter and feces (amount and type) were also recorded. Aerial photographs were permanently marked with the transect location. Plot layout information is included in Appendix 2.

Percent cover for each species was calculated by averaging the cover estimates over all 100 plots at each treatment. Percent frequency for each species was calculated with the following formula:

$$\text{Frequency} = \frac{\text{Number of plots with species A}}{\text{Total number of plots sampled}} \times 100$$

Results are presented in Appendix 3.

2.4 Permanent Photo-points

Permanent photopoints were established at each transect location. Photos are located in Appendix 4.

2.5 Light Measurements

The percentage of the available light penetrating the overstory was calculated at each plant cover plot. The amount of light penetrating the canopy (diffuse non-interceptance) was calculated as the ratio of the diffuse light measured at the top of the Daubenmire frame used for the plant canopy cover measurement to the diffuse light measurement simultaneously taken from a vantage point with an unobstructed sky view. Diffuse non-interceptance was recorded with two LI-COR® LAI-2000 Plant Canopy Analyzers. Diffuse non-interceptance values were corrected for the intensity distribution of the sky

radiation above the canopy by using normalized values of the 5 mean gap fractions measured by the LAI-2000.

2.6 Statistical Analysis

The relationships between understory plant cover, available light and density of overstory trees were explored with linear regression techniques. Individual plant species, total graminoid cover, total forb cover, total shrub cover and total plant cover were regressed against their corresponding light measurements for each site. Logarithmic and square-root transformations of the plant cover data were also conducted in an attempt to improve the fit of the linear regressions. Comparisons of individual regression lines to determine if the relationship between sites was similar were to be conducted. However, no significant relationships between available light and understory (all $r^2<0.20$) were detected and, as such, comparisons of regression lines was not necessary. Data for each site were graphed and inspected for non-linear relationships.

Treatment averages for all sites were conducted: total average understory plant cover was regressed against average available light, with each site forming one point in the regression. Burned and unburned sites were regressed separately. Histograms of the frequency of select plant species at 10% increments of available light across all sites were also constructed. Average light availability at each tree stocking was also calculated.

3.0 Results

3.1 Understory Plant Cover

There are areas on these sites where the principal bunchgrass species, bluebunch wheatgrass, rough fescue and Idaho fescue, are still relatively abundant under a comparatively open forest canopy, but this is a minor portion. The more common scenario is canopy closure exceeding 30%, where the bunchgrasses are still present but with reduced density and vigour. In other areas the understory vegetation is dominated by pinegrass. Areas also exist where there is no understory vegetation whatsoever; it has been completely buried by needle-cast.

Shrubs such as saskatoon, bitterbrush, rose and buckbrush are present in the understory in the more open regions. Like the bunchgrasses, however, they appear subject to the same declines in density and vigour with increased forest canopy cover.

Plant community results are presented in Appendix 3.

The composition of the forest canopy was similar at all sites. Ponderosa pine cover ranged between 29-47% canopy cover at all sites except for the Cranbrook FD 760 sph burned site where cover was only 3%. Douglas-fir varied between 0-11%. Larch and lodgepole pine were the only other species to exhibit less than 5% cover at any site. Ponderosa pine regen was <1% at all sites, while douglas-fir regen ranged between 0-17%. Litter was between 67-89% at all sites, while bare soil was generally less than 5%.

Forest cover at the Control sites was dominated by ponderosa pine which ranged between 32-47%. Douglas-fir cover ranged between 1-23% of which up to 15% was comprised of overstory and understory trees. Douglas-fir regen was nearly 9% at the Cranbrook FD Control. Ponderosa pine regen was less than 1% at both sites. Pinegrass was the most common grass species at the Control sites ranging up to 7%. Idaho fescue cover was less than 2%, while rough fescue and bluebunch wheatgrass were both less than 1%. Old man's whiskers and small-flowered penstemon were the only forbs to exceed 1% cover. Bearberry was the most common shrub at the Control sites, contributing up to 5% of cover. Bitterbrush, low Oregongrape and soopolallie were the only other shrubs which exceeded 1% cover.

Forest cover was similar at the 400 sph and 700 sph unburned sites with ponderosa pine cover at approximately 30% and Douglas-fir at less than 1%. Ponderosa pine regen was less than 1%, while Douglas-fir regen was approximately 8%. Grass cover was noticeably higher than at the Control sites. Although pinegrass still contributed up to 14%, cover of Idaho fescue (3-14%), rough fescue (up to 3%) and bluebunch wheatgrass (up to 3%) were all higher than at the Control sites. The most notable difference was the higher Idaho fescue cover in the 400 sph sites. Pussytoes, spiny phlox, balsamroot, lupines, aster, wild strawberry and small-flowered penstemon were the only forbs to exceed 1% cover at these sites. Bitterbrush and bearberry were the dominant shrubs at the 400 sph sites, with saskatoon, soopolallie and rose also noted. Bearberry was dominant at the 700 sph sites with trace amounts of saskatoon, low Oregongrape and rose.

At the 400 sph and 700 sph burned sites ponderosa pine was the leading species on 3 of the blocks with cover between 30-42%. Lodgepole pine, ponderosa pine and Douglas-fir combined accounted for nearly 15% canopy cover at the Cranbrook FD 700 sph burned site. Pinegrass was not recorded at the Invermere FD 400 sph burned site, but ranged between 3-19% at the other burned sites. Idaho fescue and rough fescue were present at all sites with cover ranging between 1-7%, and 1-6%, respectively. Bluebunch wheatgrass was recorded at nearly 11% at the Invermere FD 400 sph burned site, but was less than 1% at all other burned sites. Forbs which exceeded 1% cover include; pussytoes, spiny phlox, old man's whiskers, small-flowered penstemon and stoneseed. Saskatoon, bearberry, low Oregongrape, bitterbrush and rose were found at most of the burned sites. Shrub composition was similar among sites, except for the Invermere FD 700 sph burned site where bearberry was nearly 48% cover, and the absence of bitterbrush at the Cranbrook FD sites.

3.2 Understory Plant Cover/Available Light Relationships

The amount of light penetrating the forest canopy was regressed against understory plant cover (Table 2). The resulting regression statistics revealed that when data from the unburned and burned sites were combined an average of 30% of the variability in the plant community was accounted for by the amount of light penetration. In the unburned sites a higher percentage of the plant community variability (r^2=0.39) was accounted for by light penetration than in the burned sites (r^2=0.25). The majority of the sites experienced light penetration in the range of 30-60%. It is likely that more sites were required, particularily in the lower (0-30%) and higher (60-100%) ranges of available light. This would have improved the fit of these relationships.

The amount of light penetrating to the understory is influenced by the percentage canopy cover, the size of the basal area of the stems and by stem density. Available light is the most important factor governing the composition of the understory vegetation. While no strong relationships were found with regression techniques, a definite linear trend can be observed between the available light penetrating the canopy and the percentage cover of the understory vegetation.

Understory plant cover increased with increasing light penetration. Light penetration at all sites varied from approximately 15-60%, while percentage understory plant cover at most sites was measured between 10-45% (Figure 1). The controls and two of the 700 sph sites are at the lower end of the graph in terms of light penetration (15-30%) and plant cover (10-40%), while at the 400 sph sites both light penetration (40-60%) and plant cover (35-40%) are higher.

Trend lines graphed for the burned and unburned sites reveal that cover is approximately 15% higher at the burned sites (Figure 1). This implies that burning following spacing treatments speeds recovery of understory vegetation. This may also partially explain why less of the variability in understory plant cover (r^2=0.25) was explained by the amount of available light in the burned sites.

Available light averaged 41% at the 700 sph sites while at the 400 sph sites it was 50%. No significant difference was found between understory vegetation at the 400 sph and 700 sph.

3.3 Frequency of Key Grasses at Different Light Regimes

No significant relationships were found between available light and cover of individual plant species. However, trends were noted in the distribution of individual species by frequency. Pinegrass and rough fescue were chosen as key species. Pinegrass is indicative of the lower available light conditions found in a closed forest, while the presence of rough fescue characterizes that of a more open forest. Figure 2 displays these species frequencies relative to available light.

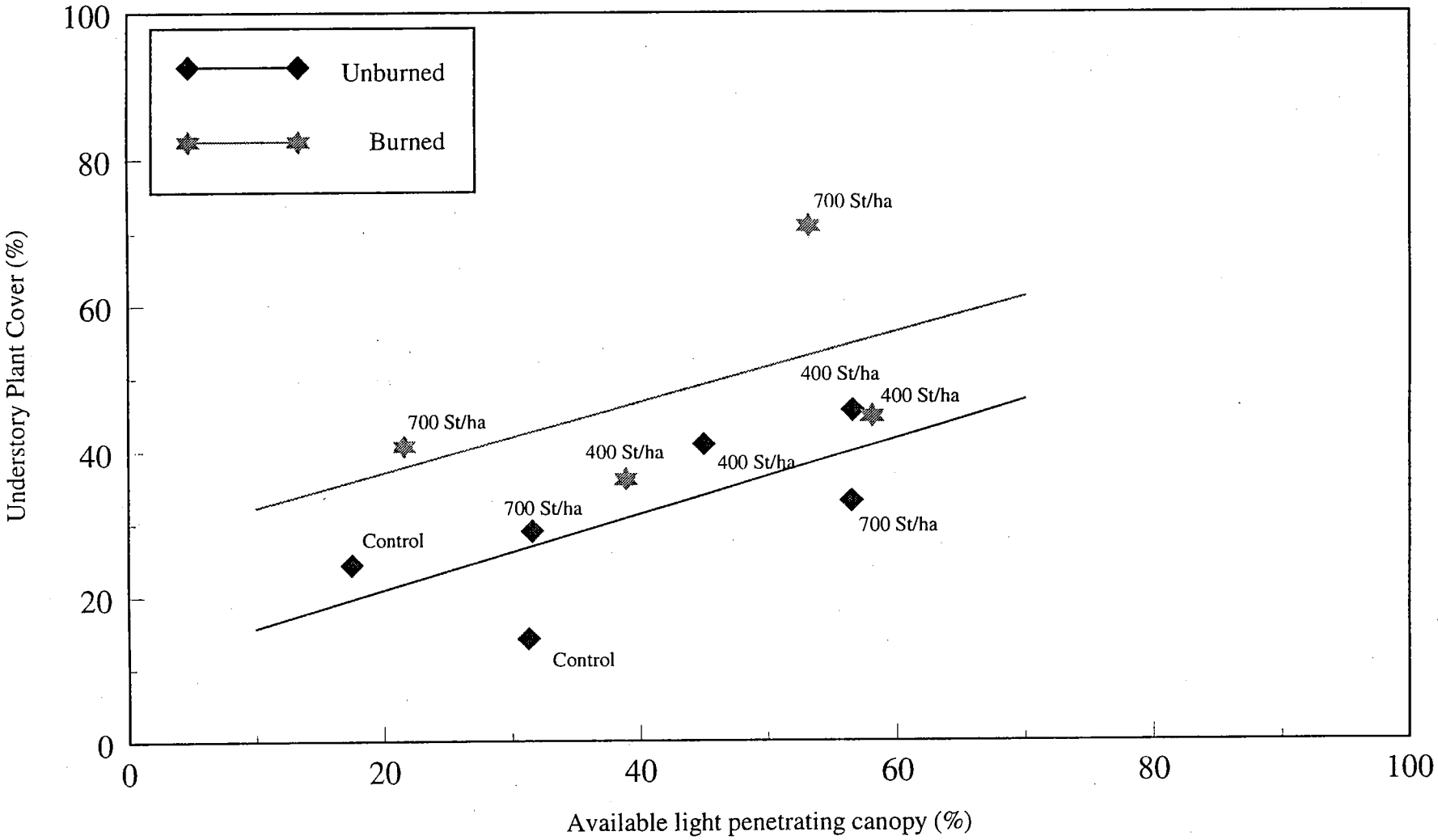


Figure 1. Effect of Thinning and Burning on PPdh2 Understory.

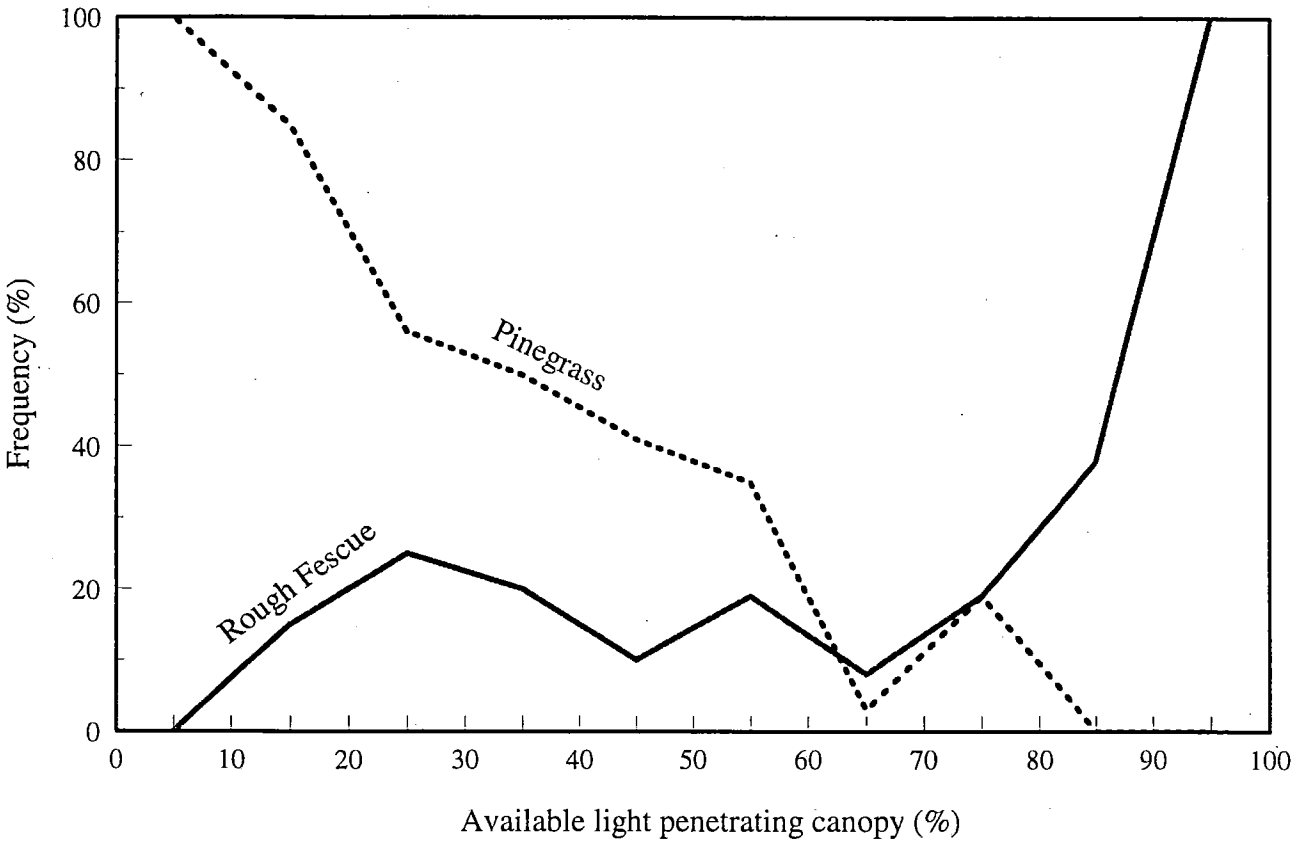


Figure 2. Frequency of Key Grasses at Different Light Regimes.

Pinegrass frequency was highest in the Control sites where available light averaged 24%. From that point, it declined to a point at approximately 55% where its frequency fell below 20%. At approximately 85% available light pinegrass frequency equalled 0%. In contrast, rough fescue was absent from the plant community at 5% available light, and frequency never exceeded 25% until available light was approximately 75%. From this point there appears to be a release of rough fescue as frequency increased by 20% for each 5% increase in available light (Figure 2).

4.0 Conclusions and Recommendations

Forage release in the 15 to 20 year span since these treatments, is mainly dependant on the nature of the herbaceous and shrub layer pre-treatment. While the composition of the pre-treatment understory plant cover was not available, we have shown that populations of rough fescue and pinegrass are light dependant. It appears as though burning speeds recovery, but again, pre-treatment data was not available with which to make comparisons. Even at the lowest stem density treatment (400 sph) the maximum light penetration did not exceed 60%. These treatments are probably insufficient for forage release in an ecosystem restoration program, but warrant more study.

Additional sampling in this forest type under differing light conditions is required, particularly at lower (0-30%) and higher (60-100%) ranges of available light.
It is recommended that this study be repeated in more detail and with additional replication in the Ponderosa Pine zone. A similar study should be initiated at similar stand-tending sites in the Douglas-fir zone.

5.0 Literature Cited

Braumdahl, T. F. and M. P. Curran. 1992. A field guide for site identification and interpretation for the Nelson Forest Region. B.C. Ministry of Forests, Nelson, B.C., 311 p.

Daubenmire, R.F. 1959. A canopy coverage method of vegetation analysis. Northwest Sci. 33: 43-64.

Gayton, D. 1997. Preliminary calculation of excess forest ingrowth and resulting forage impact in the Rocky Mountain Trench. unpubl. mimeo, BC Ministry of Forests, Nelson, B.C.

Hitchcock, C.L. and A. Cronquist. 1973. Flora of the Pacific northwest. University of Washington Press, Seattle, Wa., 730 p.

Holland, S.S. 1976. Landforms of British Columbia, a physiographic outline. Bulletin 48. British Columbia Department of Mines and Petroleum Resources. Victoria, B.C., 138 p.

Lacelle, L.E.H. 1990. Biophysical resources of the East Kootenay area: Soils. Wildlife Technical Monograph TM-1. Report No. 20 B.C Soil Survey. B.C. Ministry of Environment, Victoria, B.C., 359 p.

BC Ministry of Forests/BC Environment. 1995. Biodiversity guidebook. Forest Practises Code of British Columbia. 99 p.

SAS Institute Inc. 1988. SAS/STAT User's Guide, Release 6.03. SAS Institute., Cary, N.C.

Trench Integrated Resource Management Plan. 1993. B.C. Ministry of Forests, unpublished mimeo, Cranbrook Forest District, Cranbrook, B.C.

6.0 Appendices

Appendix 1. Plant Species

Latin Name	Common Name
Acer glabrum	Douglas maple
Achillea millefolium	Western yarrow
Agropyron spp.	Wheatgrass
Agrostis alba	Redtop
Agropyron cristatum	Crested wheatgrass
Agropyron dasytachyum	Western wheatgrass
Agoseris glauca	Pale agoseris
Agropyon riparium	Streambank wheatgrass
Agropyron spicatum	Bluebunch wheatgrass
Agrostis scabra	Hair bentgrass
Agropyron subsecundum	Bearded wheatgrass
Agropyron trachycaulum	Slender wheatgrass
Allium cernuum	Nodding onion
Alnis tenuiflolia	Mountain alder
Amelanchier alnifolia	Saskatoon
Antennaria dimorpha	Pussytoes
Antennaria microphylla	Pussytoes
Anemone multifida	Pacific anemone
Antennaria parvifolia	Pussytoes
Anemone patens	Prairie crocus
Antennaria rosea	Pussytoes
Androsace septentrionalis	Fairy candelabra
Apocynum androsaemifolium	Spreading dogbane
Artemesia frigida	Pasture sage
Arnica fulgens	Orange arnica
Arabis holboellii	Hoelboel's rockcress
Artemesia spp.	Sage
Arctostaphylos uva-ursi	Bearberry
Aster campestris	Western meadow aster
Aster ciliolatus	Lindley's aster
Aster foliaceous	Leafy aster
Aster pansies	Tufted white prairie aster
Astragalus miser	Timber milkvetch
Balsamorhiza sagittata	Balsamroot
Betula glandulosa	Bog-birch
Berberis repens	Low Oregongrape
Beckmannia syzigachne	Beckmannia
Bromus inermis	Smooth bromegrass
Bromus tectorum	Cheatgrass

Appendix 1. Plant Species (cont'd).

Latin Name	Common Name
Bryophytes	Mosses and Lichens
Calochortus apiculatus	Baker's mariposa lily
Calamagrostis canadensis	Bluejoint
Carex douglasii	Douglas sedge
Calochortus macrocarpum	Mariposa lily
Campanula rotundifolia	Scottish bells
Calamagrostis rubescens	Pinegrass
Carex spp	Sedge
Castilleja thompsonii	Thompsons paintbrush
Cerastium arvense	Chickweed
Centaurea diffusa	Diffuse knapweed
Centaurea maculosa	Spotted Knapweed
Ceanothus velutinus	Buckbrush
Chenopodium capitatum	Alkali goosefoot
Chrysanthemum leucanthemum	Oxeye daisy
Cirsium hookerianum	Hooker's thistle
Chrysothamnus nauseosus	Rabbitbrush
Chrysopsis villosa	Hairy goldaster
Cirsium arvense	Canada thistle
Cirsium vulgare	Bull thistle
Collinsia parviflora	Blue-eyed Mary
Commandra umbellata	Bastard toadflax
Crepis atrabarba	Slender hawksbeard
Cynoglossum officianale	Houndstongue
Danthonia intermedia	Timber oatgrass
Dactylis glomerata	Orchardgrass
Delphinium nuttallianum	Upland larkspur
Distichlis stricta	Inland saltgrass
Dodecatheon pauciflorum	Shooting star
Echium vulgare	Viper's bugloss
Elaeagnus commutata	Wolf-willow
Elymus cinereus	Giant wild-rye
Elymus glauca	Blue wild-rye
Epilobium angustifolium	Fireweed
Erigeron compositus	Compound fleabane
Erigeron pumilis	Shaggy fleabane
Eriogonum umbellatum	Sulphur buckwheat
Festuca idahoensis	Idaho fescue
Festuca scabrella	Rough fescue

Appendix 1. Plant Species (cont'd).

Latin Name	Common Name
Fragaria virginiana	Wild strawberry
Gaillardia aristata,	Brown-eyed susan
Gallium boreale	Northern bedstaw
Geum triflorum	Old man's whiskers
Grindellia squarosa,	Curly-cup gumweed
Heuchra cylindrica	Alum root
Hieracium gracile	Slender hawkweed
Hypericum perforatum	St. John's-wort
Juniper communis	Common juniper
Juncus spp.	Rush species
Juniper scropulorum,	Rocky Mountain juniper
Koeleria cristata	Prairie junegrass
Lappula echinata	Stickseed
Larix occidentalis	Western larch
Lepidium densiflorum	Field peppergrass
Lewisia rediviva	Bitterroot
Linnaea borealis	Twinflower
Linnum perenne	False flax
Lithospermum ruderale	Stoneseed
Lupinus sericeus	Silky lupine
Lotus corniculatus	Birdsfoot trefoil
Lolium perenne	Perennial ryegrass
Lomatium macrocarpum	Large-leafed desert parsley
Lomatium triternatum	Nine-leafed lomatium
Medicago lupulina	Black medic
Medicago sativa	Alfalfa
Melilotus alba	White sweet-clover
Monarda fistulosa	Wild bergamo
Oryzopsis asperifolia	Rough-leaved ricegrass
Orthocarpus luteus	Thin-leafed owlclover
Oxytropis campestris	Locoweed
Penstemon confertus	Tiny penstemon
Penstemon procerus	Small-flowered penstemon
Philadelphus lewisii	Mock-orange
Phalaris arundinacea	Reed canarygrass
Phleum pratense	Timothy
Phlox rigida	Spiny phlox
Pinus contorta	Lodgepole pine
Picea spp.	Spruce

Appendix 1. Plant Species (cont'd).

Latin Name	Common Name
Pinus ponderosa	Ponderosa pine
Plantago patigonica	Narrow-leafed plantain
Potentilla anserina	Silverweed
Populus balsamifera	Cottonwood
Poa compressa	Canada bluegrass
Potentilla gracilis	Graceful cinquefoil
Potentilla hippiana	Woolly cinquefoil
Poa junctifolia	Alkali blugrass
Poa pratensis	Kentucky bluegrass
Potentilla recta	Sulphur cinquefoil
Poa sandbergii	Sandberg bluegrass
Poa spp.	Bluegrass
Populus tremuloides	Trembling aspen
Prunus virginiana	Chokecherry
Pseudotsuga menziesii	Douglas-fir
Puccinellia nuttallianum	Alkaligrass
Purshia tridentata	Bitterbrush
Ranunculus acris	Meadow buttercup
Ranunculus glaberrimus	Sagebrush buttercup
Ribes spp.	Currant
Rosa spp.	Rose
Rubus spp.	Raspberry
Senecio canus	Prairie groundsel
Shepherdia canadensis	Soopolallie
Sonchas arvense	Prickly sow-thistle
Solidago spathulata	Dune goldenrod
Spirea betulifolia	Birch-leafed spirea
Sporabolis cryptandrus	Sand dropseed
Spartina gracilis	Alkali cordgrass
Stipa columbiana	Columbia needlegrass
Stipa comata,	Needle-and-thread
Stipa occidentalis,	Western needlegrass
Stipa richardsonii	Richardsons needlegrass
Symphoricarpus albus	Snowberry
Taraxacum officinale	Dandelion
Trisetum cernuum,	Nodding trisetum
Trifolium hybridum	Alsike clover
Trifolium pratense	Red clover
Tragopogon pratense	Goatsbeard
Trifolium repens	White clover

Appendix 1. Plant Species (cont'd).

Latin Name	Common Name
Verbascum thapsis	Common mullein
Viola adunca	Early blue violet
Vicia americana	American vetch
Zygadenus venenosus	Death camas

Appendix 2. Plant Cover Sampling Methodology and Plot Layout.

Sampling Methodology

Plot (1st half)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Sample Location	1	2	4	6	7	8	9	12	14	15	17	18	19	22	23
Plot (2nd half)	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
Sample Location	25	26	28	30	31	33	35	38	41	42	43	44	47	48	50

Daubenmire Cover Classes

1 = 0% to 5%; 2 = 6% to 25%; 3 = 26% to 50%; 4 = 51% to 75%; 5 = 75% to 95%; 6 = 96% to 100%

Photopoints

A permanent photopoint was marked with a 7 cm. X 11 cm. metal tag at T3+30M.
Two photos were taken from this point;
1) 0 ° from T+25m. at T+20m.
2) 0 ° from T+25m. at T+30m.

Intensive Survey Plot Location.

Site [1]	**Code**	**Airphoto**	**Treatment**	**Block**	**Polygon**	**Leading Species**
CFD - T1	420M5	BCC94132-195	N/A	N/A	136	Py, F
CFD - T2	420M3	BCC 94026-169	J80	18	354	Py
CFD - T3	430G5	BCC 94132-195	L76/J80	10	141	Py
CFD - T4	530G5	BCC94153-185	J82/B82	22	382	Py, F
CFD - T5	320G3		J77/B77	26	492	Py, F, Pl
IFD - T1	4107-9	30BCC865-071	N/A	N/A	154	Py
IDF - T2	4202-11	30BCC865-071	J81/M83	52	151	Py
IFD - T3	4202-11	30BCC865-071	J81/M83	52	151	Py
IFD - T4	4201-11		J81/M83	55	206	Py
IFD - T5	42002-11		J80/M82	56	600	Py

[1] Cranbrook sites are found on 1:20,000 Forest Cover mapsheets 82G.061and 82G.071
Invermere sites are found on 1:20,000 Forest Cover mapsheet 82G.082

Appendix 2. (cont'd)

Site	Bearing/ Distance	Tie-Point
CFD - T1	220°/50 m.	265°/40m. from tagged fence brace off road
CFD - T2	310°/50 m.	220°/90m from tagged Fd on powerline r/w
CFD - T3	360°/50 m.	360°/57m. from flagged Lw on edge of landing
CFD - T4	360°/50 m.	360°/12m. from fence-line to the south
CFD - T5	360°/50 m.	270°/60m. from flagged fence-post
IDF - T1	040°/50 m.	070°/67m. from flagged Py on edge of clearing
IFD - T2	050°/50 m.	055°/60m. from flagged Py by fence-line road
IFD - T3	360°/50 m.	360°/50m. from trail
IFD - T4	075°/50 m.	170°/57m. from flagged Py by road
IFD - T5	210°/50 m.	230°/50m. from flagged Py by road

Appendix 3. Understory Plant Cover.

SITE DESCRIPTION: CFD - T1

SPECIES NAME	AVERAGE COVER	% FREQUENCY
GRASS AND GRASSLIKE		
Agropyron dasytachyum	0.2	6.7
Calamagrostis rubescens	7.4	83.3
Carex spp.	0.7	10.0
Festuca idahoensis	1.2	13.3
Festuca scabrella	0.8	16.7
FORBS		
Achillea millefolium	0.3	13.3
Antennaria parvifolia	2.8	13.3
Fragaria virginiana	0.1	3.3
Penstemon procerus	1.2	30.0
TREES AND SHRUBS		
Amelanchier alnifolia	0.2	6.7
Arctostaphylos uva-ursi	5.3	33.3
Berberis repens	1.7	33.3
Larix occidentalis	2.0	13.3
Pinus ponderosa	32.3	66.7
Pseudotsuga menziesii	12.0	26.7
Pseudotsuga menziesii understory	2.9	20.0
Pseudotsuga menziesii regen	8.6	70.0
Rosa spp.	0.1	3.3
Shepherdia canadensis	1.9	13.3
Spirea betulifolia	0.5	20.0
OTHERS		
Bryophytes	5.8	26.7
Litter	81.4	100.0

Appendix 3. (cont'd)

SITE DESCRIPTION: IFD - T1

SPECIES NAME	AVERAGE COVER	% FREQUENCY
GRASS AND GRASSLIKE		
Agropyron spicatum	0.8	16.7
Festuca idahoensis	0.7	10.0
Festuca scabrella	0.8	16.7
Koeleria cristata	0.1	3.3
Stipa richardsonii	0.6	6.7
FORBS		
Achillea millefolium	0.2	6.7
Antennaria microphylla	0.9	20.0
Apocynum androsaemifolium	0.3	10.0
Aster foliaceus	0.5	3.3
Geum triflorum	0.5	3.3
Penstemon procerus	0.3	10.0
Phlox rigida	0.1	3.3
TREES AND SHRUBS		
Arctostaphylos uva-ursi	5.0	53.3
Pinus ponderosa	47.6	90.0
Pinus ponderosa understory	0.3	13.3
Pseudotsuga menziesii	0.5	3.3
Pseudotsuga menziesii regen	0.1	3.3
Purshia tridentata	3.2	43.3
Rosa spp.	0.1	3.3
Spirea betulifolia	0.1	3.3
OTHERS		
Bryophytes	2.7	26.7
Elk feces	0.5	3.3
Litter	91.4	100.0
Rock	0.3	10.0
Soil	0.3	13.3

Appendix 3. (cont'd)

SITE DESCRIPTION: CFD - T2

SPECIES NAME	AVERAGE COVER	% FREQUENCY
GRASS AND GRASSLIKE		
Agropyron spicatum	1.0	23.3
Calamagrostis rubescens	12.3	50.0
Dactylis glomerata	0.6	6.7
Festuca idahoensis	14.5	70.0
Koeleria cristata	1.0	6.7
FORBS		
Achillea millefolium	0.4	16.7
Antennaria microphylla	1.5	10.0
Balsamorhiza sagittata	6.7	50.0
Lupinus sericeus	5.9	43.3
Penstemon procerus	0.1	3.3
TREES AND SHRUBS		
Amelanchier alnifolia	0.3	13.3
Arctostaphylos uva-ursi	0.5	3.3
Pinus ponderosa	29.3	66.7
Pinus ponderosa regen	0.3	13.3
Pseudotsuga menziesii	1.0	6.7
Pseudotsuga menziesii regen	7.7	50.0
Spirea betulifolia	0.7	10.0
OTHERS		
Bryophytes	11.3	53.3
Litter	77.5	100.0
Rock	0.5	3.3
Soil	0.5	20.0

Appendix 3. (cont'd)

SITE DESCRIPTION: IFD - T2

SPECIES NAME	AVERAGE COVER	% FREQUENCY
GRASS AND GRASSLIKE		
Agropyron spicatum	1.3	16.7
Carex spp.	4.3	30.0
Festuca idahoensis	2.9	33.3
Festuca scabrella	3.3	30.0
Koeleria cristata	0.7	10.0
FORBS		
Achillea millefolium	0.7	10.0
Antennaria microphylla	2.0	30.0
Aster foliaceus	0.9	20.0
Fragaria virginiana	0.8	16.7
Penstemon procerus	0.1	3.3
Phlox rigida	5.1	56.7
Viola adunca	0.1	3.3
TREES AND SHRUBS		
Arctostaphylos uva-ursi	4.3	26.7
Pinus ponderosa	29.0	76.7
Pinus ponderosa regen	0.1	3.3
Purshia tridentata	14.2	96.7
Rosa spp.	0.1	3.3
Shepherdia canadensis	0.1	3.3
OTHERS		
Bryophytes	13.2	76.7
Litter	67.3	100.0
Rock	1.6	13.3
Soil	5.0	70.0

Appendix 3. (cont'd)

SITE DESCRIPTION: CFD - T3

SPECIES NAME	AVERAGE COVER	% FREQUENCY
GRASS AND GRASSLIKE		
Agropyron spicatum	0.8	13.3
Agropyron trachycaulum	0.1	3.3
Calamagrostis rubescens	14.0	83.3
Carex spp.	0.3	13.3
Festuca idahoensis	0.5	3.3
Festuca scabrella	3.3	20.0
Koeleria cristata	0.5	3.3
FORBS		
Achillea millefolium	0.2	6.7
Antennaria parvifolia	3.2	26.7
Arnica fulgens	0.5	3.3
Fragaria virginiana	0.2	6.7
Penstemon procerus	3.0	23.3
TREES AND SHRUBS		
Arctostaphylos uva-ursi	1.2	13.3
Berberis repens	0.8	13.3
Larix occidentalis	4.7	23.3
Pinus ponderosa	32.3	70.0
Pinus ponderosa regen	0.6	23.3
Pseudotsuga menziesii	1.0	6.7
Pseudotsuga menziesii regen	17.0	86.7
Rosa spp.	0.3	10.0
Spirea betulifolia	0.1	3.3
OTHERS		
Bryophytes	8.8	20.0
Litter	84.7	100.0
Soil	0.9	20.0

Appendix 3. (cont'd)

SITE DESCRIPTION: IFD - T3

SPECIES NAME	AVERAGE COVER	% FREQUENCY
GRASS AND GRASSLIKE		
Agropyron spicatum	2.3	56.7
Carex spp.	0.3	10.0
Festuca idahoensis	0.6	6.7
Festuca scabrella	0.3	10.0
Koeleria cristata	1.3	16.7
FORBS		
Achillea millefolium	0.1	3.3
Agoseris glauca	0.1	3.3
Allium cernuum	0.1	3.3
Antennaria microphylla	0.8	16.7
Aster foliaceus	1.8	20.0
Fragaria virginiana	1.1	26.7
Penstemon procerus	0.2	6.7
Phlox rigida	1.5	26.7
TREES AND SHRUBS		
Arctostaphylos uva-ursi	12.7	80.0
Juniperus communis	0.1	3.3
Pinus ponderosa	30.1	60.0
Pinus ponderosa regen	0.2	6.7
Pseudotsuga menziesii	4.2	6.7
Pseudotsuga menziesii regen	0.1	3.3
Purshia tridentata	9.8	93.3
OTHERS		
Bryophytes	9.6	43.3
Litter	80.4	100.0
Rock	0.3	13.3
Soil	2.6	36.7

Appendix 3. (cont'd)

SITE DESCRIPTION: CFD - T4

SPECIES NAME	AVERAGE COVER	% FREQUENCY
GRASS AND GRASSLIKE		
Agropyron subsecundum	6.6	66.7
Agropyron trachycaulum	0.5	3.3
Calamagrostis rubescens	19.0	56.7
Carex spp.	0.2	6.7
Festuca idahoensis	0.7	10.0
Festuca scabrella	1.6	13.3
Koeleria cristata	0.5	3.3
Poa pratensis	0.7	10.0
FORBS		
Galium boreale	0.1	3.3
Geum triflorum	2.2	20.0
Lomatium triternatum	0.2	6.7
Lupinus sericeus	0.5	3.3
Penstemon procerus	2.8	26.7
TREES AND SHRUBS		
Pinus ponderosa	42.2	100.0
Pinus ponderosa regen	0.2	6.7
Pseudotsuga menziesii regen	0.2	6.7
Rosa spp.	0.5	20.0
OTHERS		
Bryophytes	3.3	46.7
Litter	89.0	100.0
Soil	0.7	10.0

Appendix 3. (cont'd)

SITE DESCRIPTION: IFD - T4

SPECIES NAME	AVERAGE COVER	% FREQUENCY
GRASS AND GRASSLIKE		
Agropyron spicatum	10.7	86.7
Festuca idahoensis	6.7	53.3
Festuca scabrella	0.1	3.3
Koeleria cristata	2.5	50.0
Poa pratensis	0.7	10.0
FORBS		
Achillea millefolium	0.6	23.3
Antennaria microphylla	2.4	30.0
Aster foliaceus	0.3	10.0
Fragaria virginiana	0.2	6.7
Lupinus sericeus	0.1	3.3
Penstemon procerus	0.2	6.7
Phlox rigida	3.7	46.7
Solidago spathulata	0.5	3.3
TREES AND SHRUBS		
Arctostaphylos uva-ursi	9.5	60.0
Pinus ponderosa	30.5	60.0
Pinus ponderosa regen	0.1	3.3
Pseudotsuga menziesii	11.8	13.3
Pseudotsuga menziesii regen	0.1	3.3
Purshia tridentata	6.5	46.7
OTHERS		
Bryophytes	10.5	53.3
Cattle feces	1.3	3.3
Elk feces	0.5	3.3
Litter	74.3	100.0
Rock	0.2	6.7
Soil	2.9	36.7

Appendix 3. (cont'd)

SITE DESCRIPTION: CFD - T5

SPECIES NAME	AVERAGE COVER	% FREQUENCY
GRASS AND GRASSLIKE		
Agropyron spicatum	0.7	10.0
Agropyron trachycaulum	1.2	13.3
Calamagrostis rubescens	9.3	76.7
Carex spp.	0.6	6.7
Festuca idahoensis	3.3	33.3
Festuca scabrella	0.9	20.0
Koeleria cristata	0.9	20.0
Poa pratensis	3.2	13.3
Stipa occidentalis	1.6	13.3
Stipa richardsonii	0.7	10.0
Sporobolis cryptandrus	1.3	20.0
FORBS		
Achillea millefolium	0.6	23.3
Antennaria microphylla	2.3	26.7
Antennaria parvifolia	1.3	3.3
Fragaria virginiana	0.5	20.0
Lithospermum ruderale	1.3	3.3
Lupinus sericeus	0.4	16.7
Medicago lupulina	0.7	10.0
Penstemon procerus	0.8	30.0
Solidago spathulata	0.6	6.7
Taraxacum officinale	0.2	6.7
Viola adunca	0.1	3.3
TREES AND SHRUBS		
Arctostaphylos uva-ursi	2.7	26.7
Berberis repens	4.1	50.0
Pinus contorta	3.7	20.0
Pinus contorta regen	1.3	16.7
Pinus ponderosa	2.5	20.0
Pseudotsuga menziesii	5.6	16.7
Pseudotsuga menziesii understory	1.3	3.3
Pseudotsuga menziesii regen	12.8	66.7
Rosa spp.	0.4	16.7
Spirea betulifolia	1.0	40.0

Appendix 3. (cont'd)

SITE DESCRIPTION: CFD - T5 (cont'd)

SPECIES NAME	AVERAGE COVER	% FREQUENCY
OTHERS		
Bryophytes	6.2	66.7
Cattle feces	1.5	10.0
Elk feces	0.1	3.3
Litter	74.1	100.0
Rock	0.1	3.3
Soil	0.8	33.3

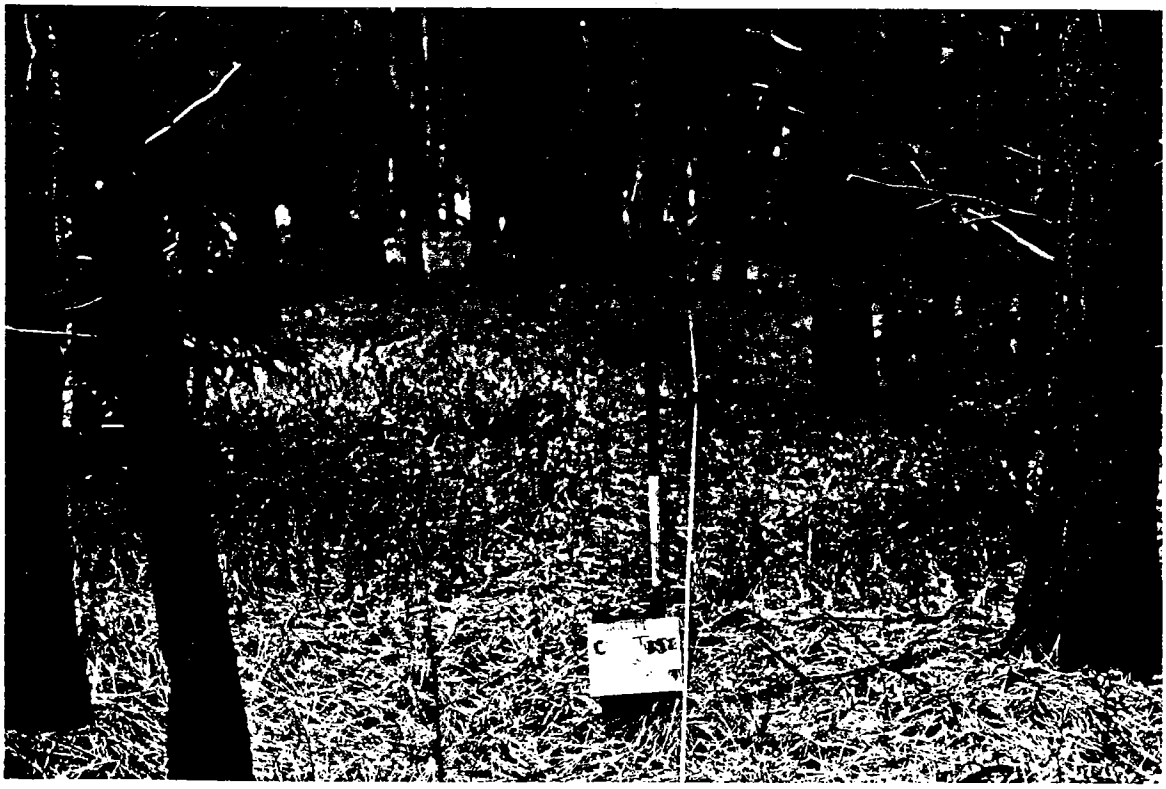
Appendix 3. (cont'd)

SITE DESCRIPTION: IFD - T5

SPECIES NAME	AVERAGE COVER	% FREQUENCY
GRASS AND GRASSLIKE		
Agropyron spicatum	0.1	3.3
Calamagrostis rubescens	3..3	33.3
Carex spp.	0.5	3.3
Festuca idahoensis	0.3	13.3
Festuca scabrella	5.8	43.3
Koeleria cristata	1.0	6.7
FORBS		
Achillea millefolium	0.3	13.3
Antennaria microphylla	0.7	10.0
Aster foliaceus	0.7	10.0
Fragaria virginiana	0.8	13.3
Penstemon procerus	0.2	6.7
TREES AND SHRUBS		
Amelanchier alnifolia	1.7	50.0
Arctostaphylos uva-ursi	47.8	96.7
Pinus ponderosa	34.8	63.3
Populus tremuloides	0.1	3.3
Prunus virginiana	0.3	13.3
Purshia tridentata	6.7	70.0
Rosa spp.	0.6	23.3
OTHERS		
Bryophytes	1.5	26.7
Elk feces	0.5	3.3
Litter	85.8	100.0
Soil	0.3	13.3

Appendix 4. Photo-Points

Cranbrook FD - T1 - from T1+25 m. at T1+20- 040°

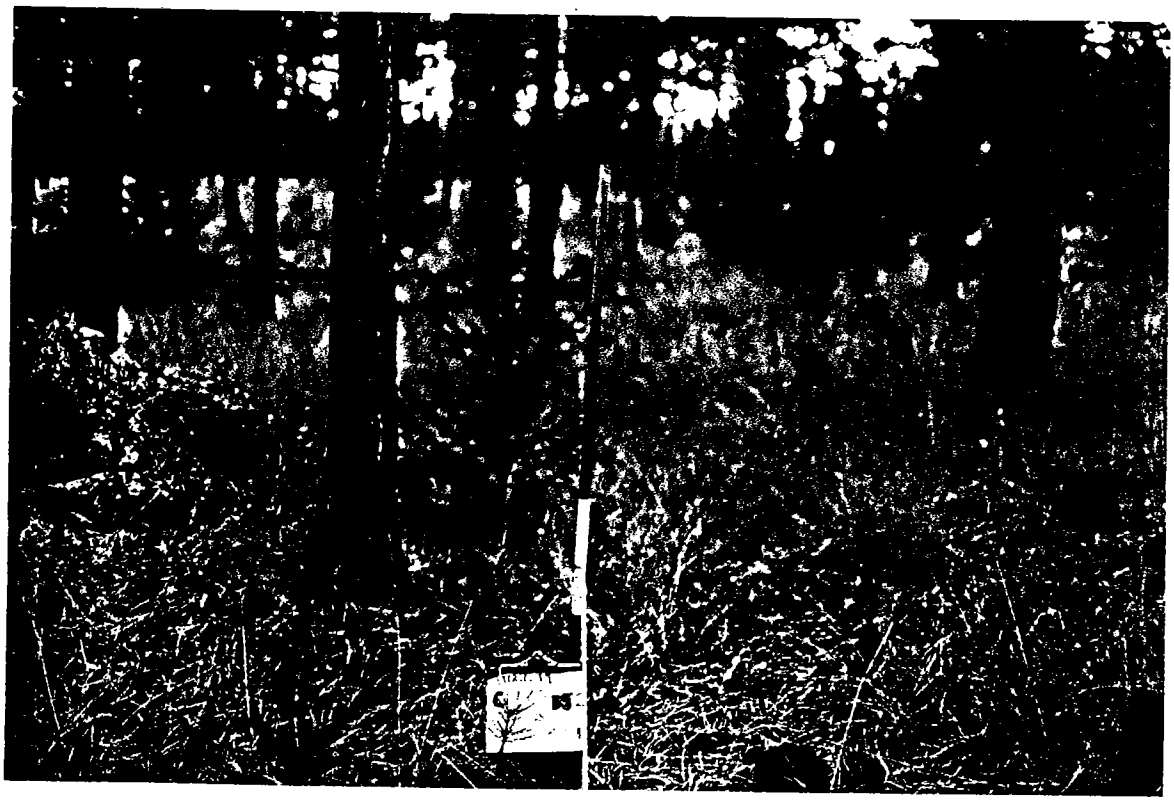


Cranbrook FD - T1 - from T1+25 m. at T1+30- 220°

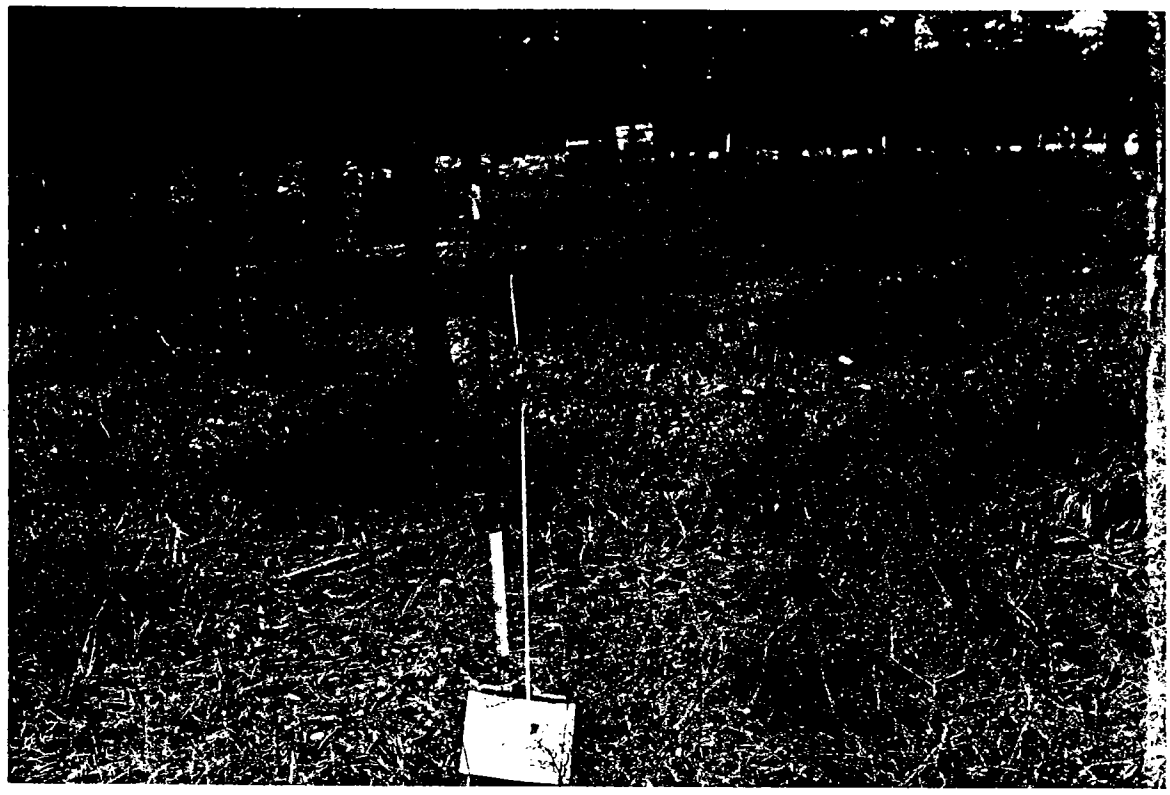
Invermere FD - T1 - from T1+25 m. at T1+20m.- 220°

Invermere FD - T1 - from T1+25 m. at T1+30- 040°

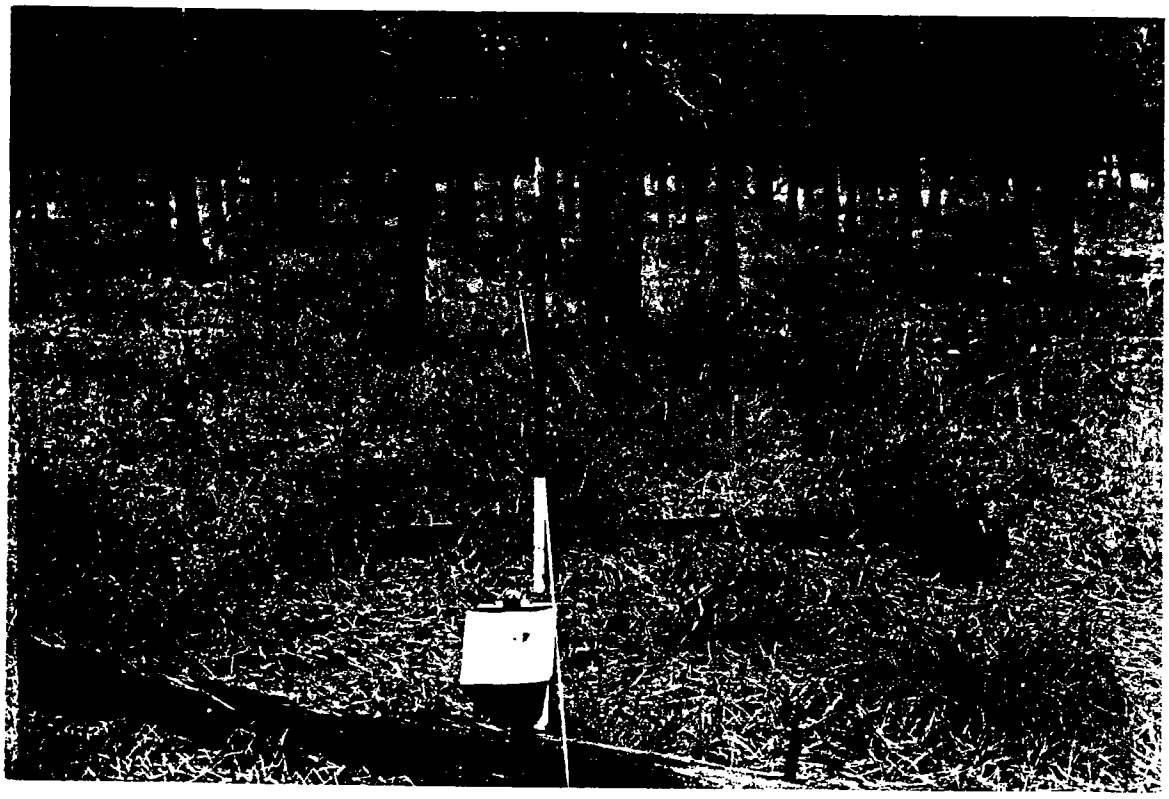
Cranbrook FD - T2 - from T2+25 m. at T2+20m.- 130°



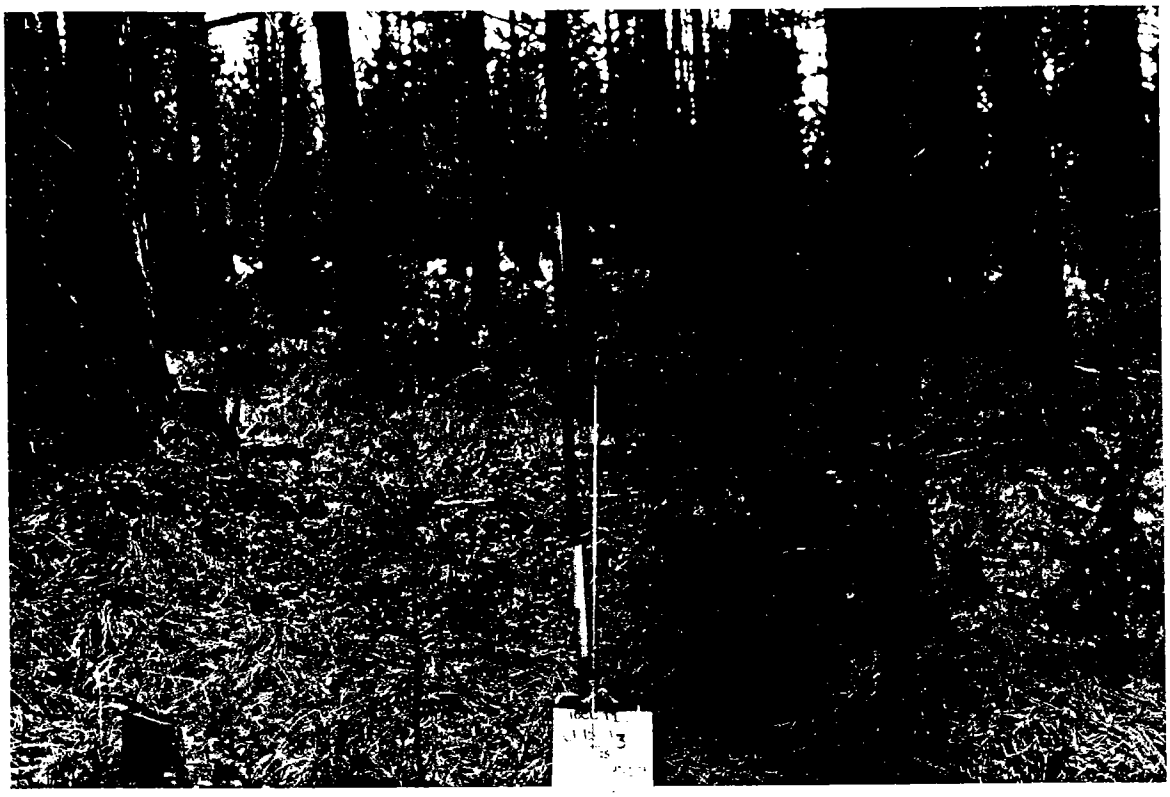
Cranbrook FD - T2 - from T2+25 m. at T2+30m.- 310°



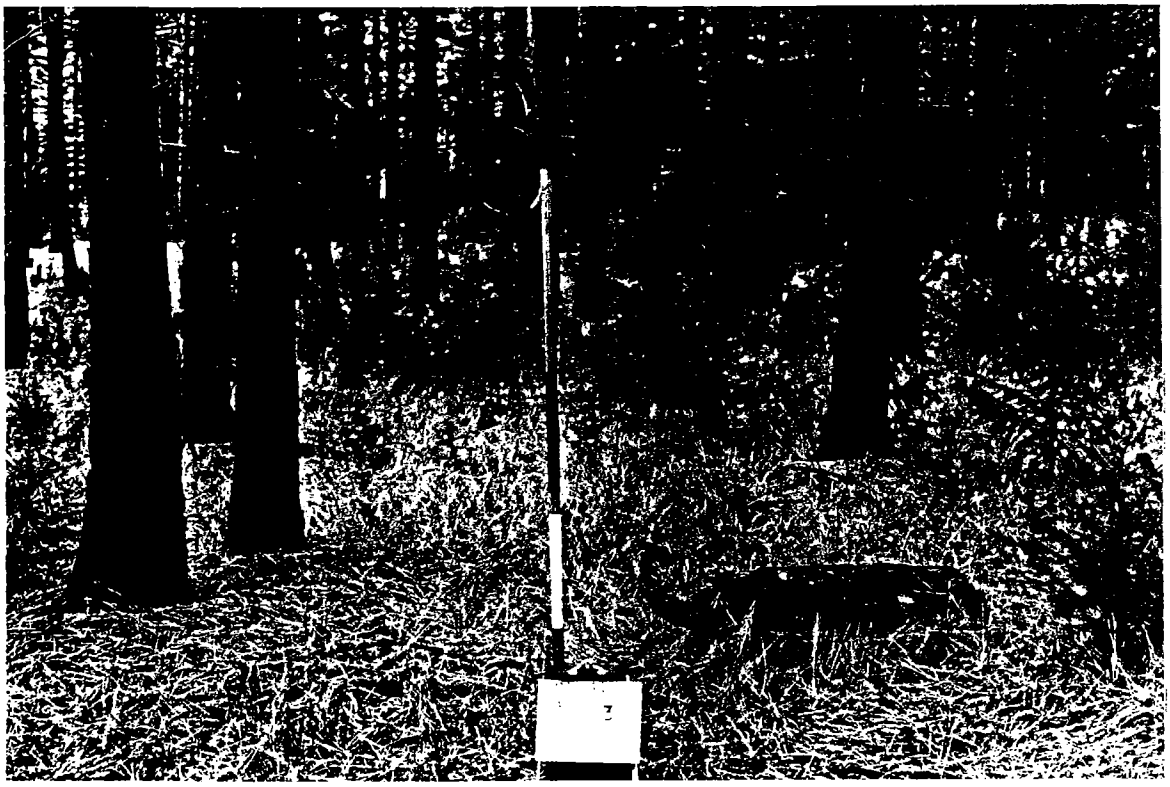
Invermere FD - T2 - from T2+25 m. at T2+20- 230°



Invermere FD - T2 - from T2+25 m. at T2+30- 050°



Cranbrook FD - T3 - from T3+25 m. at T3+20m.- 180°



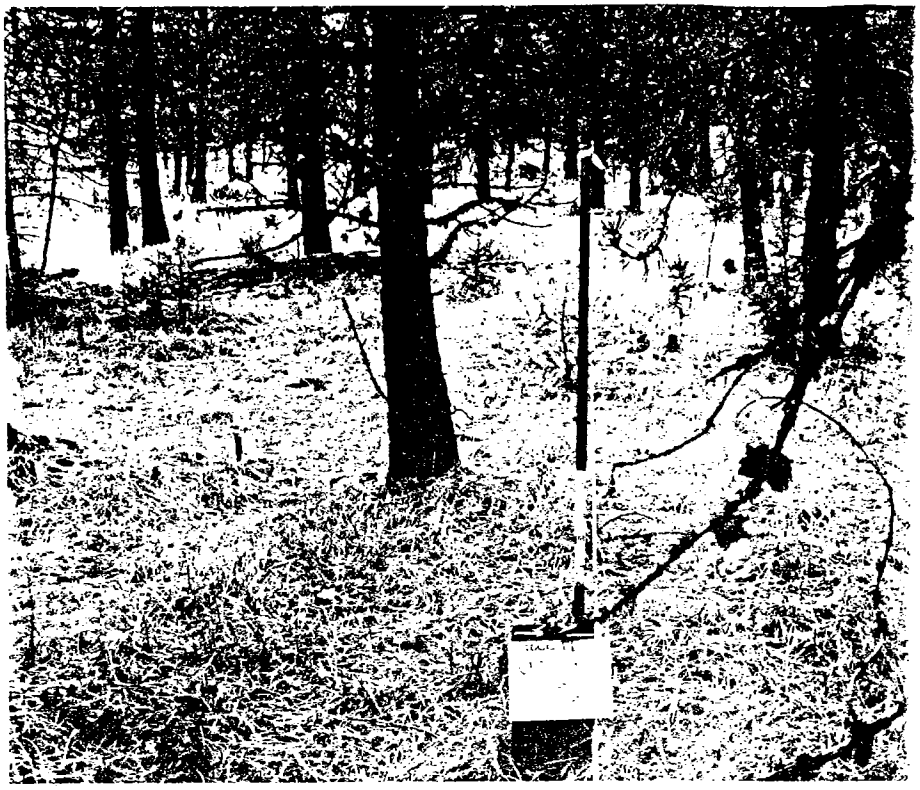
Cranbrook FD - T3 - from T3+25 m. at T3+30m.- 360°

Invermere FD - T3 - from T3+25 m. at T3+20- 180°

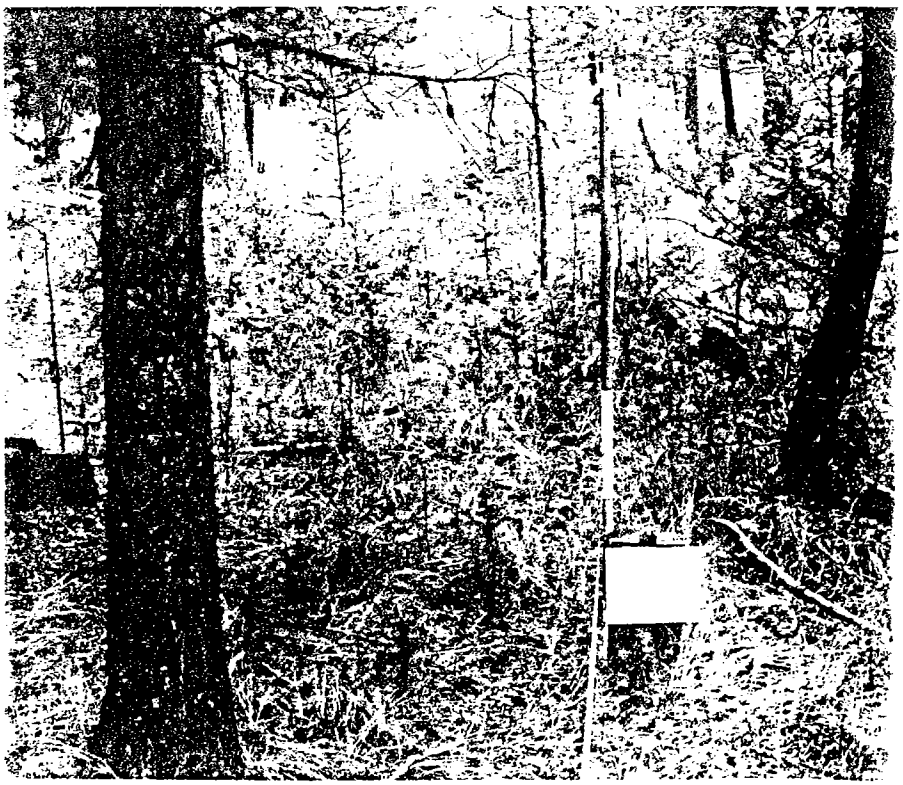
Invermere FD - T3 - from T3+25 m. at T3+30- 360°

Cranbrook FD - T4 - from T4+25 m. at T4+20m.- 180°

Cranbrook FD - T4 - from T4+25 m. at T4+30m.- 360°



Cranbrook FD - T5 - from T5+25 m. at T5+20m.- 180°



Cranbrook FD - T5 - from T5+25 m. at T5+30m.- 180°

Inverm+25 m. at T5+2

Inverm25 m. at T5+30 m

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SERVICE

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