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A Study of Understory Plant Recovery After a Forest Fire in the Columbia River Gorge

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THESIS APPROVAL

The abstract and thesis of Mark Alan Pittsenbarger for the Master of Science in Biology: were presented May 3, 1994 and accepted by the thesis committee and the department.

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ABSTRACT

An abstract of the thesis of Mark Alan Pittsenbarger for the Master of Science In Biology: presented May 3, 1994.

Title: A Study of Understory Plant Recovery After A Forest Fire in the Columbia River Gorge.

Between October 9, 1991 and October 16, 1991 a fire burned 577 hectares in the Columbia River Gorge near the west end on the Oregon side. All of the area burned consisted of second growth *Pseudotsuga menziesii* and the accompanying understory. This was the first disturbance of this magnitude in this part of the Columbia River Gorge since 1902.

The purpose of this study was to examine the pattern of understory recovery in the first two years following the fire. This study also sought to learn: 1) how *Pseudotsuga menziesii* seedlings are recruited into the population, 2) how quickly the litter layer is a reforming, and 3) how quickly snags and downed logs are recruited into the understory.

Four 800 square meter circular plots were established within the burned area of the Columbia River Gorge. Two plots were designated sun plots since the fire had killed the overstory. The other two were designated shade sites since the canopy over them was still intact. Twenty five randomly placed sample units (20 x 50 centimeters) were placed in each main plot. The plots were then sampled at approximately one-month intervals from May through September of 1992 and 1993. The frequency and percentage of cover was recorded for all plant species that occurred in each sample unit.

The data from 1992 and 1993 were compared by date of visit and type of plot, either (sun or shade) using the Pearson Goodness-of-Fit Test to examine and compare differences in the extent of cover and distribution of understory species. No significant differences were found. An increase in species richness and relative abundance of understory species was noted between pre-fire data collected by the US Forest Service and what I found. However, statistical analysis was not possible because of the limited data collection in the pre-fire sample.

A STUDY OF UNDERSTORY PLANT RECOVERY AFTER A FOREST FIRE IN THE COLUMBIA RIVER GORGE

by

MARK ALAN PITTSENBARGER

A thesis submitted in partial fulfillment of the
requirments for the degree of

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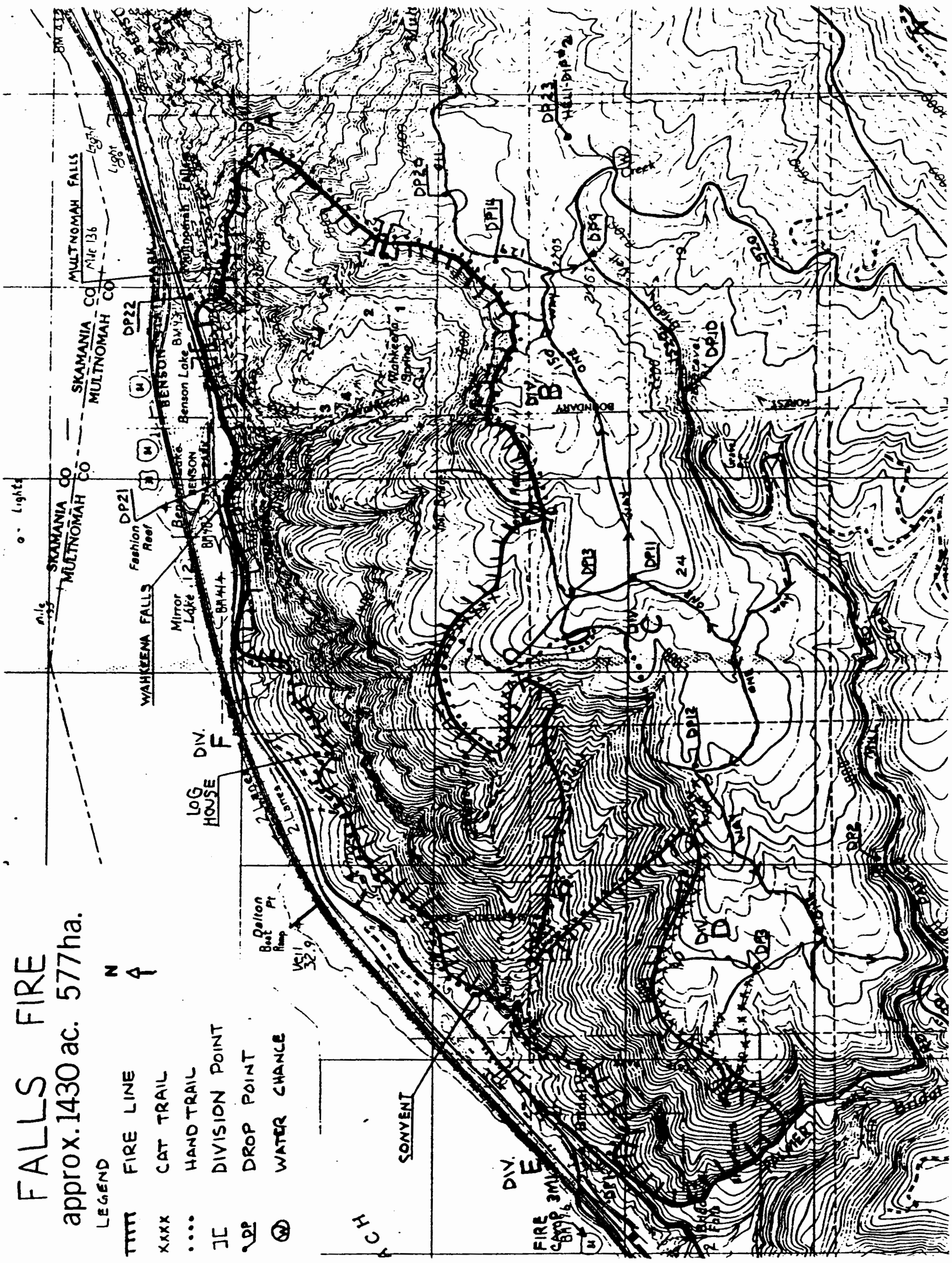
INTRODUCTION

On October 9, 1991 a fire began in the Columbia River Gorge. The fire continued well into October 16, 1991, and a total of 577 hectares were burned (Fig. 1). The last disturbance of this magnitude in the Columbia River Gorge was a large fire in 1902 (US Forest Service unpublished). The area burned by the 1991 fire consisted of sections of second growth *Pseudotsuga menziesii* (Douglas Fir) and the accompanying understory. The Columbia River Gorge is classified as a National Scenic Area and has never been subjected to logging operations.

Most available literature concerning the response of vegetation to fire deals with areas that were burned either in conjunction with or several years after a logging operation (Dyrness 1965,1973, Covington et al 1991). In these previous studies the understory was not only disturbed by the fire but by all of the other activities involved with mechanical removal of the overstory. Several of the articles presenting information about the understory described very broad successional stages and were based on information taken not from one area over time, but on many areas that were burned at different times (Dyrness 1973).

In mature forests the spatial distribution of understory vegetation is very heterogeneous. Without disturbance, the patchy distribution of herbs and shrubs changes little from year to year. Removal of the overstory, however, results in a change in community structure (Hughes 1991). This change in community structure was one aspect investigated in this study, since this part of the Columbia River Gorge has essentially not been disturbed in the last 90 years.

Changes in the understory in an area that was essentially undisturbed except by fire presented a fine opportunity for study. Accordingly, the general purpose of this study



<u>Figure 1</u> USFS map of the Falls Fire of October 1991. Plots are marked with numbers. Scale is 1 5/8 inches to the mile, and contour lines are spaced at 40 feet.

was to describe the change of the understory community in a forest ecosystem after the removal of the overstory by fire. To accomplish this, I compared the recovery of the understory on 4 plots within the burned area of the Columbia River Gorge by monitoring the percent cover of each species encountered and its frequency of occurrence on each of two types of plots in the understory community. Sites were compared with regard to how badly damaged the canopy was, i.e. whether the site was a sun site with nearly the entire canopy removed or a shade site with only a small portion of the canopy removed by the fire. In all cases, the fire burned down to bare mineral soil. Data collected in 1992 and 1993 were also compared to data collected prior to the fire US Forest Service (unpublished). Data were also collected on the recruitment of *Pseudotsuga menziesii* seedlings.

REVIEW OF THE LITERATURE

Most of the literature on recovery from fire in forest ecosystems deals with the woody canopy rather than the herbaceous understory (Alban 1977, Ne'eman et al 1992, Romme 1982). The articles I reviewed were about evenly divided between burns conducted for experimental reasons and burns that occurred naturally. In the experiments involving logging and then burning either the same year or one year later, it is often difficult to tell whether fire or other disturbances contributed more to the patterns of recovery. Only those articles where investigators adequately addressed the problems presented by other types of disturbance, and focused only on the damages caused by fire were considered for the purpose of this study.

Many studies (Dyrness 1965, 1973, Hughes and Fahey 1991, Kaufman and Martin 1989, and Collins 1992) examined experimental burns after logging and slash burning, or in areas subjected to prescribed burning. These articles validated the use of the Daubenmire (1959) scale of canopy closure by using coverage classes of 0-5, 5-25, 50-75, 75-95 , and 95-100 percent cover. This scale was used extensively by others (Reich et al 1990, Forgeard 1990, Kay 1993), although in some cases it was modified to render coverage estimates that were coarser than the original (Collins 1992). Matlack and Good (1989) stated that cover is a good descriptor for determining the recovery pattern of the understory in fire-dominated forests. This method was also used by Kaufman and Martin (1989) to monitor moss and lichens, rock, bare ground and woody materials for two years after a fire in the Sierra Nevada. Although Kaufman and Martin did not measure herbaceous growth, they showed that the method may be used for small vegetation in the understory as well. Collins (1992) used the Daubenmire method to describe tall grass prairie vegetation and described the method as "being a highly repeatable method for sampling a large number of plots over a short period of time".

Herbaceous plants do not grow as fast or have coverages as high in conifer stands as in deciduous stands such as *Quercus dumosa* (Scrub Oak) in California scrub communities (Rice and Green 1964). The difference may reflect low pH, low available nitrogen, or available phosphorus of the soil. Fire often improves the growth of herbaceous species in coniferous forests. Alban (1977) found that while some elements are volatilized by fire, others are left in the ash and subsequently are leached into the soil by precipitation. This leaching increases the pH and base concentration. Also increased during this process are the amount of cations and the cation exchange capacity. Alban found that Ca and Mg were significantly increased over control sites on all tested sites. He also found that the cation exchange sites held ammonium, which generally is organically bound until released by fire. Covington and Sackett (1988) found that increased soil nitrogen encouraged re-vegetation through higher growth rates. Although many believe that most of the N tied up in the fuel is volatilized and lost, Hough (1981) found that when prescribed burns were used, primarily to reduce fuel loads, much of the nutrient loss that was predicted failed to occur. Hough found that the burning of the forest floor materials actually released more nutrients than were tied up in downed biomass. This result was also noted by Lewis (1974) and Debano et al. (1977). Hough found that even if 100 kilogram\hectare of N contained within the understory and litter was lost, there were still significant amounts contained within the top layers of mineral soil and in the residue and ash. Allen et al (1969) found that although more than half of the C, N, and S in heather was lost due to fire, as much if not more was restored by minerals returning to the area in the form of precipitation.

By burning the forest floor down to the mineral soil, fire may have a negative impact on herbaceous understory plants while exerting a positive impact on woody plants. Grime (1977) and Facelli and Pickett (1991) found that "litter substantially reduced the density and biomass of herbs." Reducing the competition from herbs frees the woody plants, such as conifer canopy species seedlings, from competition which can increase in both biomass and density. The finding that litter hinders the growth of herbaceous plants and thus helps woody (canopy and shrub) seedlings supports earlier findings by Clary, Ffolliott and Jameson (1968). These authors found that as the number of layers of the forest floor increased in depth, that is the humus layer, the duff layer, and the litter layer, herbage production decreased.

Some of the experimental burns that followed logging operations, and most of the natural burns, showed that many plants in the residual community come back from seed banks that survive the fire, sprouting either from root crowns (Stein et al) or underground rhizomes (Uemura, Tsuda and Hasegawa 1990), and from seeds imported from sources outside the burned area (Stickney 1990). The seeds of the immigrants tend to be light in weight, airborne, and have a short term viability. As for survivors and residual colonizers, the closer to the ground the growing points are, the better they can survive fire. Alternatively, seeds survive the high temperatures caused by fire because they are either insulated by the soil in which they are buried or preserved in the canopy high above the fire.

Hughes (1991) found that understory plants in general, and specifically the herbaceous layer in northern forests, responded very much as predicted by Grimes (1977). Dominant members of the pre-fire community tend to be stress tolerators. They responded very conservatively to the increased nutrient levels caused by disturbance. Their populations remained at or near pre-fire levels, and most replacement was through the breaking apart of the products of a single zygote or ramet replacement. This happens in plants that spread new root systems by means of a laterally extending stem. Species following a competitive strategy maintained small stable populations in the area prior to disturbance. These plants responded quickly to the increased availability of nutrients by vegetative growth or by increased flowering. Off-site colonizers were not in the pre-disturbed area, but invaded and responded very vigorously to the increase in space and nutrient levels that followed disturbances such as fire (Rice and Green 1964). Without disturbance, the patchy nature of herbs undergoes little to no change from year to year. Removal of the canopy, however can cause a remarkable change in the community structure and species importance (Hughes 1991).

Oswald (1983) monitored the understory vegetation of a mixed *Pinus ponderosa/ Psuedotsuga menziesii* forest for eight years following a burn in 1972. His plots had been established prior to the fire for another study. After the fire Oswald found that during years 1-3 the biomass of the herbaceous cover increased significantly on both moderately and severely burned areas as compared with plots that were unburned. There was also an increase of biomass over that which existed prior to the burn. After year 3 there was a significant decline of herbage production and standing biomass on the severely burned plots. Caution needs to be used, however, in interpreting this since the area of the severe burn was heavily grazed during years 5-8. The productivity of the moderately burned area remained steady from year 3 through the end of the study in spite of grazing due to the increased numbers of forage and browse species.

Romme (1982) recognized three stages of succession in Yellowstone Park. Succession began with a herbaceous and small shrub cover stage. After 40 years this stage was followed by a middle stage in which conifers tended to dominate. It is during this stage that canopy closure began and the herb and shrub stage began to decline both in numbers and in species diversity. The final stage goes from initial canopy closure through the maturation of the even-aged canopy. The plots observed in my study were in the final conifer dominated stage prior to the fire, and are now entering into the first stage of herb and small shrub dominance. If this study were to be carried out longer it could be possible to observe all of the stages described by Romme.

To summarize, the effect on understory communities following large disturbances such as fires is a patchwork of small, very different successions. Herbs and low shrubs tend to dominate early stages of succession. While a large shrub stage is followed by canopy closure and maturation of the canopy tree species. These differing stages of succession proceed at different rates that reflect the differing fire intensities on the understory (Hughes 1991).

MATERIALS AND METHODS

On June 13, 1992 four circular plots of 800 square meters each were established within the National Scenic Area of the Columbia River Gorge. These plots were in the area burned by the Falls Fire of 1991. On all plots the understory was completely removed baring the mineral soil. The forest canopy over the plots had been primarily *Pseudotsuga menziesii,* with a mid-story of *Acer circinatum* (Vine Maple). On sites #1 and #4 the canopy was still essentially intact because the fire on those sites was only a surface burn. On sites #2 and #3 the fire "crowned out", leaving mineral soil exposed among burned snags. Plots #1 and #2 were located within 100 meters off the Perdition Trail between Multnomah and Wakeena Falls, about 1.6 kilometers from the junction of the two trails. Plots #3 and #4 were located about 100 meters east of the Wakeena Falls Trail approximately 0.5 kilometers below the top of the trail. All of the plots were north facing and had slopes of 20 ° to 45°. To illustrate the differences among plots, photographs were taken using a Pentax K1000 camera fitted with a 50 millimeter standard lens and attached Soligor fisheye lens.

Each of the four main plots was sampled using 25 randomly located sample units 20 x 50 centimeters in size. This size allowed me to view the whole sample unit without moving my eyes. Eye movement tends to introduce errors due to accumulated memory effects (Daubenmire 1959). Frequency and percent cover was noted for each species present in each sub plot. Each of the sample units was marked in June of 1992 with small bamboo stakes that were subsequently changed in June 1993 to blue colored surveyors flags for easier location.

Part of this study included monitoring the recruitment of *Pseudotsuga menziesii* seedlings into the understory. Each seedling was marked with a small plastic stick during the 1992 season to prevent redundant counting of seedlings the second year, and to note mortality into the second year. Diameters of dead snags and the diameter of any downed trees and large pieces of wood were measured using a standard diameter tape. These measurements were taken to observe the recruitment of large diameter dead wood into the soil profile. Depth of the litter layer was also recorded as distinct from ash. The litter layer was measured using a standard metric ruler throughout the course of this study.

The vegetation in the research areas was first surveyed on June 13, 1992 with subsequent follow up surveys performed at one-month intervals through late September. This sample schedule was repeated in 1993.

The data collected were tested using the Pearson Goodness-of-Fit Test (Marascuilo et al 1977). This statistical test was chosen so that the distribution of discrete data in the form of observed frequencies on one main plot could be compared with the distribution of the other main plots. I calculated a total frequency by visit date and main plot for each species. These became the observed frequencies (OF). These OFs were converted to probabilities by summing all of the actual counts of all species for a particular main plot and then dividing the actual count of a particular species by the total of all actual counts for that particular visit. This was computed for each main plot on a plot by plot basis. To compare two main plots, the frequencies of one plot became the expected while those of the other were the observed. Then the main plot that had been the observed frequency was changed to the expected, the one which had been the expected became the observed, since for this study $(x - y)^2$ does not equal $(y - x)^2$, the test was performed again and the results were compared to those of the of the first Pearson Goodness-of-Fit test. This was done 52 times so that all plots were compared to each other for both years, and the pooled data was compared. The frequency probabilities were run through the test of: $X^2 = \Sigma (P_1 - P_2)^2 / P_2$, where P_1 is the observed and P_2 is the expected probability of occurrence (Marascuilo et al 1977). The X^2 was compared to a critical value of X^2 at an alpha level of 0.05.

All species nomenclature follows (Hitchcock and Cronquist, 1973).

RESULTS

After the removal of the understory and part of the canopy by the Falls Fire in October 1991 the species in the understory increased in diversity and coverage. Prior to the fire the highest percent coverage was 35% for *Smilacina stellata* (Small False Solomon's Seal), the most dominant species in the understory. The next highest coverage was 2% for 5 species and 1% for the other 12 species in the study area unpublished data (US Forest Service). After the fire there were 37 species present in the area studied, and many of them had greater coverages than the pre-fire community. Tables I-VIII present the percent coverage by species and visit date, for each main plot and for each of the two years of study. The coverages in each column are derived by totaling the percent cover of each species for each plot and then dividing that total by the numbers of sample units in the main plot. This estimates the percentage of the entire plot covered by a given species on a particular visit. Frequencies were obtained by counting the number of sample units on which each species occurred and then dividing that number by the total number of sample units on that main-plot.

Some problems were encountered in sampling. The number of sample units in each main plot started out as a constant of 25 / main plot, trail clearing by the US Forest Service eliminated some of the sample units on plots #3 and #4. Flags used to mark sample units were occasionally removed by hikers. Generally the removal was of one or two flags at any given time. However, on July 7, 1993, all of the flags on plot #3 except one had been removed, including the plot center flag. Upon close examination I found three of the original bamboo stakes from 1992 and the one flag that was left. Using these and the original coordinates I re-established all of the original sub-plots.

By 1993, 13 of the original 18 species present returned from seed bank sources,

TABLE I

PERCENT COVER BY SPECIES AND VISIT FOR PLOT #1 1992

	Date of Observation					
SPECIES	6/13/92	7/11/92	8/7/92	9/7/92	MEAN[1]	FREQ[2]
Acer circinatum	2.0[3]	2.0	2.0	4.0	2.50	0.04
Achlys triphylla	0	0	0	0	0	0
Adenocaulon bicolor	0	0	0	0	0	0
Antenaria spp.	0	0	0	0.04	0.01	0.04
Arenaria macrophylla	0	0	0	0	0	0
Berberis nervosa	5.50	7.80	8.80	10.20	8.10	0.40
Campanula scoulari	0	0	0	0	0	0
Cornus cornuta	0	0	0	0	0	0
Dicentra formosa	0	0	0	0	0	0
Digitalis purpurea	0	0	0	0	0	0
Disporum hookeri	0.28	0.28	0.68	1.70	0.73	0.20
Epilobium minutum	0.20	0.20	0.40	0.40	0.30	0.04
Galium trifoliata	0.32	0.32	0.36	1.20	0.55	0.28
Holodiscus discolor	0	0	0	0	0	0
Hydrophyllum tenuipes	0	0	0	0	0	0
Lactuca spp.	0	0	0	0	0	0
Lapsana communis	0	0	0	0	0	0
Lathyrus spp.	0	0	0	0	0	0
Lilium columbiana	0.20	0.20	0	0	0.10	0.04
Maianthimum dilata	0	0	0	0	0	0
Montia siberica	0.48	0.68	0.52	1.10	0.70	0.36
Nemophila parviflora	0	0	0	0	0	0
Oxalis oregana	0.20	0.20	0.20	0.40	0.25	0.04
Polystichum munitum	0	0	0	0	0	0
Pteridium aquilinum	2.80	3.20	3.40	4.50	3.50	0.28
Rosa gymnocarpa	1.00	1.40	1.40	1.40	1.30	0.16
Rubus parviflora	0	0	0	0	0	0
Rubus ursinus	2.50	3.40	3.20	3.50	3.15	0.16
Smilacina stellata	0.04	0.08	0.20	0.32	0.16	0.08
Spirea densiflora	0	0	0	0	0	0
Symphoricarpos alba	0	0	0	0	0	0
Trientalis latifolia	2.50	2.60	3.30	2.40	2.70	0.92
Trillium ovatum	0.28	0.32	0	0	0.15	0.08
Vaccinium spp.	1.60	3.00	5.90	6.70	4.30	0.48
Vancouveria hexandra	0	0	0	0	0	0
Vicia spp.	0	0	0	0.08	0.02	0.04
Viola glabella	0	0	0	0.04	0.01	0.04

[1] Mean = $\frac{\Sigma \text{ Species coverage by date of observation}}{\text{Total number of observation dates}}$

[2] Frequency = $\frac{\Sigma \text{ Species occurrence for all sample units on a main plot}}{\text{Total sample units for that main plot}}$

[3] $\frac{\Sigma \text{ Species coverage on each sample unit on a main plot}}{\text{Number of sample units in that main plot}}$

TABLE III

PERCENT COVER BY SPECIES AND VISIT FOR PLOT #2 1992

SPECIES	Date of Observation 6/13/92	7/11/92	8/7/92	9/7/92	MEAN[1]	FREQ[2]
Acer circinatum	0.04[3]	0.65	0.87	1.10	0.67	0.04
Achlys triphylla	0	0	0	0	0	0
Adenocaulon bicolor	0.88	0.88	0.88	1.00	0.91	0.09
Antenaria spp.	1.40	1.80	2.20	2.10	1.90	0.52
Arenaria macrophylla	0.22	0.65	0.65	1.70	0.81	0.09
Berberis nervosa	0.48	0.65	0.65	0.65	0.61	0.09
Campanula scoulari	0	0	0	0	0	0
Cornus cornuta	0	0	0	0.22	0.06	0.04
Dicentra formosa	0.43	0.43	0.35	0.65	0.47	0.17
Digitalis purpurea	0	0	0	0	0	0
Disporum hookeri	1.50	2.00	2.40	2.40	2.10	0.13
Epilobium minutum	0	0	0	0	0	0
Galium trifoliata	0	0	0	0.17	0.04	0.04
Holodiscus discolor	0	0	0	0	0	0
Hydrophyllum tenuipes	0	0	0	0	0	0
Lactuca spp.	0	0	0	0	0	0
Lapsana communis	0	0	0	0	0	0
Lathyrus spp.	0	0	0	0	0	0
Lilium columbiana	0	0	0	0	0	0
Maianthimum dilata	0	0	0	0	0	0
Montia siberica	0	0	0	0	0	0
Nemophila parviflora	0	0	0	0	0	0
Oxalis oregana	0	0	0	0	0	0
Polystichum munitum	0	0	0	0	0	0
Pteridium aquilinum	0	0	0.87	2.20	0.77	0.04
Rosa gymnocarpa	0.13	0.43	0.43	0.43	0.36	0.04
Rubus parviflora	0	0	0	0	0	0
Rubus ursinus	0	0	0	0	0	0
Smilacina stellata	0	0	0	0	0	0
Spirea densiflora	0	0	0	0.22	0.06	0.04
Symphoricarpos alba	0	0	0	0	0	0
Trientalis latifolia	3.10	5.30	6.70	5.30	5.10	0.96
Trillium ovatum	0	0	0	0.13	0.03	0.04
Vaccinium spp.	1.50	3.70	4.30	4.70	3.60	0.35
Vancouveria hexandra	0.83	1.50	2.20	1.70	1.60	0.17
Vicia spp.	0.07	0.07	0.07	0.87	0.27	0.22
Viola glabella	0	0	0	0	0	0

[1] $\text{Mean} = \frac{\Sigma \text{ Species coverage by date of observation}}{\text{Total number of observation dates}}$

[2] $\text{Frequency} = \frac{\Sigma \text{ Species occurrence for all sample units on a main plot}}{\text{Total sample units for that main plot}}$

[3] $\frac{\Sigma \text{ species coverage on each on each sample unit on a main plot}}{\text{Number of sample units in that main plot}}$

TABLE II

PERCENT COVER BY SPECIES AND VISIT FOR PLOT #1 1993

SPECIES	Date of Observation 5/23/93	7/10/93	8/31/93	9/5/93	MEAN[1]	FREQ[2]
Acer circinatum	0[3]	4.40	4.40	7.0	3.40	0.12
Achlys triphylla	0.20	0.40	0.40	1.00	0.50	0.04
Adenocaulon bicolor	0.80	0.80	1.60	2.60	1.45	0.04
Antenaria spp.	0.08	0.08	0.60	0	0.19	0.04
Arenaria macrophylla	0	0.60	0.60	0.60	0.45	0.04
Berberis nervosa	4.88	12.00	14.60	15.60	11.77	0.48
Campanula scoulari	0	0	0	0	0	0
Cornus cornuta	0	0	0	0	0	0
Dicentra formosa	0	0	0	0	0	0
Digitalis purpurea	0	0	0	0	0	0
Disporum hookeri	1.20	4.20	7.60	5.20	4.55	0.24
Epilobium minutum	0	0	0	0	0	0
Galium trifoliata	2.48	7.20	13.60	20.40	10.92	0.48
Holodiscus discolor	0	0	0	0	0	0
Hydrophyllum tenuipes	0	0	0	0	0	0
Lactuca spp.	0	2.20	0.80	0	0.75	0.12
Lapsana communis	0	0	0	0	0	0
Lathyrus spp.	0	0	1.60	0.60	0.55	0.04
Lilium columbiana	0	0	0	0	0	0
Maianthimum dilata	0.20	0.40	1.00	0	0.40	0.08
Montia siberica	2.80	2.80	5.40	7.60	4.65	0.24
Nemophila parviflora	0	0	0	0	0	0
Oxalis oregana	0	3.40	3.80	3.80	2.75	0.04
Polystichum munitum	0	0.80	0	0	0.20	0.04
Pteridium aquilinum	0.20	2.40	5.60	8.80	4.25	0.20
Rosa gymnocarpa	1.20	6.80	8.00	8.20	6.05	0.24
Rubus parviflora	0	0	0	0	0	0
Rubus ursinus	0	0	0.80	1.00	0.45	0.04
Smilacina stellata	0	0	0	0	0	0
Spirea densiflora	0	0.60	0	0	0.15	0.04
Symphoricarpos alba	0	0	0	0	0	0
Trientalis latifolia	6.70	11.80	17.00	25.20	15.18	0.76
Trillium ovatum	2.60	0.60	1.60	2.60	1.85	0.16
Vaccinium spp.	1.16	3.00	0	0	1.04	0.24
Vancouveria hexandra	0	0	0	0	0	0
Vicia spp.	0	0	0	0	0	0
Viola glabella	0	0	0	0	0	0

[1] Mean = $\frac{\Sigma \text{ Species coverage by date of observation}}{\text{Total number of observation dates}}$

[2] Frequency = $\frac{\Sigma \text{ Species occurrence for all sample units on a main plot}}{\text{Total sample units for that main plot}}$

[3] $\frac{\Sigma \text{ Species coverage on each sample unit on a main plot}}{\text{Number of sample units in that main plot}}$

TABLE IV

PERCENT COVER BY SPECIES AND VISITFOR PLOT #2 1993

SPECIES	Date of Observation 5/23/93	7/10/93	8/31/93	9/5/93	MEAN[1]	FREQ[2]
Acer circinatum	0[3]	4.00	5.80	6.60	4.10	0.08
Achlys triphylla	0.06	0	1.20	1.80	0.76	0.04
Adenocaulon bicolor	1.00	1.00	2.40	1.00	1.35	0.08
Antenaria spp.	0	0	0	0	0	0
Arenaria macrophylla	0	0	0	0	0	0
Berberis nervosa	2.60	6.40	18.60	14.60	10.55	0.56
Campanula scoulari	0	0	0	0	0	0
Cornus cornuta	0	0	0	0	0	0
Dicentra formosa	0	2.60	2.40	0	1.25	0.12
Digitalis purpurea	0	0.80	1.40	2.00	1.05	0.04
Disporum hookeri	2.60	3.00	7.56	3.40	4.14	0.20
Epilobium minutum	0	1.60	1.80	1.40	1.20	0.04
Galium trifoliata	2.60	12.20	10.80	21.40	11.75	0.32
Holodiscus discolor	0	0	0	0	0	0
Hydrophyllum tenuipes	0	0	0	1.60	0.40	0.04
Lactuca spp.	0	0	0	0	0	0
Lapsana communis	0	0	0	0	0	0
Lathyrus spp.	3.68	1.40	9.20	3.00	4.32	0.36
Lilium columbiana	0	0	0	0	0	0
Maianthimum dilata	1.00	1.60	2.00	3.60	2.05	0.16
Montia siberica	1.60	3.20	4.60	6.60	4.00	0.20
Nemophila parviflora	0	0	0	0	0	0
Oxalis oregana	0	0	1.00	3.20	1.05	0.04
Polystichum munitum	1.20	3.60	4.20	4.40	3.35	0.08
Pteridium aquilinum	8.80	17.40	16.60	23.00	16.45	0.48
Rosa gymnocarpa	0	0.80	2.20	3.40	1.60	0.08
Rubus parviflora	9.20	15.20	16.20	16.40	14.25	0.36
Rubus ursinus	0	0.40	11.60	8.60	5.15	0.20
Smilacina stellata	0	0	0	0	0	0
Spirea densiflora	0	0	0	0	0	0
Symphoricarpos alba	0	0	0	2.60	0.65	0.04
Trientalis latifolia	1.24	3.60	4.60	5.40	3.71	0.28
Trillium ovatum	0	0	0	0	0	0
Vaccinium spp.	0	0	0	0	0	0
Vancouveria hexandra	1.20	3.40	4.20	7.40	4.05	0.20
Vicia spp.	0	0	0	0	0	0
Viola glabella	0	0.04	0	0	0.01	0.04

[1] Mean = $\frac{\Sigma \text{ Species coverage by date of observation}}{\text{Total number of observation dates}}$

[2] Frequency = $\frac{\Sigma \text{ Species occurrence for all sample units on a main plot}}{\text{Total sample units for that main plot}}$

[3] $\frac{\Sigma \text{ Species coverage on each sample unit on a main plot}}{\text{Number of sample units in that main plot}}$

TABLE V

PERCENT COVER BY SPECIES AND VISIT FOR PLOT #3 1992

	Date of Observation					
SPECIES	6/13/92	7/11/92	8/7/92	9/7/92	MEAN[1]	FREQ[2]
Acer circinatum	0[3]	0	0	0	0	0
Achlys triphylla	1.20	1.40	1.40	1.40	1.35	0.09
Adenocaulon bicolor	0.09	0.09	0.09	0	0.07	0.05
Antenaria spp.	0	0	0	0	0	0
Arenaria macrophylla	0	0	0	0	0	0
Berberis nervosa	6.40	9.60	11.80	15.60	10.85	0.73
Campanula scoulari	0	0	0	0	0	0
Cornus cornuta	0	0	0	0	0	0
Dicentra formosa	0.36	0.36	0.36	1.10	0.55	0.09
Digitalis purpurea	0	0	0	0	0	0
Disporum hookeri	1.70	5.70	5.70	6.10	4.80	0.27
Epilobium minutum	0	0	0	0	0	0
Galium trifoliata	0.14	0.32	0.32	0.55	0.33	0.09
Holodiscus discolor	0	0	0	0	0	0
Hydrophyllum tenuipes	0	0	0	0	0	0
Lactuca spp.	0	0	0	0	0	0
Lapsana communis	0	0	0	0	0	0
Lathyrus spp.	0	0	0	0	0	0
Lilium columbiana	0	0	0	0	0	0
Maianthimum dilata	0	0	0.91	0.91	0.45	0.09
Montia siberica	0	0	0	0	0	0
Nemophila parviflora	0	0	0	0	0	0
Oxalis oregana	1.10	1.10	1.10	1.10	1.10	0.09
Polystichum munitum	0	0	0	0	0	0
Pteridium aquilinum	0	0	0	0	0	0
Rosa gymnocarpa	0	0	0	0	0	0
Rubus parviflora	0	0	0	0	0	0
Rubus ursinus	0	0	0	1.50	0.38	0.05
Smilacina stellata	0	0	0	0.14	0.04	0.05
Spirea densiflora	0	0	0	0	0	0
Symphoricarpos alba	0	0	0	0	0	0
Trientalis latifolia	0.95	1.90	2.20	1.90	1.20	0.23
Trillium ovatum	0	0	0	0	0	0
Vaccinium spp.	2.10	3.20	3.60	4.10	3.25	0.50
Vancouveria hexandra	0.32	0.45	0.45	0.68	0.36	0.09
Vicia spp.	0.55	0.77	0.77	1.30	0.85	0.32
Viola glabella	0	0	0	0	0	0

[1] Mean = $\frac{\Sigma \text{ Species coverage by date of observation}}{\text{Total number of observation dates}}$

[2] Frequency = $\frac{\Sigma \text{ Secies occurrence for all sample units on a main plot}}{\text{Total sample units for that main plot}}$

[3] $\frac{\Sigma \text{ Species coverage on each sample unit on a main plot}}{\text{Number of sample units in that main plot}}$

TABLE VI

PERCENT COVER BY SPECIES AND VISIT FOR PLOT #3 1993

SPECIES	Date of Observation 5/23/93	7/10/93	8/31/93	9/5/93	MEAN[1]	FREQ[2]
Acer circinatum	3.60[3]	8.60	X[4]	8.20	6.80	0.12
Achlys triphylla	0.60	0.60	X	1.00	0.73	0.04
Adenocaulon bicolor	0	0	X	0.60	0.20	0.04
Antenaria spp.	0	0	0	0	0	0
Arenaria macrophylla	0	0.80	X	0	0.27	0.04
Berberis nervosa	7.44	20.20	X	27.20	18.28	0.84
Campanula scoulari	0	0	0	0	0	0
Cornus cornuta	0	0	0	0	0	0
Dicentra formosa	1.40	0.80	X	0.80	1.00	0.12
Digitalis purpurea	0	0	0	0	0	0
Disporum hookeri	2.64	3.60	X	5.60	3.95	0.20
Epilobium minutum	0	0	0	0	0	0
Galium trifoliata	0.40	3.80	X	7.60	3.93	0.20
Holodiscus discolor	0	0.20	X	0.60	0.27	0.04
Hydrophyllum tenuipes	0	0	0	0	0	0
Lactuca spp.	0	0	0	0	0	0
Lapsana communis	0	0	0	0	0	0
Lathyrus spp.	2.50	5.20	X	14.80	7.40	0.32
Lilium columbiana	0	0	0	0	0	0
Maianthimum dilata	0.20	0	X	0	0.07	0.04
Montia siberica	0	0	X	0.80	0.27	0.04
Nemophila parviflora	0	0	0	0	0	0
Oxalis oregana	0.80	1.60	X	2.20	1.53	0.04
Polystichum munitum	0	0	0	0	0	0
Pteridium aquilinum	3.40	8.80	X	14.20	8.80	0.24
Rosa gymnocarpa	4.24	5.60	X	9.80	6.55	0.16
Rubus parviflora	0	0.80	X	0.80	0.53	0.04
Rubus ursinus	0	0.40	X	5.00	1.80	0.16
Smilacina stellata	0.40	1.00	X	0	0.47	0.04
Spirea densiflora	0	0	0	0	0	0
Symphoricarpos alba	0	0	0	0	0	0
Trientalis latifolia	4.88	6.08	X	6.40	5.79	0.52
Trillium ovatum	0.40	0	X	0	0.13	0.04
Vaccinium spp.	0	0	0	0	0	0
Vancouveria hexandra	3.60	5.88	X	2.40	3.96	0.32
Vicia spp.	0	0	0	0	0	0
Viola glabella	0	0	0	0	0	0

[1] Mean = $\frac{\Sigma \text{ Species coverage by date of observation}}{\text{Total number of observation dates}}$

[2] Frequency = $\frac{\Sigma \text{ Species occurrence for all sample units on a main plot}}{\text{Total sample units for that main plot}}$

[3] $\frac{\Sigma \text{ Species coverage on each sample unit on a main plot}}{\text{Number of sample units in that main plot}}$

[4] X = Data lost between the field and data entry

TABLE VII

PERCENT COVER BY SPECIES AND VISIT FOR PLOT #4 1992

SPECIES	Date of Observation 6/13/92	7/11/92	8/7/92	9/7/92	MEAN[1]	FREQ[2]
Acer circinatum	0[3]	0	0	0	0	0
Achlys triphylla	0.42	0.42	0.42	0.42	0.42	0.04
Adenocaulon bicolor	0.83	0.71	0.71	0.71	0.74	0.21
Antenaria spp.	0.53	0.79	0.83	0.88	0.77	0.13
Arenaria macrophylla	0	0	0	0	0	0
Berberis nervosa	6.40	7.70	9.60	9.60	8.30	0.50
Campanula scoulari	0	0	0	0	0	0
Cornus cornuta	0	0	0	0	0	0
Dicentra formosa	0.08	0.08	0	0	0.04	0.04
Digitalis purpurea	0	0	0	0	0	0
Disporum hookeri	0.63	1.00	0.58	0.63	0.71	0.17
Epilobium minutum	0	0	0	0	0	0
Galium trifoliata	1.50	1.70	3.10	3.80	2.50	0.38
Holodiscus discolor	0	0	0	0	0	0
Hydrophyllum tenuipes	0	0	0	0	0	0
Lactuca spp.	0	0	0	0	0	0
Lapsana communis	0	0	0	0	0	0
Lathyrus spp.	0	0	0	0	0	0
Lilium columbiana	0	0	0.42	0.42	0.21	0.04
Maianthimum dilata	0.08	0.08	0.08	0.17	0.10	0.08
Montia siberica	0.71	0.71	1.30	1.30	1.00	0.17
Nemophila parviflora	0	0	0	0	0	0
Oxalis oregana	0	0	0	0	0	0
Polystichum munitum	0	0	0	0	0	0
Pteridium aquilinum	0	4.40	4.60	4.60	3.40	0.08
Rosa gymnocarpa	0	0	0	1.30	0.33	0.08
Rubus parviflora	1.50	8.20	14.60	17.10	10.40	0.25
Rubus ursinus	0	0	0	1.30	0.33	0.08
Smilacina stellata	0.21	0.21	1.00	1.00	0.61	0.04
Spirea densiflora	0	0	0	0	0	0
Symphoricarpos alba	0	0	0	0	0	0
Trientalis latifolia	1.10	1.50	1.60	1.00	1.30	0.54
Trillium ovatum	0	0	0	0	0	0
Vaccinium spp.	2.60	4.70	5.50	5.50	4.60	0.58
Vancouveria hexandra	0	0	1.50	1.80	0.83	0.08
Vicia spp.	0	0	0	0.92	0.23	0.13
Viola glabella	0.04	0	0	0	0.01	0.04

[1] Mean = $\frac{\Sigma \text{ Species coverage by date of observation}}{\text{Total number of observation dates}}$

[2] Frequency = $\frac{\Sigma \text{ Species occurrence for all sample units on a main plot}}{\text{Total sample units for that main plot}}$

[3] $\frac{\Sigma \text{ Species coverage on each sasmple unit on a main plot}}{\text{Number of sample units in that main plot}}$

TABLE VIII

PERCENT COVER BY SPECIES AND VISIT FOR PLOT #4 1993

SPECIES	Date of Observation 6/13/92	7/11/92	8/7/92	9/7/92	MEAN[1]	FREQ[2]
Acer circinatum	0[3]	0	0	0	0	0
Achlys triphylla	0	0	2.14	2.05	0.80	0.05
Adenocaulon bicolor	1.14	2.95	4.77	6.59	3.86	0.14
Antenaria spp.	0.45	0	0	0	0.11	0.05
Arenaria macrophylla	0	9.18	0	0	2.30	0.55
Berberis nervosa	1.00	1.00	6.60	3.20	2.95	0.14
Campanula scoulari	0	1.14	1.26	0	0.60	0.05
Cornus cornuta	0	0	0	0	0	0
Dicentra formosa	2.50	2.95	2.50	2.05	2.50	0.27
Digitalis purpurea	0	0	0	0	0	0
Disporum hookeri	5.77	8.73	8.40	8.40	7.83	0.59
Epilobium minutum	0	0	1.14	0	0.29	0.09
Galium trifoliata	6.23	13.41	22.27	29.55	17.87	0.68
Holodiscus discolor	0	0	2.27	1.82	1.02	0.09
Hydrophyllum tenuipes	0	0	0	0	0	0
Lactuca spp.	0	0	0	1.14	0.29	0.05
Lathyrus spp.	0	0	0	0	0	0
Lapsana communis	0	0	0.91	0.91	0.46	0.05
Lilium columbiana	0.23	0.68	0	0	0.23	0.09
Maianthimum dilata	0.45	0.45	0	0	0.23	0.09
Montia siberica	0	0	0	0	0	0
Nemophila parviflora	0	0.23	0.45	0.91	0.40	0.05
Oxalis oregana	0	0	0	0	0	0
Polystichum munitum	1.36	1.82	2.95	3.41	2.39	0.05
Pteridium aquilinum	0.68	3.41	16.82	12.04	8.24	0.36
Rosa gymnocarpa	0.45	3.41	8.86	11.14	5.97	0.23
Rubus parviflora	0.23	0.23	10.68	15.91	6.76	0.23
Rubus ursinus	0	1.82	3.18	9.77	3.69	0.18
Smilacina stellata	0	0	0	0	0	0
Spirea densiflora	0	2.27	0	0	0.57	0.14
Symphoricarpos alba	0	0	0	0	0	0
Trientalis latifolia	7.41	12.95	16.36	20.68	14.35	0.73
Trillium ovatum	0.23	0.23	0.45	0	0.23	0.05
Vaccinium spp.	0	0	0	0	0	0
Vancouveria hexandra	2.77	5.00	5.00	7.95	5.18	0.27
Vicia spp.	0	0	0	0	0	0
Viola glabella	0	0	0	0	0	0

[1] Mean = $\frac{\Sigma \text{ Species coverage by date of observation}}{\text{Total number of obsevation dates}}$

[2] Frequency = $\frac{\Sigma \text{ Species occurrence for all sample units on a main plot}}{\text{Total sample units for that main plot}}$

[3] $\frac{\Sigma \text{ Species coverage on each sample unit on a main plot}}{\text{Number of sample units in that main plot}}$

root crowns or underground rhizomes. These species are considered to be residuals, since they were present in the community prior to disturbance even if in very low density (Dyrness 1973). The returning species that benefited most from the disturbance were *Berberis nervosa* (Oregon Grape), which went from 2% in the pre-fire community to 16% coverage in the post-fire; *Disporum hookeri* (Fairy Bells), which increased from 1% to 5.5%; *Galium trifoliata* (Bedstraw), which increased from 1 to 21%; and *Trientalis latifolia* (Star Flower), which went from 1% to 26%. During the summer of 1993 all of the species present in 1992 returned except for *Smilacina stellata*, the understory dominant from the pre-fire community. There were 7 species present in 1993 that were not present either before the fire or in 1992 (see Table X).

Four pre-burn species, one fern and three shrubs, were not found after the fire. Twenty five of the species making up the post-fire understory after both years were new or invaders. These species were not in the pre-disturbance community and must have come in either from airborne seed sources outside of the disturbed area, on animals, or on people and their equipment, or from dormant seeds that were buried in the soil.

The main tree species, *Pseudotsuga menziesii,* remained the dominant canopy species, but the amount of canopy closure was reduced on plots #2 and #3 to about 1% live crown material as a result of the fire burning the crowns of the canopy trees (Figures 3,4). Prior to the fire the closure was closer to 80 - 100% live crown material providing canopy closure. Plots #1 and #4 have canopies which remain nearly intact with closures of 70 - 90% (Figures 2,5).

The Pearson Goodness-of-Fit Test (Tables X-XVIII) was used to calculate similarities in the frequencies of distribution between plots in which the canopy remained intact and where the fire removed most of the canopy. Each visit to each main plot was compared by this test to every other visit to the same main plot, and the

TABLE IX

SPECIES PRESENT

	Pre-burn	Post-burn 1992	Post-burn 1993
Acer circinatum	X[1]	X	X
Achlys triphylla	X	X	X
Adenocaulon bicolor	X	X	X
Antenaria spp.		X	X
Arenaria macrophylla		X	X
Berberis nervosa	X	X	X
Campanula scoulari			X
Cornus cornuta	X	X	
Dicentra formosa	X	X	X
Digitalis purpurea			X
Disporum hookeri	X	X	X
Dryopteris austriaca	X		
Epilobium minutum		X	X
Galium trifoliata	X	X	X
Holodiscus discolor	X		X
Hydrophyllum tenuipes			X
Lactuca spp.			X
Lapsana communis			X
Lathyrus spp.		X	X
Lilium columbiana		X	X
Maianthimum dilata		X	X
Montia siberica		X	X
Nemophila parviflora			X
Oplopanax horridum	X		
Oxalis oregana		X	X
Polystichum munitum			X
Pteridium aquilinum		X	X
Rhamnus purshiana	X		
Rosa gymnocarpa	X	X	X
Rubus parviflora		X	X
Rubus ursinus		X	X
Sambucus spp.	X		
Smilacina racemosa	X	X	X
Smilacina stellata		X	X
Spirea densiflora			X
Symphoricarpos alba			X
Trientalis latifolia	X	X	X
Trillium ovatum		X	X
Vaccinium spp.		X	X
Vancouveria hexandra	X	X	X
Vicia spp.		X	
Viola glabella		X	X

[1] X = Present for that year.

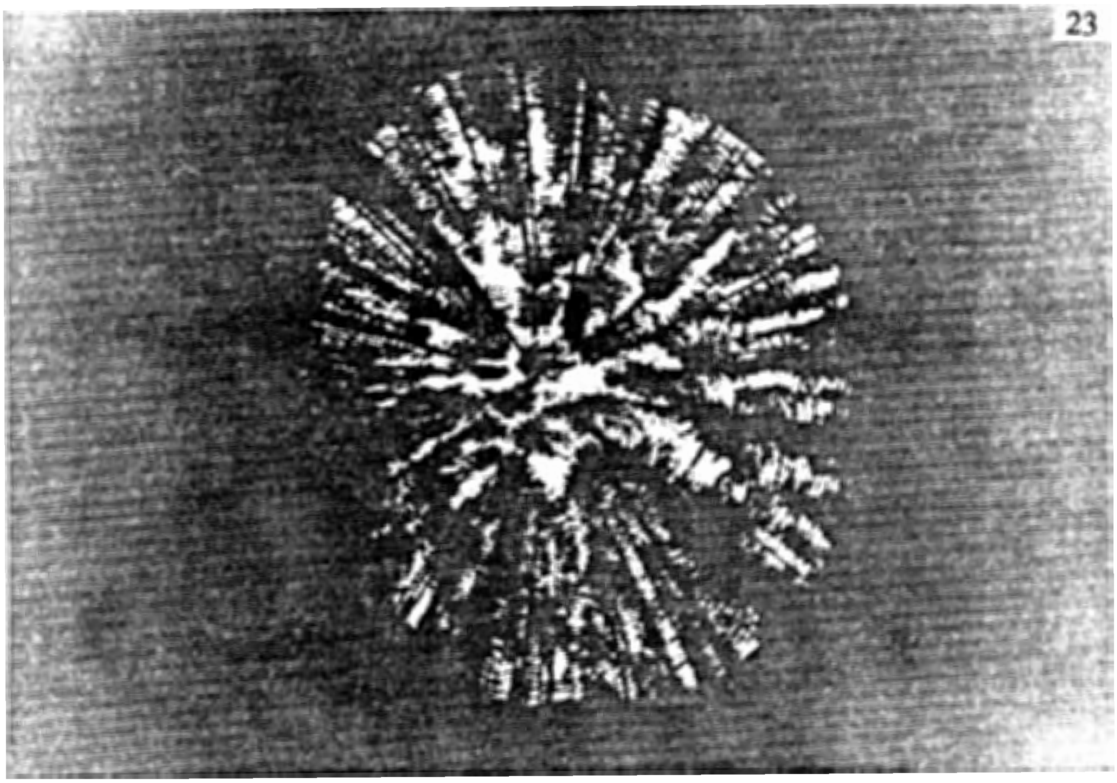


Figure 2 Photograph of canopy closure on plot #1 a shade site. Taken with a Soligor fish eye lens.

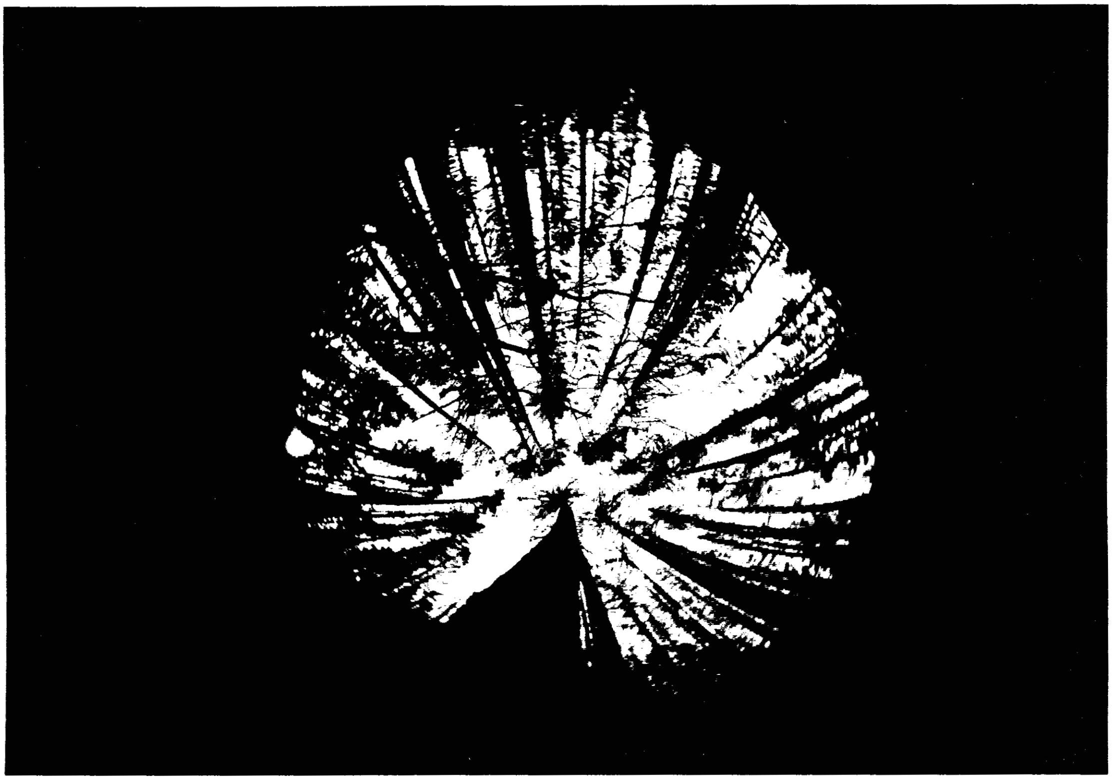


Figure 3 Photograph of canopy closure on plot #2 a sun site. Taken with a Soligor fish eye lens.

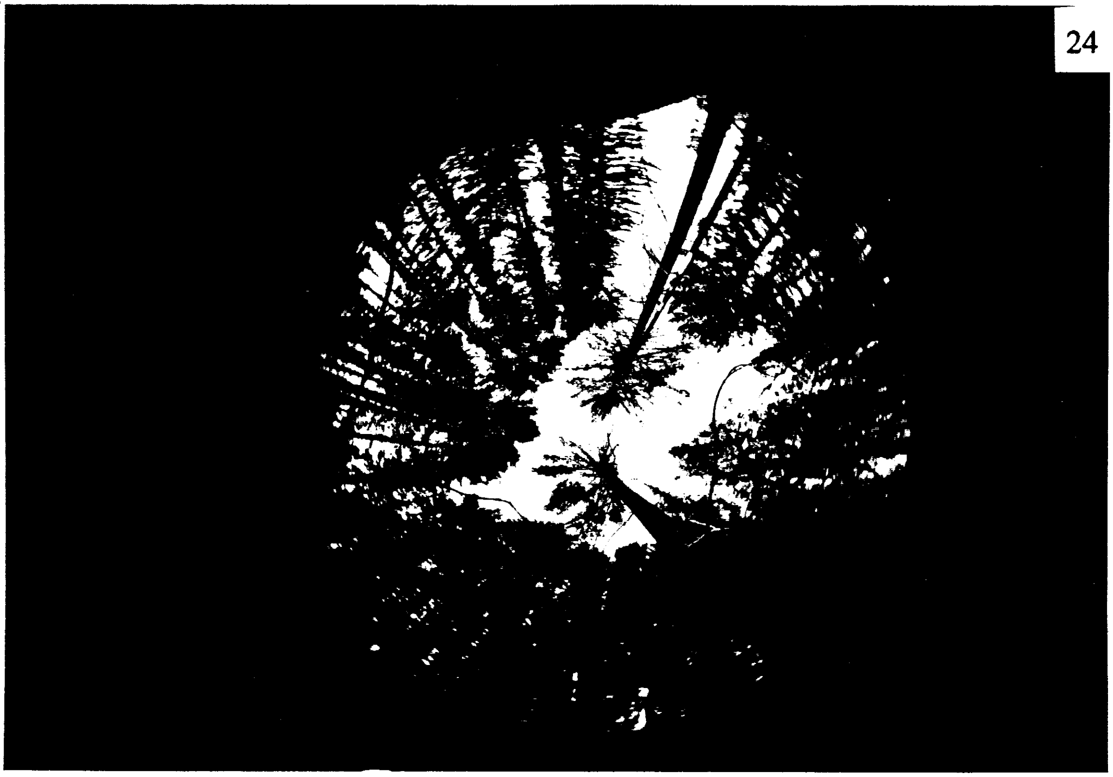


Figure 4 Photograph of canopy closure on plot #3 a sun site. Taken with a Soligor fish eye lens.

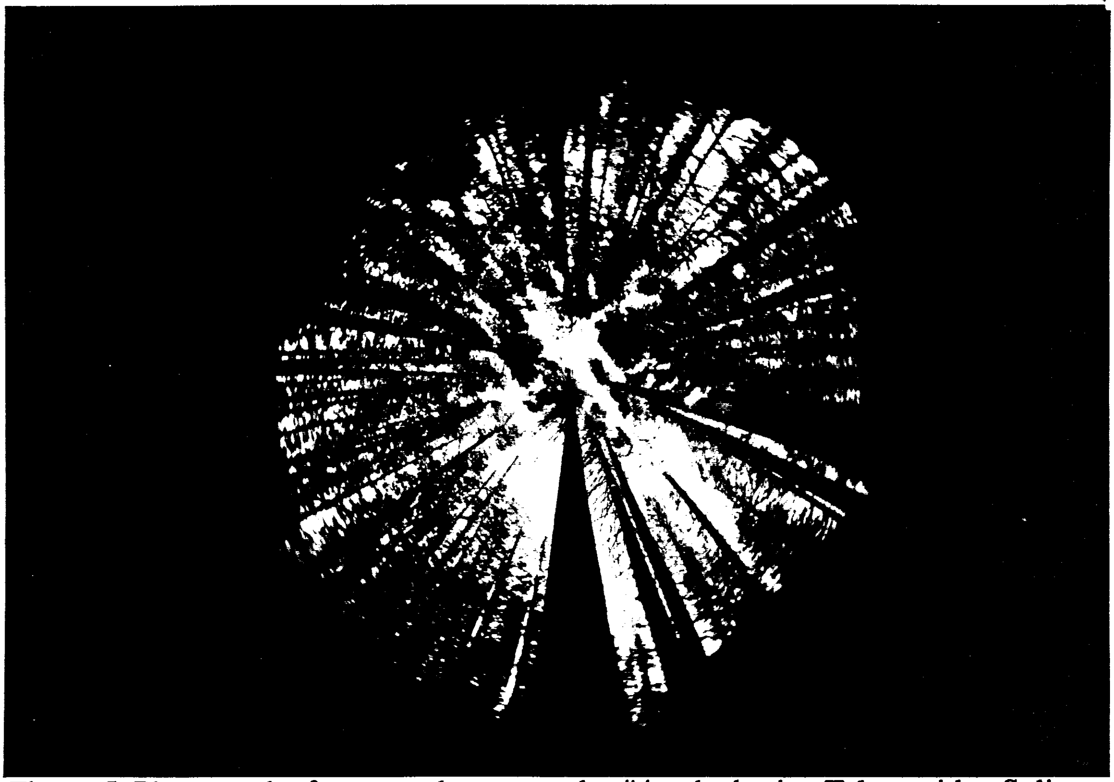


Figure 5 Photograph of canopy closure on plot #4 a shade site. Taken with a Soligor fish eye lens.

TABLE X

STATISTICAL TREATMENTS: BY USE OF THE KARL PEARSON GOODNESS-OF-FIT

1. $X^2 = \Sigma (X_i - np_i)^2 / np_i$ where X_i = observed frequency of each species.
   np_i = theoretical probability of a species occurring on a given plot.

2. Modified so that only probabilities are used.
   $X^2 = \Sigma (P_{A1} - P_{A2})^2 / P_{A2}$ where P_{A1} = The probability of species A on plot 1
   P_{A2} = The probability or species A on plot 2
   Species with $P_{A2} = 0$ were excluded.

This modification allows the summation of all species on all plots to be compared.

TABLE XI

SPECIES COUNTS BY VISIT DATE WITH THE PROBABILITY OF OCCURRENCE FOR PLOT #1 1992

SPECIES	6/13/92		7/11/92		8/7/92		9/7/92	
	ACT	PROB	ACT	PROB	ACT	PROB	ACT	PROB
Acer circinatum	1	0.02	1	0.02	1	0.01	1	0.01
Achlys triphylla	0	0	0	0	0	0	0	0
Adenocaulon bicolor	0	0	0	0	0	0	0	0
Antenaria spp.	0	0	0	0	1	0.01	1	0.01
Arenaria macrophylla	0	0	0	0	0	0	0	0
Berberis nervosa	7	0.13	6	0.10	10	0.14	11	0.11
Campanula scoulari	0	0	0	0	0	0	0	0
Cornus cornuta	0	0	0	0	0	0	0	0
Dicentra formosa	0	0	0	0	0	0	0	0
Digitalis purpurea	0	0	0	0	0	0	0	0
Disporum hookeri	1	0.02	1	0.02	2	0.03	5	0.05
Epilobium minutum	1	0.02	1	0.02	0	0	1	0.01
Galium trifoliata	3	0.06	4	0.06	4	0.06	7	0.07
Holodiscus discolor	0	0	0	0	0	0	0	0
Hydrophyllum tenuipes	0	0	0	0	0	0	0	0
Lactuca spp.	0	0	0	0	0	0	0	0
Lapsana communis	0	0	0	0	0	0	0	0
Lathyrus spp.	0	0	0	0	0	0	0	0
Lilium columbiana	1	0.02	1	0.02	1	0.01	1	0.01
Maianthimum dilata	0	0	0	0	0	0	0	0
Montia siberica	2	0.04	3	0.05	4	0.06	9	0.09
Nemophila parviflora	0	0	0	0	0	0	0	0
Oxalis oregana	1	0.02	1	0.02	1	0.01	1	0.01
Polystichum munitum	0	0	0	0	0	0	0	0
Pteridium aquilinum	3	0.06	1	0.02	2	0.03	2	0.02
Rosa gymnocarpa	2	0.04	2	0.03	3	0.04	4	0.04
Rubus parviflora	0	0	0	0	0	0	0	0
Rubus ursinus	3	0.06	3	0.05	3	0.04	4	0.04
Smilacina stellata	0	0	1	0.02	2	0.03	3	0.03
Spirea densiflora	0	0	0	0	0	0	0	0
Symphoricarpos alba	0	0	0	0	0	0	0	0
Trientalis latifolia	15	0.28	23	0.37	21	0.30	24	0.25
Trillium ovatum	2	0.04	2	0.03	1	0.01	2	0.02
Vaccinium spp.	0	0	0	0	0	0	0	0
Vancouveria hexandra	0	0	0	0	0	0	0	0
Vicia spp.	9	0.17	11	0.17	12	0.17	14	0.14
Viola glabella	0	0	0	0	0	0	0	0
Total	51		61		68		90	

[1] Probability = Actual count / Total of that column

TABLE XII

SPECIES COUNTS BY VISIT DATE WITH THE PROBABILITY OF OCCURRENCE FOR PLOT #1 1993

SPECIES	5/23/93		7/10/93		8/31/93		9/5/93	
	ACT	PROB	ACT	PROB	ACT	PROB	ACT	PROB
Acer circinatum	0	0	2	0.03	2	0.02	2	0.03
Achlys triphylla	1	0.02	1	0.01	1	0.01	1	0.01
Adenocaulon bicolor	1	0.02	1	0.01	1	0.01	1	0.01
Antenaria spp.	1	0.02	2	0.03	1	0.01	0	0
Arenaria macrophylla	0	0	0	0	0	0	0	0
Berberis nervosa	8	0.16	13	0.16	10	0.12	9	0.13
Campanula scoulari	0	0	0	0	0	0	0	0
Cornus cornuta	0	0	0	0	0	0	0	0
Dicentra formosa	0	0	0	0	0	0	0	0
Digitalis purpurea	0	0	0	0	0	0	0	0
Disporum hookeri	2	0.04	6	0.08	8	0.10	3	0.04
Epilobium minutum	0	0	0	0	0	0	0	0
Galium trifoliata	6	0.12	11	0.14	11	0.14	13	0.18
Holodiscus discolor	0	0	0	0	0	0	0	0
Hydrophyllum tenuipes	0	0	0	0	0	0	0	0
Lactuca spp.	0	0	3	0.04	1	0.01	0	0
Lapsana communis	0	0	0	0	0	0	0	0
Lathyrus spp.	0	0	0	0	0	0	0	0
Lilium columbiana	0	0	0	0	0	0	0	0
Maianthimum dilata	1	0.02	1	0.01	1	0.01	0	0
Montia siberica	3	0.06	4	0.05	5	0.06	6	0.08
Nemophila parviflora	0	0	0	0	0	0	0	0
Oxalis oregana	0	0	1	0.01	1	0.01	1	0.01
Polystichum munitum	0	0	1	0.01	1	0.01	0	0
Pteridium aquilinum	1	0.02	2	0.03	4	0.05	5	0.07
Rosa gymnocarpa	2	0.04	5	0.06	6	0.07	5	0.07
Rubus parviflora	0	0	1	0.01	1	0.01	1	0.01
Rubus ursinus	0	0	0	0	0	0	0	0
Smilacina stellata	0	0	0	0	0	0	0	0
Spirea densiflora	0	0	1	0.01	1	0.01	0	0
Symphoricarpos alba	0	0	0	0	0	0	0	0
Trientalis latifolia	17	0.33	18	0.23	21	0.26	21	0.30
Trillium ovatum	4	0.08	1	0.01	3	0.04	2	0.03
Vaccinium spp.	0	0	0	0	0	0	0	0
Vancouveria hexandra	0	0	0	0	0	0	0	0
Vicia spp.	4	0.08	6	0.08	3	0.03	1	0.01
Viola glabella	0	0	0	0	0	0	0	0
Total	51		80		82		71	

[1] Probability = Actual count / Total for that column

TABLE XIII

SPECIES COUNTS BY VISIT DATE WITH THE PROBABILITY OF OCCURRENCE FOR PLOT #2 1992

SPECIES	6/13/92		7/11/92		8/7/92		9/7/92	
	ACT	PROB	ACT	PROB	ACT	PROB	ACT	PROB
Acer circinatum	1	0.02	1	0.02	1	0.01	1	0.01
Achlys triphylla	0	0	0	0	0	0	0	0
Adenocaulon bicolor	2	0.04	2	0.04	2	0.03	2	0.03
Antenaria spp.	9	0.18	10	0.18	11	0.14	12	0.15
Arenaria macrophylla	0	0	1	0.02	1	0.01	2	0.03
Berberis nervosa	1	0.02	2	0.04	2	0.03	2	0.03
Campanula scoulari	0	0	0	0	0	0	0	0
Cornus cornuta	0	0	0	0	0	0	0	0
Dicentra formosa	2	0.04	4	0.07	4	0.05	4	0.05
Digitalis purpurea	0	0	0	0	0	0	0	0
Disporum hookeri	3	0.06	2	0.04	3	0.04	4	0.05
Epilobium minutum	0	0	0	0	0	0	0	0
Galium trifoliata	0	0	0	0	13	0.17	1	0.01
Holodiscus discolor	0	0	0	0	0	0	0	0
Hydrophyllum tenuipes	0	0	0	0	0	0	0	0
Lactuca spp.	0	0	0	0	0	0	0	0
Lapsana communis	0	0	0	0	0	0	0	0
Lathyrus spp.	0	0	0	0	0	0	0	0
Lilium columbiana	0	0	0	0	1	0.01	0	0
Maianthimum dilata	0	0	0	0	1	0.01	0	0
Montia siberica	0	0	0	0	1	0.01	1	0.01
Nemophila parviflora	0	0	0	0	1	0.01	0	0
Oxalis oregana	0	0	0	0	0	0	0	0
Polystichum munitum	0	0	0	0	0	0	3	0.04
Pteridium aquilinum	0	0	0	0	2	0.03	1	0.01
Rosa gymnocarpa	1	0.02	1	0.02	1	0.01	1	0.01
Rubus parviflora	0	0	0	0	0	0	0	0
Rubus ursinus	0	0	0	0	0	0	0	0
Smilacina stellata	0	0	0	0	0	0	0	0
Spirea densiflora	0	0	0	0	0	0	1	0.01
Symphoricarpos alba	0	0	0	0	0	0	0	0
Trientalis latifolia	17	0.35	22	0.39	22	0.28	21	0.27
Trillium ovatum	0	0	0	0	0	0	1	0.01
Vaccinium spp.	0	0	0	0	0	0	0	0
Vancouveria hexandra	4	0.08	4	0.07	4	0.05	4	0.05
Vicia spp.	9	0.18	8	0.14	9	0.11	11	0.14
Viola glabella	0	0	0	0	0	0	0	0
Total	49		57		78		72	

[1] Probability = Actual count / Total of that column.

TABLE XIV

SPECIES COUNTS BY VISIT DATE WITH THE PROBABILITY OF OCCURRENCE FOR PLOT #2 1993

SPECIES	5/23/93		7/10/93		8/31/93		9/5/93	
	ACT	PROB	ACT	PROB	ACT	PROB	ACT	PROB
Acer circinatum	0	0	0	0	0	0	0	0
Achlys triphylla	0	0	0	0	0	0	1	0.01
Adenocaulon bicolor	1	0.02	3	0.03	4	0.05	4	0.06
Antenaria spp.	1	0.02	1	0.01	0	0	0	0
Arenaria macrophylla	0	0	11	0.12	0	0	0	0
Berberis nervosa	2	0.03	2	0.02	3	0.04	2	0.03
Campanula scoulari	0	0	0	0	1	0.01	0	0
Cornus cornuta	0	0	0	0	0	0	0	0
Dicentra formosa	4	0.06	4	0.04	3	0.04	2	0.03
Digitalis purpurea	0	0	0	0	0	0	0	0
Disporum hookeri	11	0.17	12	0.13	5	0.06	4	0.06
Epilobium minutum	0	0	0	0	2	0.02	0	0
Galium trifoliata	11	0.17	14	0.16	13	0.15	13	0.19
Holodiscus discolor	0	0	0	0	1	0.01	2	0.03
Hydrophyllum tenuipes	0	0	0	0	0	0	0	0
Lactuca spp.	0	0	0	0	0	0	1	0.01
Lapsana communis	0	0	0	0	1	0.01	1	0.01
Lathyrus spp.	0	0	0	0	0	0	0	0
Lilium columbiana	1	0.02	1	0.01	1	0.01	0	0
Maianthimum dilata	1	0.02	1	0.01	1	0.01	0	0
Montia siberica	0	0	0	0	1	0.01	0	0
Nemophila parviflora	0	0	1	0.01	1	0.01	1	0.01
Oxalis oregana	0	0	0	0	0	0	0	0
Polystichum munitum	0	0	0	0	2	0.02	2	0.02
Pteridium aquilinum	1	0.02	2	0.02	8	0.10	3	0.04
Rosa gymnocarpa	2	0.03	3	0.03	5	0.06	5	0.07
Rubus parviflora	1	0.02	2	0.02	5	0.06	5	0.07
Rubus ursinus	0	0	0	0	3	0.04	4	0.06
Smilacina stellata	0	0	0	0	0	0	0	0
Spirea densiflora	0	0	1	0.01	1	0.01	0	0
Symphoricarpos alba	0	0	0	0	0	0	0	0
Trientalis latifolia	16	0.25	16	0.18	8	0.10	14	0.21
Trillium ovatum	1	0.02	1	0.01	1	0.01	0	0
Vaccinium spp.	0	0	0	0	0	0	0	0
Vancouveria hexandra	5	0.08	7	0.08	5	0.06	4	0.06
Vicia spp.	6	0.09	5	0.06	10	0.12	11	0.16
Viola glabella	0	0	0	0	0	0	0	0
Total	64		90		84		79	

[1] Probability = Actual count / Total for that column

TABLE XV

SPECIES COUNTS BY VISIT DATE WITH THE PROBABILITY OF OCCURRENCE FOR PLOT #3 1992

SPECIES	6/13/92		7/11/92		8/7/92		9/7/92	
	ACT	PROB	ACT	PROB	ACT	PROB	ACT	PROB
Acer circinatum	0	0	0	0	0	0	0	0
Achlys triphylla	2	0.03	2	0.03	2	0.03	3	0.04
Adenocaulon bicolor	2	0.03	1	0.02	2	0.03	2	0.03
Antenaria spp.	1	0.02	1	0.02	1	0.01	0	0
Arenaria macrophylla	0	0	0	0	0	0	0	0
Berberis nervosa	16	0.27	16	0.28	17	0.23	18	0.23
Campanula scoulari	0	0	0	0	0	0	0	0
Cornus cornuta	0	0	0	0	0	0	0	0
Dicentra formosa	2	0.03	2	0.03	2	0.03	2	0.03
Digitalis purpurea	0	0	0	0	0	0	0	0
Disporum hookeri	6	0.10	5	0.09	7	0.09	8	0.10
Epilobium minutum	0	0	0	0	0	0	0	0
Galium trifoliata	2	0.03	2	0.03	2	0.03	2	0.03
Holodiscus discolor	0	0	0	0	0	0	0	0
Hydrophyllum tenuipes	0	0	0	0	0	0	0	0
Lactuca spp.	0	0	0	0	0	0	0	0
Lapsana communis	0	0	0	0	0	0	0	0
Lathyrus spp.	0	0	0	0	0	0	0	0
Lilium columbiana	0	0	0	0	0	0	0	0
Maianthimum dilata	0	0	0	0	1	0.01	1	0.01
Montia siberica	0	0	0	0	0	0	0	0
Nemophila parviflora	0	0	0	0	0	0	0	0
Oxalis oregana	1	0.02	1	0.02	1	0.01	1	0.01
Polystichum munitum	0	0	0	0	0	0	0	0
Pteridium aquilinum	2	0.03	2	0.03	2	0.03	2	0.03
Rosa gymnocarpa	0	0	0	0	0	0	0	0
Rubus parviflora	0	0	0	0	0	0	0	0
Rubus ursinus	0	0	0	0	4	0.05	4	0.05
Smilacina stellata	0	0	0	0	0	0	0	0
Spirea densiflora	0	0	0	0	0	0	0	0
Symphoricarpos alba	0	0	0	0	0	0	0	0
Trientalis latifolia	11	0.18	14	0.24	15	0.20	15	0.19
Trillium ovatum	0	0	0	0	0	0	0	0
Vaccinium spp.	0	0	0	0	2	0.03	2	0.03
Vancouveria hexandra	2	0.03	1	0.02	3	0.04	3	0.04
Vicia spp.	13	0.21	13	0.24	14	0.19	14	0.18
Viola glabella	0	0	0	0	0	0	0	0
Total	60		60		75		77	

[1] Probability = Actual count / Total of that column

TABLE XVI

SPECIES COUNTS BY VISIT DATE WITH THE PROBABILITY OF OCCURRENCE FOR PLOT #3 1993

SPECIES	5/23/93		7/10/93		8/31/93		9/5/93	
	ACT	PROB	ACT	PROB	ACT	PROB	ACT	PROB
Acer circinatum	2	0.04	3	0.04	X[2]	X	3	0.05
Achlys triphylla	1	0.02	1	0.01	X	X	1	0.02
Adenocaulon bicolor	0	0	0	0	X	X	1	0.02
Antenaria spp.	0	0	0	0	X	X	0	0
Arenarial macrophylla	0	0	1	0.01	X	X	0	0
Berberis nervosa	13	0.24	20	0.25	X	X	17	0.28
Campanula scoulari	0	0	0	0	X	X	0	0
Cornus cornuta	0	0	0	0	X	X	0	0
Dicentra formosa	3	0.06	2	0.03	X	X	2	0.03
Digitalis purpurea	0	0	0	0	X	X	0	0
Disporum hookeri	3	0.06	3	0.04	X	X	5	0.08
Epilobium minutum	0	0	0	0	X	X	0	0
Galium trifoliata	1	0.02	5	0.06	X	X	4	0.07
Holodiscus discolor	0	0	1	0.01	X	X	0	0
Hydrophyllum tenuipes	0	0	0	0	X	X	0	0
Lactuca spp.	0	0	0	0	X	X	0	0
Lapsana communis	0	0	0	0	X	X	0	0
Lathyrus spp.	0	0	0	0	X	X	0	0
Lilium columbiana	0	0	0	0	X	X	0	0
Maianthimum dilata	1	0.02	0	0	X	X	0	0
Montia siberica	0	0	0	0	X	X	1	0.02
Nemophila parviflora	0	0	0	0	X	X	0	0
Oxalis oregana	0	0	0	0	X	X	1	0.02
Polystichum munitum	0	0	0	0	X	X	0	0
Pteridium aquilinum	3	0.06	7	0.09	X	X	1	0.02
Rosa gymnocarpa	3	0.06	3	0.04	X	X	4	0.07
Rubus parviflora	1	0.02	2	0.03	X	X	4	0.07
Rubus ursinus	0	0	0	0	X	X	0	0
Smilacina stellata	1	0.02	2	0.03	X	X	0	0
Spirea densiflora	0	0	0	0	X	X	0	0
Symphoricarpos alba	0	0	0	0	X	X	0	0
Trientalis latifolia	12	0.22	14	0.18	X	X	6	0.10
Trillium ovatum	1	0.02	1	0.01	X	X	0	0
Vaccinium spp.	0	0	0	0	X	X	0	0
Vancouveria hexandra	3	0.06	6	0.08	X	X	2	0.03
Vicia spp.	7	0.13	10	0.13	X	X	8	0.13
Viola glabella	0	0	0	0	X	X	0	0
Total	55		80		X		60	

[1] Probability = Actual count / Total of that column
[2] Collected data lost prior to data entry procedures

TABLE XVII

SPECIES COUNTS BY VISIT DATE WITH THE PROBABILITY OF OCCURRENCE FOR PLOT #4 1992

SPECIES	5/23/93		7/10/93		8/31/93		9/5/93	
	ACT	PROB	ACT	PROB	ACT	PROB	ACT	PROB
Acer circinatum	0	0	0	0	0	0	0	0
Achlys triphylla	1	0.01	1	0.01	1	0.01	1	0.01
Adenocaulon bicolor	5	0.07	7	0.10	3	0.04	5	0.05
Antenaria spp.	2	0.03	3	0.04	3	0.04	3	0.03
Arenaria macrophylla	0	0	1	0.01	0	0	1	0.01
Berberis nervosa	11	0.16	11	0.15	11	0.15	12	0.12
Campanula scoulari	0	0	0	0	1	0.01	0	0
Cornus cornuta	0	0	0	0	0	0	0	0
Dicentra formosa	1	0.01	1	0.01	0	0	1	0.01
Digitalis purpurea	0	0	0	0	0	0	0	0
Disporum hookeri	4	0.06	4	0.06	2	0.03	5	0.05
Epilobium minutum	0	0	0	0	0	0	0	0
Galium trifoliata	5	0.07	6	0.08	8	0.11	9	0.09
Holodiscus discolor	0	0	0	0	0	0	0	0
Hydrophyllum tenuipes	0	0	0	0	0	0	0	0
Lactuca spp.	0	0	0	0	0	0	0	0
Lapsana communis	0	0	0	0	0	0	0	0
Lathyrus spp.	0	0	0	0	0	0	0	0
Lilium columbiana	0	0	0	0	1	0.01	1	0.01
Maianthimum dilata	1	0.01	1	0.01	1	0.01	2	0.02
Montia siberica	3	0.04	3	0.04	4	0.06	4	0.04
Nemophila parviflora	0	0	0	0	0	0	0	0
Oxalis oregana	0	0	0	0	0	0	0	0
Polystichum munitum	0	0	0	0	0	0	2	0.02
Pteridium aquilinum	6	0.09	6	0.08	9	0.13	9	0.09
Rosa gymnocarpa	0	0	0	0	0	0	2	0.02
Rubus parviflora	5	0.07	4	0.06	4	0.06	7	0.07
Rubus ursinus	0	0	0	0	0	0	2	0.02
Smilacina stellata	1	0.01	1	0.01	1	0.01	0	0
Spirea densiflora	0	0	0	0	0	0	0	0
Symphoricarpos alba	0	0	0	0	0	0	0	0
Trientalis latifolia	10	0.15	11	0.15	9	0.13	13	0.13
Trillium ovatum	0	0	0	0	0	0	0	0
Vaccinium spp.	0	0	0	0	0	0	0	0
Vancouveria hexandra	0	0	0	0	1	0.01	2	0.02
Vicia spp.	12	0.18	11	0.15	13	0.18	16	0.16
Viola glabella	1	0.01	0	0	0	0	0	0
Total	68		71		71		98	

[1] Probability = Actual count / Total for that column

TABLE XVIII

SPECIES COUNTS BY VISIT DATE WITH THE PROBABILITY OF OCCURRENCE FOR PLOT #4 1993

SPECIES	5/23/93		7/10/93		8/31/93		9/5/93	
	ACT	PROB	ACT	PROB	ACT	PROB	ACT	PROB[1]
Acer circinatum	0	0	0	0	2	0.04	2	0.04
Achlys triphylla	1	0.02	1	0.02	1	0.02	1	0.02
Adenocaulon bicolor	1	0.02	1	0.02	1	0.02	1	0.02
Antenaria spp.	0	0	0	0	0	0	0	0
Arenaria macrophylla	0	0	0	0	0	0	0	0
Berberis nervosa	6	0.11	7	0.11	19	0.36	7	0.12
Campanula scoulari	0	0	0	0	0	0	0	0
Cornus cornuta	0	0	0	0	0	0	0	0
Dicentra formosa	0	0	3	0.05	3	0.06	0	0
Digitalis purpurea	0	0	1	0.02	1	0.02	0	0
Disporum hookeri	5	0.09	3	0.05	5	0.09	3	0.06
Epilobium minutum	0	0	1	0.03	0	0	0	0
Galium trifoliata	6	0.11	9	0.14	2	0.04	11	0.19
Holodiscus discolor	0	0	0	0	0	0	0	0
Hydrophyllum tenuipes	0	0	0	0	0	0	1	0.02
Lactuca spp.	0	0	0	0	0	0	0	0
Lapsana communis	0	0	0	0	0	0	0	0
Lathyrus spp.	0	0	0	0	0	0	0	0
Lilium columbiana	0	0	0	0	0	0	0	0
Maianthimum dilata	2	0.04	2	0.03	3	0.06	3	0.06
Montia siberica	1	0.02	3	0.05	3	0.06	1	0.02
Nemophila parviflora	0	0	0	0	0	0	0	0
Oxalis oregana	0	0	0	0	1	0.02	1	0.02
Polystichum munitum	0	0	1	0.02	1	0.02	1	0.02
Pteridium aquilinum	8	0.15	12	0.19	3	0.06	10	0.17
Rosa gymnocarpa	0	0	1	0.02	1	0.02	1	0.02
Rubus parviflora	9	0.16	5	0.08	5	0.09	5	0.09
Rubus ursinus	0	0	0	0	0	0	4	0.08
Smilacina stellata	0	0	0	0	0	0	0	0
Spirea densiflora	0	0	0	0	0	0	0	0
Symphoricarpos alba	0	0	0	0	0	0	1	0.02
Trientalis latifolia	4	0.07	5	0.08	4	0.08	4	0.08
Trillium ovatum	1	0.02	1	0.02	0	0	0	0
Vaccinium spp.	0	0	0	0	0	0	0	0
Vancouveria hexandra	3	0.05	5	0.08	3	0.06	2	0.04
Vicia spp.	8	0.15	2	0.04	4	0.08	3	0.06
Viola glabella	0	0	1	0.02	0	0	0	0
Total	55		65		62		62	

[1] Probability = Actual count / Total from that column

corresponding visits to the other similar main plot. Resulting in 52 separate tests, since each comparison was done with each plot or visit date being the expected and observed. These year-to-year comparisons were done by visit dates that were generally correlated, but could be within 3 weeks of each other. Finding no differences, the data for the two sun plots were pooled, as were the data from the two shade plots. The pooled data were then compared using the Pearson Goodness-of-Fit test. My statistical evaluations revealed no significant differences at the 0.05 level between sun plots and shade plots. Any species with $P_{A2} = 0$ was thrown out of the calculation.

There is a clear difference between pre and post-burn communities. The diversity as well as the coverage and frequency were much lower in the pre-fire community (US Forest Service unpublished). I could not compare the pre and post-fire data using the Pearson Goodness-of-Fit test, however, because the original data was collected by US Forest Service personnel walking through the area and noting the approximate coverages for all of the plant species present.

Recruitment of *Pseudotsuga menziesii* seedlings was of particular interest to the US Forest Service. Plot #1 had no seedlings present on any of the sub-plots during the study period (Table XIX), perhaps because this plot had the most closed canopy. All of the other plots had seedlings surviving from 1992 to 1993 with some mortality occurring. The mortality of the seedlings came in different forms. One of the possible causes of the missing seedlings was grazing by an unidentified animal perhaps *Cervus elaphus or Odocoileas hemionus* (Two Deer Species) or *Aplodontia rufa (*Sewellel or Mt. Beaver). A second possibility was disturbance by humans. Perhaps some of the seedlings were, as the literature suggests, out competed for sunlight or nutrients by the understory plants (Grime 1977, Facelli and Picket 1991).

I also monitored the accumulation of litter on the 4 main plots. The litter depth never exceeded 1 millimeter above the mineral soil over the two years of study.

TABLE XIX

Pseudotsuga menziesii SEEDLING RECRUITMENT

	PLOT 1	PLOT 2	PLOT 3	PLOT 4
YEAR 1	0	11	9	4
YEAR 2	0	7	6	4
RETURN	0	5	4	3
NEW	0	2	2	1

The last item monitored was the recruitment of snags and downed woody material into the understory. No changes were observed during the course of this study.

Recovery in this area is following the pattern presented by Dyrness (1973). I have described a dominant herb stage. All precipitation data are reported for the time period September of one year through August of the following year. This study was conducted during a severe drought. From September of 1989 through August of 1990 the area received a total of 175.97 centimeters of precipitation, which was 18.39 centimeters below average for the area. Then during the September to August period in 1990 and 1991, the time frame of the fire, precipitation dropped even lower to 172.27 centimeters, which is 21.59 centimeters below average. The observed period including the spring and summer of 1992 brought only 150.90 centimeters, or 30.76 centimeters under the average for the area, and data available for the same time period in 1993 suggest that the dry conditions may be coming to an end. For the spring and early summer of 1993 the total was 188.26 centimeters or only 0.36 centimeters under average (National Climatic Data Center Records). The wettest months in this area are October through March according to the data from 1989 - 1993. Data for August of 1993 were not available at the time of writing.

DISCUSSION

Fire is a disturbance that played a major role in many ecosystems prior to the suppression of wildfires by Europeans (Stein et al. 1992). The last fire of any magnitude in the west end of the Columbia River Gorge occurred around 1902 (US Forest Service unpublished data).

Removal of litter layers by fire can do many things for the understory community, including releasing resources for growth (Lewis 1974, Debano et al 1977, Covington et al 1991). This can be especially important in a maturing second growth forest where the canopy is essentially closed and the understory is limited to shade tolerant species.

The recovery of understory species involves many environmental factors including micro site characteristics such as nutrient availability and concentration, depth of the leaf litter in different areas, and amount of light through holes in the canopy. According to related data collected by Romme (1982), the fire that burned the Columbia River Gorge in October 1991 may have been ecologically beneficial. With the resulting reduction in fuel load, the intensities of any future fires in this area will be reduced (Despain and Sellers 1977). These fuel loads will gradually be replenished as the snags in the area fall to the ground although there is the added benefits of the snag adding nutrients and becoming a nurse log, creating new habitats as it decays (McCullough 1948). Not only is this the case for areas where the fire burned the crowns of the canopy, but also in areas where the canopy was left intact, since the understory and litter layers were removed. The fire has opened up sections of canopy allowing more light and promoting regeneration of conifers and deciduous shrubs. Clearing away the fuel and litter allowed for a renewed growth of herbaceous plants, which are returning with greater density and diversity. This is the case both on plots where the canopy was removed and those plots where the canopy was left intact and only the understory removed. Nutrients that were previously tied up in the standing biomass are now available to re-form the community (Lewis 1974, Debano et al 1977, and Covington et al 1991).

Litter layer reformation is slow in this type of environment, since the canopy is primarily conifers which have small leaves, and thus do not contribute to the litter layer as quickly as the larger hardwood leaves. Conifer leaves decay at a much slower rate than deciduous leaves, so they will build up over time, not contributing as quickly to the available nutrients. The shrub and herbaceous layers were removed so they were not available to contribute any material to the litter layer the first year after the fire. During the second year there were still not enough herbaceous plants to contribute a significant amount to the litter layer.

Recruitment of *Pseudotsuga menziesii* seedlings was as predicted from the literature (Hughes and Fahey 1991, Ne'eman et al 1992). These seedlings occurred in smallest numbers on plots where the canopy was left intact, and in greatest numbers on plots where the canopy had been killed, probably due to increased light (Strothman 1972). Strothman also noted that *Psuedotsuga menziesii* seeds germinated well in shaded areas, but needed less than 50% sunlight after the first 5 weeks. This species does much better in areas that have little to no open canopy. It is also known as a pioneer species, and is generally the first conifer to re-establish itself on disturbed areas within habitats similar to the Columbia River Gorge.

A second factor in the recruitment of *P. menziesii* seedlings is the amount of litter available. Grime (1977) and Facelli and Pickett (1991) found that the presence of a litter layer helps woody seedlings gain a competitive advantage over herbaceous plants. This is primarily because some herbs are mechanically impeded by the litter layer while the sturdier woody seedlings can push their way through the litter. Herbaceous plants are also able to grow faster thus taking up nutrients at a greater rate than the woody seedlings. My study supports these findings. The litter was burned away leaving only mineral soil, nutrients were made available by the fire, both of which allowed for the great success of the herbaceous layer.

I found no significant difference in species coverage of understory species among any of the plots studied. There are two types of species in the understory. One type resprouts from surviving underground parts. The second type returns after disturbance from seed sources either in the disturbed ground or from outside sources (Stickney 1990). Most species that were present in the community prior to the fire and return are growing from resprouts or by germinating from seeds in the disturbed area (Moreno and Oechel 1991). Hughes and Fahey (1991) also noted that species which resprout do not generally change their spatial distributions. Those species classified as invaders, which were not in the original community, probably arrive as seeds on air currents from the surrounding second growth forest. Adequate seed sources exist around the study area and winds blow both directions through the Gorge (Dyrness 1973, Hughes and Fahey 1991). Seed sources for all species are within 1 kilometer and, for most species, within 500 meters of the study area. Larger animals and humans frequently move from these source areas into the burn and could be the source of introduced propagules.

In following the recovery of the understory community in the Columbia River Gorge I was able to observe the patchy nature of the re-growth of the herbaceous layer. I was able to see one sample unit recovering rapidly while a sample unit a few meters away was not doing as well, or some plants were doing well while others were not.

There is opportunity for more research in this burn area. A long-term study could document the course of succession for a moist *Pseudotsuga menziesii* forest in the Columbia River Gorge. Since the first years after the fire are now known, it would be interesting to compare these results over time with those of other forest types of such as those in the study by Dyrness (1979).

At the start of this project I wanted to look at four questions. The items were 1) What was the difference in recovery between plants on sites with very little canopy closure compared with those on sites with an almost closed canopy. 2) How were *Pseudotsuga menziesii* seedlings recruited into the community. 3) How quickly was the litter layer reforming, and 4) How rapidly are snags recruited into the litter. I found that there was no difference in the cover or frequency of understory recovery on the two types of plots. I did however, find that there was a significant difference in the species richness between pre-fire data and the two years of this study. The probable reason for there being no real difference in the two types of plots was that there really was not that much difference in the amounts of light getting to the ground. The recruitment of Pseudotsuga menziesii seedlings was slower than expected, probably because there was to much light getting through and to much competition from herbaceous plants. The litter layer is slowly reforming and snags have not been significantly recruited within the two years of my study.

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