VEGETATION AND SMALL MAMMAL SURVEY OF A SERAL FOREST COMMUNITY ON THE EVERGREEN STATE COLLEGE CAMPUS THURSTON COUNTY, WASHINGTON

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DATE? 1975? WRS Based on source dates and state of Field Work

Abstract. A study of the flora and vertebrate fauna of an 8.1 ha seral forest community was undertaken in the summer of 1975. Mark and recapture techniques were used to assess small mammal populations. Systematic observations of birds and large mammals were made to determine species present. Quadrat sampling was utilized to define vegetation communities.

The population density of Peromyscus maniculatus was estimated to be 18.6/ha. Density of Clethrionomys occidentalis was 6.2/ha. Vegetation communities defined were Pseudotsuga menziesii—Pteridium aquilinum, P. menziesii—Gaultheria shallon, Alnus rubra—Polystichum munitum, Acer macrophyllum—P. munitum, and Thuja plicata—P. munitum. Successional dynamics in relation to environmental gradients and historical background are discussed.

INTRODUCTION

The study described here was undertaken to provide a description of the flora and vertebrate fauna of a seral forest community on the campus of The Evergreen State College, Thurston County, Washington. It includes a study of Peromyscus maniculatus (deer mouse) and Clethrionomys occidentalis (western red-backed mouse), a description of other mammal and bird species present, and a study of the vegetation and its relationship to selected environmental factors. Detailed studies of this type are valuable as reference for land use planning by the college and serve as baseline studies for future research. The study area was chosen because of its well defined borders and its history of research. Field work was conducted in the summer of 1975.

The forest is characteristic of the Tsuga heterophylla (western hemlock) zone described by Franklin and Dyrness (1973). This is the most extensive vegetation zone in western Washington, and the most important in terms of timber production. Although the zone is named after its potential climax species, large areas are composed of Pseudotsuga menziesii (Douglas-fir),

usually where logging or natural disturbance (such as fire) has taken place (Munger 1940). According to Franklin and Dyrness (1973), eight old growth associations occur along a moisture gradient. These are most easily distinguished by their understory composition. Driest sites are dominated by Holodiscus discolor (ocean spray), with P. menziesii as the dominant tree. Tsuga heterophylla replaces P. menziesii on more mesic sites in association with (from dry to moist) Gaultheria shallon (salal), Berberis nervosa (Oregon grape), and Polystichum munitum (sword fern). On the wetter sites of western Washington, competitive interrelationships apparently favor the dominance of Thuja plicata (western red cedar) over T. heterophylla. Associated understory species are Oplopanax horridum (devil's club) and Athyrium filix-femina (lady fern).

Thurston County has a temperate marine climate with little seasonal variation in temperature. The mean annual temperature is 10.5°C. Precipitation averages 128 cm/yr, the majority falling in the winter months (Soil Conservation Service 1958). Summers are relatively dry, receiving only 6-9% of the total precipitation (Franklin and Dyrness 1973).

Soils of the area are glacial in origin. The Wisconsin Age Vashon Glacier made its southernmost penetration to a point 20 km south of Olympia. Soils are characteristically coarse textured, well drained, and low in nutrients (Soil Conservation Service 1958). Levels of phosphorous, calcium, and potassium are very low (Winje and Otto 1972). Because of the heavy rainfall and extensive leaching, the soil is slightly to strongly acidic, ranging in pH from 2.2 to 5.6 (Acker et al. 1973).

Study Area

The study area is an 8.1 ha plot in the northwest corner of The Evergreen State College campus (Fig. 1). Elevation varies from 44 to 24 m, gradually declining from south to north (Fig. 2). A stream runs through a ravine in the north central part of the plot. Overstory vegetation is characterized by Pseudotsuga menziesii, Thuja plicata, Tsuga heterophylla, Acer macrophyllum (big-leafed maple), and Alnus rubra (red alder). Dominant understory species include Polystichum munitum, Berberis nervosa, Vaccinium parviflorum (red huckleberry), Rubus ursinus (wild blackberry), and Gaultheria shallon.

The study area has been logged several times. Old growth P. menziesii was removed after 1845, when Thurston County was first settled. The area was logged again in the 1930's or 1940's. The southwest corner of the plot shows evidence of a more recent logging operation, probably in the late 1950's or early 1960's.

Four previous vegetation studies have been conducted on the college campus. Winje and Otto (1972) described eight forest communities for the entire campus. Brockway and Williams (1972) conducted an intensive study of the campus shorefront forest vegetation. A brief survey of our study area identified Acer macrophyllum and Pseudotsuga menziesii as the dominant tree species (Zito 1972). A study of the southern part of the campus defined four forest communities (Acker et al. 1973).

Three studies had been conducted on this study area. Falxa et al. (1972) found no relation between vegetation and distribution of Peromyscus maniculatus.

Klein et al. (1972) determined February density of Sorex trowbridgeii (Trowbridge shrew) to be at least 3.4 individuals/ha. Absolute density was not determined because of apparent migration into the trapping area. Lanning et al. (1972) utilized radio tracking techniques to determine the home range of Aplodontia rufa (mountain beaver).

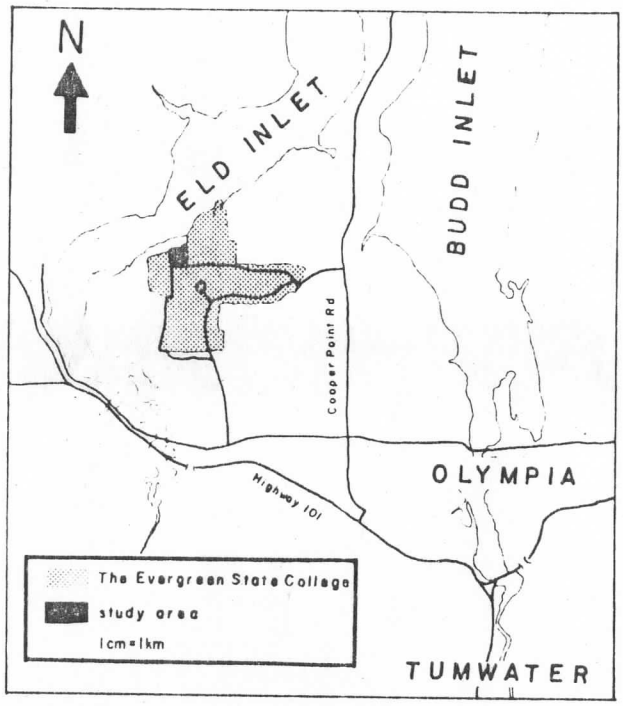

Fig. 1. Vicinity map of The Evergreen State College.

METHODS

Mammals and Birds

The study of small mammals consisted of extensive trapping to determine species and numbers present. Trapping, for genera other then Sorex, was conducted for six consecutive nights in June, July and August. In order to facilitate comparison with a previous study in the area (Falxa et al. 1972), we selected the same trapping site (Fig. 2). Sixty-four Sherman live traps (8 x 9 x 23 cm) baited with peanut butter and rolled oats were placed 15 m apart on a regular 8 x 8 grid (total area of 1.1 ha). Traps were checked every morning soon after sunrise, closed for the day, and reset in the evening. Each animal captured was toe clipped using the code devised by Martof (1953) and released. Calculations involved data from 1152 trap nights. Population densities were calculated by the Schnabel method described by Smith (1974).

The Sorex species population was sampled in a sixty hour session 16-18 August. Ten #10 drop-in cans baited with beef heart were buried with the top flush with the surface of the ground and placed randomly in the study area. Traps were

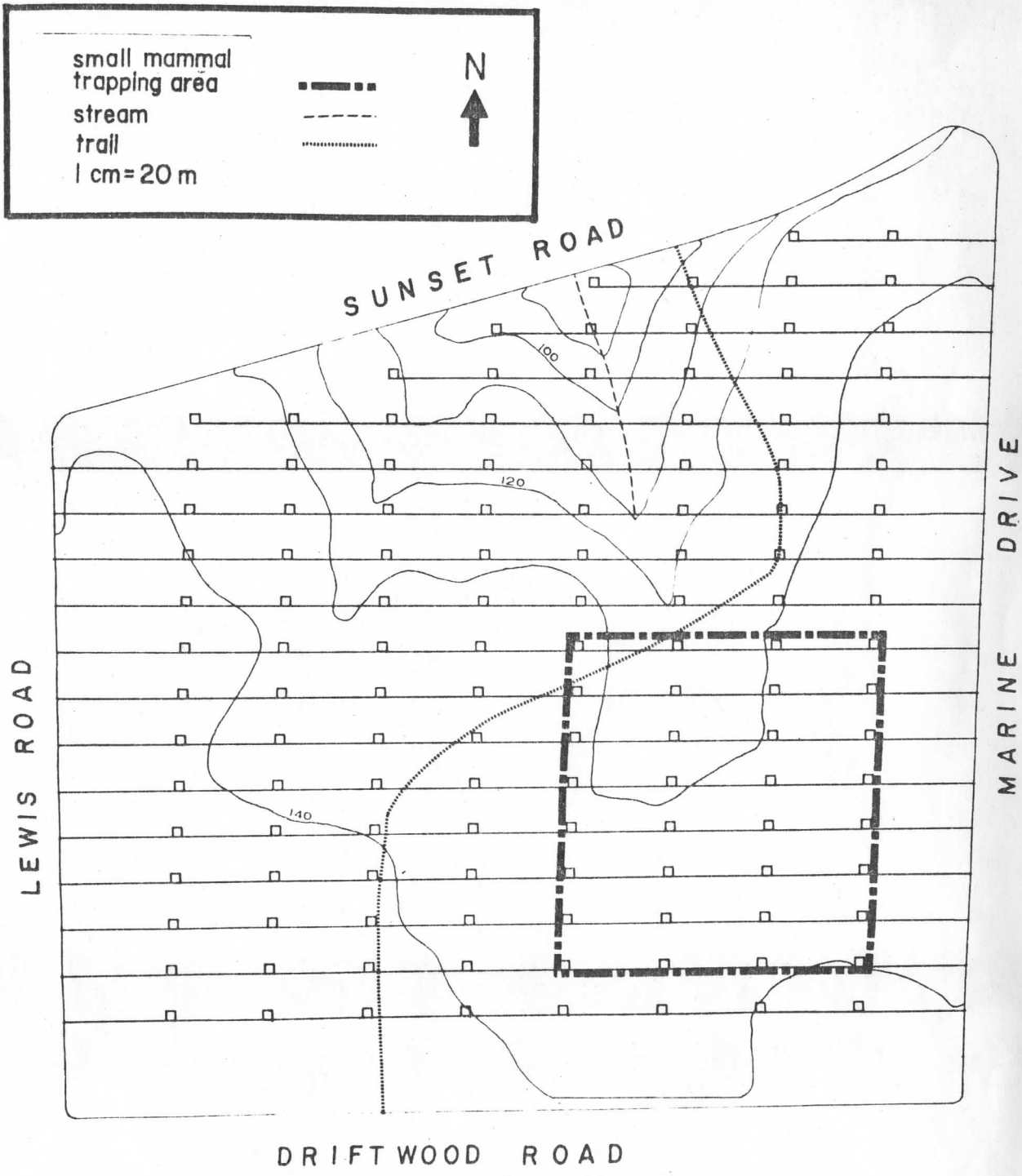

Fig. 2. Map of the study area showing quadrat location and small mammal trapping area.

checked every three hours during this period.

Vegetation

A total of 121 quadrats were placed on a regular grid of 18 east-west transects. These transects were placed 15 m apart and perpendicular to the major topographical feature, the ravine. Sampling points were 32 m apart. Each consisted of three nested quadrats (Cain and Castro 1959), sharing a common corner (initial control point).

Data pertaining to herbs, shrubs, and trees were taken from quadrats of 1, 4, and 10 m sq. respectively. Data taken were presence and areal coverage. We used the cover classes of Merkle (1951) as follows:

Class 0= less than 1% coverage
Class 1= 1%-5% coverage
Class 2= 6%-25% coverage
Class 3= 26%-50% coverage
Class 4= 51%-75% coverage
Class 5= 76%-100% coverage

Size classes and representative ages were determined for trees. Diameter at breast height (dbh) was recorded for individuals exceeding 20 cm. The remainder were classified as follows:

Seedlings = less than 1 m in height
Saplings = less than 10 cm dbh
Poles = 10-20 cm dbh

The vegetation data were analyzed using the ordination method developed by Bray and Curtis (1957) and described in detail by Mueller-Dombois and Ellenburg (1974). In this technique, each quadrat is plotted onto a two-axis graph in such a way that similar quadrats are located near each other, and may thereby form groups that represent plant communities. Data were first converted to relative density (for overstory only), relative dominance, and relative frequency, according to the method described by Cox (1974). Importance value for the overstory was then calculated by summing relative density, relative dominance, and relative frequency values. For the shrubs and herbs, only relative dominance and relative frequency were used. Species with a frequency of 15% or less were not used in the analysis.

Soil

For each quadrat, the "O" horizon (litter depth) was measured and drainage class was determined subjectively, assigning values ranging from 1 (dry) to 5 (standing water). Averages were calculated for each community.

Soil samples were taken to a depth of 15 cm in the "A" horizon. After communities were defined, five samples from each were randomly selected for texture analysis using the hydrometer soil sedimentation method outlined in Cox (1974).

RESULTS

Mammals and Birds

A total of 171 captures in Sherman traps were recorded over the three months: 123 (72%) were Peromyscus maniculatus, 20 (12%) were Clethrionomys occidentalis, and 28 (16%) were other species, including: Eutamias townsendii (Townsend's chipmunk), Glaucomys sabrinus (northern flying squirrel), Neurotrichus gibbsii (shrew-mole), Sorex trowbridgeii, Tamiasciurus douglasii (Douglas squirrel), and Zapus trinotatus (Pacific jumping mouse). Only P. maniculatus and C. occidentalis were captured with sufficient frequency to allow population density calculations (Table 1 and Fig. 3).

Table 1. Total captures per month of Peromyscus maniculatus and Clethrionomys occidentalis

	P. maniculatus	C. occidentalis
June	36	2
July	64	11
August	23	7

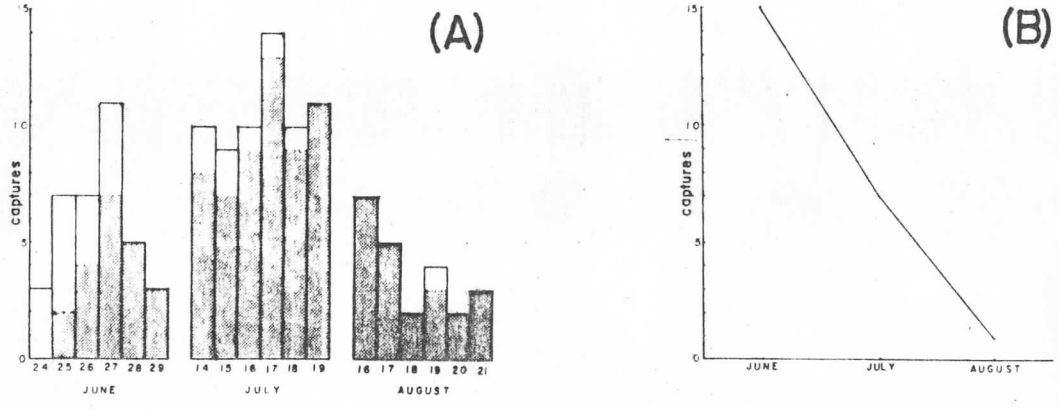

Fig. 3. Daily captures (A) and new captures per month (B) of Peromyscus maniculatus. Shading (A) represents recaptures.

For Peromyscus maniculatus, twelve male, nine female, and two of undetermined sex were taken. The population density was calculated to be 18.6 mice/ha (7.5/acre). For Clethrionomys occidentalis, three individuals were identified as female, two as male, and four were undetermined. A female captured on 26 June had enlarged nipples and appeared to be lactating. The population was estimated to be 6.8 individuals, a density of 6.2/ha (2.5/acre).

Two Sorex trowbridgeii were captured during the sixty hour session. Both of these were taken in the ravine.

Dama hemionus columbianus (black-tailed deer) were seen three times in the study area. Two were adults and one was a fawn. An adult Euarctos americanus (black bear) was observed on Lewis road at 0700, 10 July. Fresh bear scat, containing cherry pits and Rubus ursinus seeds, was found in the recently logged section of the study area. Although no Aplodontia rufa (mountain beaver) were observed, recent burrowing activity was evident, especially in the northwest corner of the study area and along the banks of the ravine.

Vegetation

Five forest communities were identified: Pseudotsuga menziesii—Pteridium aquilinum; Pseudotsuga menziesii—Gaultheria shallon; Acer macrophyllum—Polystichum munitum; Alnus rubra—Polystichum munitum; and Thuja plicata—Polystichum munitum (Fig. 4, Tables 2 and 3).

Table 2. Density of individuals greater than 10 cm dbh (#/ha)
PSME-PTAQ: Pseudotsuga menziesii—Pteridium aquilinum
PSME-GASH: Pseudotsuga menziesii—Gaultheria shallon
ACMA-POMU: Acer macrophyllum—Polystichum munitum
ALRU-POMU: Alnus rubra—Polystichum munitum
THPL-POMU: Thuja plicata—Polystichum munitum

	PSME-PTAQ	PSME-GASH	ACMA-POMU	ALRU-POMU	THPL-POMU
Pseudotsuga menziesii	220	290	48	23	53
Acer macrophyllum	30	10	344	96	150
Alnus rubra	33	65	51	360	100
Thuja plicata	26	40	20	35	210
All species	354	490	482	541	585

Table 3. Relative density (DEN), relative dominance (DOM), relative frequency (FRQ), and importance value (IV), for the species found in the five communities and selected descriptive values (average canopy closure, average soil drainage, average litter depth, and density of old growth stumps). (+ indicates value of <1)

PSME-PTAQ: *Pseudotsuga menziesii*—*Pteridium aquilinum*
PSME-GASH: *Pseudotsuga menziesii*—*Gaultheria shallon*
ACMA-POMU: *Acer macrophyllum*—*Polystichum munitum*
ALRU-POMU: *Alnus rubra*—*Polystichum munitum*
THPL-POMU: *Thuja plicata*—*Polystichum munitum*

	PSME-PTAQ	PSME-GASH	ACMA-POMU	ALRU-POMU	THPL-POMU
Average canopy closure (%)	45	67	85	79	94
Average soil drainage (1=wet; 5=dry)	2.5	2.8	2.9	3.3	3.0
Average litter depth (cm)	14.6	16.2	17.0	14.9	16.2
Density of old growth stumps (#/ha)	93	95	59	110	68

	PSME-PTAQ				PSME-GASH				ACMA-POMU				ALRU-POMU				THPL-POMU			
	DEN	DOM	FRQ	IV	DEN	DOM	FRQ	IV	DEN	DOM	FRQ	IV	DEN	DOM	FRQ	IV	DEN	DOM	FRQ	IV
Abies grandis					2	+	6	8	1	+	3	4	3	2	11	16	3	9	8	20
Acer macrophyllum	9	18	13	40	2	7	15	24	71	90	39	200	18	16	24	58	26	23	17	66
Alnus rubra	9	8	18	35	13	9	14	36	11	6	17	34	67	60	29	156	17	12	12	41
Arbutus menziesii	3	1	4	8	5	2	3	10												
Cornus nuttallii		+	3	3		+	5	5		+	1	1		+		+		+	1	1
Pseudotsuga menziesii	62	53	23	140	59	61	20	140	10	3	19	32	4	6	10	22	9	8	12	29
Salix sp.	1	+	12	13	4	1	4	9						+	1	1				
Taxus brevifolia	1	1	5	7	2	2	6	10		+	3	3		+	1	1	+	2	7	9
Thuja plicata	7	10	15	34	7	15	16	44	4	1	13	18	6	14	17	37	36	40	25	103
Tsuga heterophylla	7	7	7	21	4	3	10	17	3	+	6	9	2	2	6	10	8	6	14	28

Amelanchier alnifolia	+	1	1													
Berberis nervosa	4	10	14	15	15	30	8	10	18	4	4	8	3	10	13	
Blechnum spicant	+	1	1													
Corylus cornuta	3	5	8	+	3	3	2	3	5	3	3	6	6	5	11	
Cytisus scoparius	1	1	2													
Gaultheria shallon	47	16	63	31	15	46	4	10	14	3	7	10	5	8	13	
Holodiscus discolor	+	1	1	+	1	1	1	1	2	+	1	1	+	1	1	
Ilex sp.	+	1	1													
Lonicera ciliosa	+	1	1	1	6	7										
Oplopanax horridum							1	+	1	3	1	4				
Osmaronia cerasiformis	+	2	2	+	2	2	5	8	13	12	10	22	15	10	25	
Polystichum munitum	5	12	17	9	14	23	56	18	74	31	21	52	54	22	76	
Rhamnus purshiana	3	6	9	7	9	16	1	6	7	5	4	9	7	7	14	
Rosa gymnocarpa	+	1	1	1	1	2										
Rubus leucodermis	+	4	4	+	2	2	+	6	6	+	5	5				
Rubus parviflorus	1	6	7	+	1	1	1	2	3	1	2	3	+	4	4	
Rubus spectabilis	+	3	3				1	5	6	3	5	8	+	4	4	
Rubus ursinus	25	16	41	14	17	31	9	18	27	9	19	28	6	19	25	
Sambucus racemosa	+	1	1				4	7	11	13	11	24	+	2	2	
Vaccinium parvifolium	9	13	22	21	15	36	3	6	9	5	8	13	2	8	10	
Achlys triphylla							2	9	11				20	19	39	
Asarum caudatum										+	3	3				
Dicentra formosa										+	5	5				
Dryopteris austriaca							+	5	5	2	5	7				
Equisetum sp.							6	5	11							
Galium trifidum	+	9	9				+	10	10	+	8	8	1	19	20	
Galium triflorum	2	15	17	19	26	45	4	9	13	3	19	22	3	15	18	
Goodyera oblongifolia				2	7	9										
Hydrophyllum tenuipes										63	17	80	33	5	38	
Linnaea borealis	14	13	27	27	27	54				5	3	8	+	5	5	
Montia sibirica	+	2	2				25	9	34	11	22	33	1	9	10	
Pteridium aquilinum	83	44	127				58	32	90	2	5	7	38	15	53	
Senecio jacobaea	+	2	2													
Smilacina racemosa				2	7	9				5	3	8				
Tiarella trifoliata										1	3	4				
Trientalis latifolia				28	20	48	2	23	25	5	5	10	+	5	5	
Trillium ovatum										1	3	4	3	10	13	
Viola sp.	+	2	2	2	7	9				+	3	3				
Woodsia oregana				18	7	25										

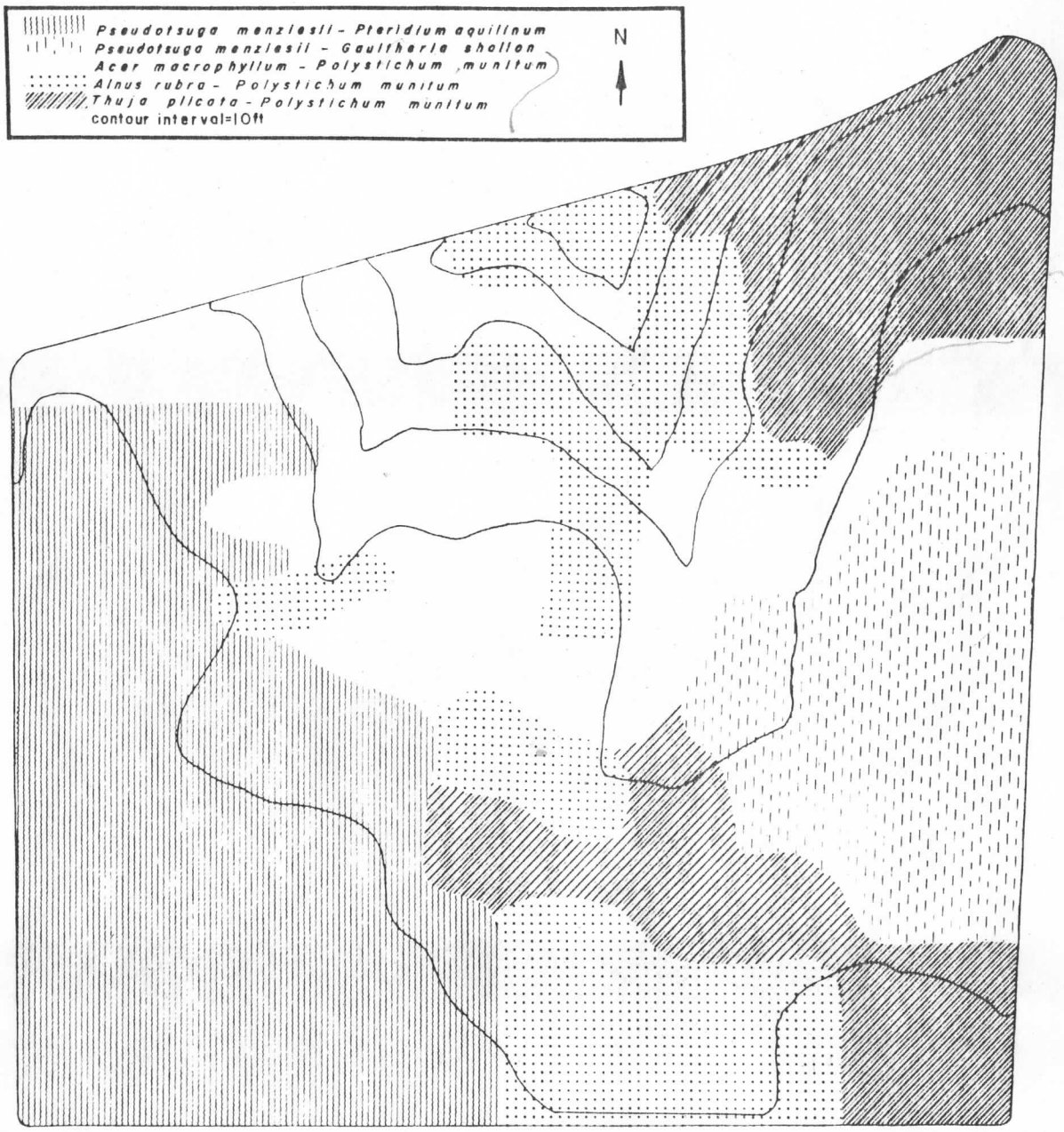

Fig. 4. Vegetation communities.

Pseudotsuga menziesii—Pteridium aquilinum community.—P. menziesii and A. macrophyllum are the dominant overstory species (importance values 140 and 40) in this community. P. aquilinum (127) and G. shallon (63) are the dominant understory species, followed by Rubus ursinus (41) and Vaccinium parviflorum (22). Thirty-five species were found in this community (27 quadrats); eight species occurred in only one quadrat.

Pseudotsuga menziesii—Gaultheria shallon community.—Dominant species of this community (20 quadrats) are P. menziesii (140), T. plicata (44), G. shallon (46), and Linnaea borealis (twinflower) (54). Thirty species were found, with seven occurring in only a single plot.

Acer macrophyllum—Polystichum munitum community.—This community is the most extensive on our study area, represented by 29 quadrats. Importance values of the dominant species are A. macrophyllum (200), P. menziesii (32), P. munitum (74), and P. aquilinum (90). A total of 30 species was found in this community, of which four occurred in only one quadrat.

Alnus rubra—Polystichum munitum community.—Represented by 26 quadrats, this is the third largest community. A. rubra (156) and A. macrophyllum (58) are the dominant overstory species, with P. munitum (52) and Hydrophyllum tenuipes (waterleaf) (80) dominating the understory. Thirty-seven species were found, with eleven species occurring in only one quadrat.

Thuja plicata—Polystichum munitum community.—Dominant species are T. plicata (103), A. macrophyllum (66), P. munitum (76), and P. aquilinum (53). Thirty species were found in this 19 quadrat community, with six occurring in only one quadrat.

Soil

Soil from the two communities dominated by P. menziesii had the greatest sand content, the Acer macrophyllum—Polystichum munitum community soil had the highest silt fraction, and the Thuja plicata—P. munitum community had the highest fraction of coarse particles and clay (Table 4). The driest soil was found in the P. menziesii community, and the wettest in the Alnus rubra—P. munitum community. Litter depth ranged from 14.6 cm in the P. menziesii—Pteridium aquilinum community to 17 cm in the A. macrophyllum—P. munitum community (Table 3).

DISCUSSION

Mammals

The captures of Peromyscus maniculatus and Clethrionomys occidentalis were highest in July and lowest in August (Table 1). This result may be attributable to the fact that the trapping period in July was characteristically warm and dry, while August was unseasonably rainy (Table 5).

Peromyscus maniculatus.--This species is found in nearly all communities and life zones of Washington, Oregon, and California. It ranges from southern Alaska to south of Mexico City and from the Pacific Ocean east to Labrador

Table 4. Soil texture analysis for the five communities
PSME-PTAQ: *Pseudotsuga menziesii*—*Pteridium aquilinum*
PSME-GASH: *Pseudotsuga menziesii*—*Gaultheria shallon*
ACMA-POMU: *Acer macrophyllum*—*Polystichum munitum*
ALRU-POMU: *Alnus rubra*—*Polystichum munitum*
THPL-POMU: *Thuja plicata*—*Polystichum munitum*

	Coarse Particles (> 2 mm) (%)	Sand (2.0-0.05 mm) (%)	Silt (0.05-0.005 mm) (%)	Clay (< 0.005 mm) (%)
PSME-PTAQ	30	70.1	15.2	14.7
PSME-GASH	43	78.5	13.2	8.4
ACMA-POMU	41.8	52.5	30.1	17.4
ALRU-POMU	35.3	55.8	24.5	19.8
THPL-POMU	53.4	48.1	27.8	24.8

Table 5. Climatic data for the summer months of 1975 and the 35 year (1939-1974) mean (from U.S. Weather Bureau, Olympia, Washington)

	Mean High Temperature (°C.)		Mean Low Temperature (°C.)		Total Precipitation (mm)	
	1975	35 yr	1975	35 yr	1975	35 yr
June	20.4	21.6	7.9	8.0	18.3	41.4
July	24.7	25.2	10.7	9.4	6.4	19.8
August	22.0	24.8	9.9	9.4	100.8	26.4

(Hall and Kelson 1959). *Peromyscus* is a nocturnal animal, feeding primarily on insects and larvae in the spring and seeds and fruit in the fall.

Ingles (1965) states that there may be 5-10 *P. maniculatus*/acre (12-25/ha) in the Sierra Nevada in California. In Maryland, Stickel (1960) found a summer and late fall fluctuation of *P. leucopus* from 3.9-8.6/acre (9.6-21.2/ha) and 0-3.6/acre (0-8.9/ha) in winter. Falxa et al. (1972), in a study on our site, found 2.7 *P. maniculatus*/acre in December, 1.7/acre in January, and 0.6/acre in March. The difference between these figures and our findings of 18.4 individuals/ha (7.4/acre) in summer may reflect normal seasonal fluctuations or actual differences in population densities.

Clethrionomys occidentalis.--This species is found within 240 km (150 mi) of the coast from northern British Columbia to northern California (Hall and Kelson 1959). Other studies of our area (Falxa et al. 1972; Klein et al. 1972; Lanning et al. 1972) did not report capture of Clethrionomys. The population estimate of Clethrionomys was not conclusive because the capture rate of new individuals did not decline as trapping progressed. Three new individuals were captured two days before the end of the final trapping period. Twenty captures were recorded; 12 (60%) of these involved three individuals. In other words, 33% of the estimated population accounted for 60% of the captures. Ingles (1965) stated that trapping success with other species often increases significantly only after Peromyscus has been removed. This could account for our difficulty in obtaining significant results with Clethrionomys.

Vegetation

The ordination analysis defined species associations that were similar to communities delineated on the basis of the topography of the study site. According to Loucks (1962), ordination axes often correspond to environmental gradients. Our analysis indicates that moisture is represented by the x-axis and canopy closure by the y-axis. Average soil drainage and canopy closure values for community groupings on the graph were calculated (Table 3), and their relative positions on the axes were noted (Fig. 5B).

Pseudotsuga menziesii—Pteridium aquilinum community.—This community was originally part of a 47 quadrat P. menziesii—Gaultheria shallon community. However, the high importance value of P. aquilinum in 27 quadrats and its absence in 20 indicated existance of two communities. An analysis of the ordination graph (Fig. 5A) showed that the Pseudotsuga grouping contained an area with high P. aquilinum values. When these quadrats were located on the map it was evident that they represented the cut-over area on the west side of the study plot.

The P. menziesii—P. aquilinum community is the site of very recent logging activity. It is characterized by an open canopy, thick brush, and large amounts of slash. Because of the abundant light penetrating the canopy, a warm, dry environment exists. Dense growth of Gaultheria shallon, Rubus ursinus, and P. aquilinum makes the area nearly impenetrable. It contains the only specimens of Ilex sp. (holly), Amelanchier alnifolia (serviceberry), Blechnum spicant (deer fern), Cytisus scoparius (Scotch broom), and Senecio jacobaea (tansy ragwort) found in the study area. The highest importance values of Pteridium aquilinum, Rubus ursinus, and R. parviflorus (thimbleberry) are found here. Moisture indicators such as Montia siberica (candy flower), and Sambucus racemosa (red elderberry) have low importance values. This is the only community in which Abies grandis (grand fir) does not occur.

The recent disturbance has resulted in reproduction dominated by Pseudotsuga, Alnus, and Salix sp. (willow) (Table 6). The thick shrub layer (more species than any other community) results in the lowest rate of herb and seedling establishment. This factor will result in a long-lived Pseudotsuga community, eventually developing Thuja dominance.

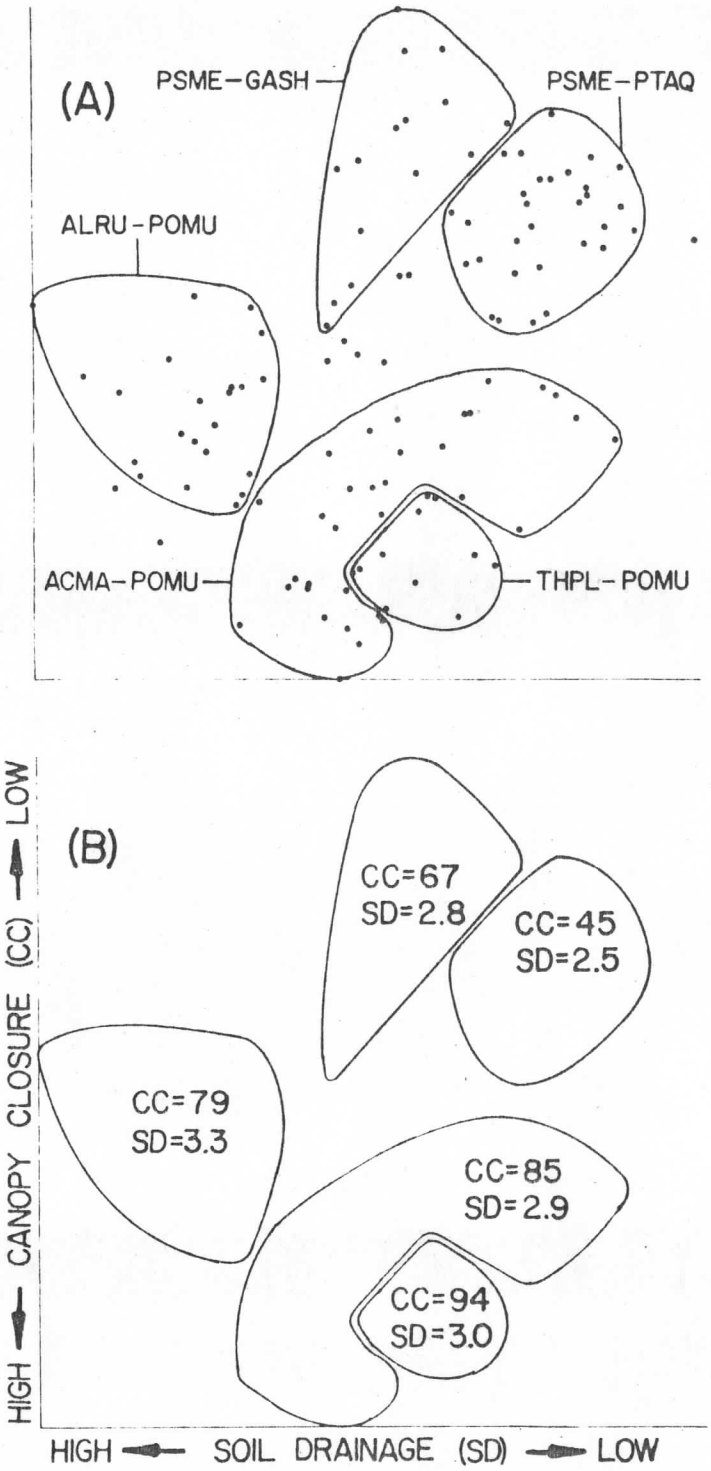

Fig. 5. Ordination graph showing communities (A) and their relationships to environmental factors (B).

PSME-PTAQ: Pseudotsuga menziesii--Pteridium aquilinum
PSME-GASH: Pseudotsuga menziesii--Gaultheria shallon
ACMA-POMU: Acer macrophyllum--Polystichum munitum
ALRU-POMU: Alnus rubra--Polystichum munitum
THPL-POMU: Thuja plicata--Polystichum munitum

Table 6. Overstory age composition of the five communities of the forest (Sed: seedlings=less than 1 meter in height; Sap: saplings=less than 10 cm dbh; Pol: poles=10-20 cm dbh; Std: standards=greater than 20 cm dbh)

Communities / Overstory species	Pseudotsuga menziesii - Pteridium aquilinum				Pseudotsuga menziesii - Gaultheria shallon				Acer macrophyllum - Polystichum munitum				Alnus rubra - Polystichum munitum				Thuja plicata - Polystichum munitum			
	Sed	Sap	Pol	Std	Sed	Sap	Pol	Std	Sed	Sap	Pol	Std	Sed	Sap	Pol	Std	Sed	Sap	Pol	Std
Abies grandis					2	5	2		1				2	19	7	1	5	1	1	3
Acer macrophyllum	71	22	12	6	150+	17	2	2	200+	100+	43	64	200+	20	14	15	200+	28	7	20
Alnus rubra	8	83	16	8	22	44	16	5	1	2	7	8	2	47	27	71			3	16
Arbutus menziesii	7	12	3		7	7	4	1												
Cornus nuttallii	1	10			9	32				1								1		
Pseudotsuga menziesii	50	76	34	35	21	85	41	44	6	9	10	6	3	11	4	4	2	5	6	5
Salix species	54	4			1	19	4							1						
Taxus brevifolia	3	3		2	4	7	2	1		1			1	1			1	4	1	1
Thuja plicata	11	20	3	1	47	58	8	5	1	16	4		14	20	10	6	22	47	18	21
Tsuga heterophylla	2	4		1	10	13	9	2	1	-		1	1	4		3	4	10	4	5

Several species occur only in the two communities dominated by Pseudotsuga. Salix saplings are locally abundant in dense clumps. Salix may occupy a niche similar to that of A. rubra, a pioneer tree species. The heavy slash in the area is unfavorable to reproduction of Alnus, which prefers a mineral seedbed (Fowells 1965). Another species unique to these communities is Arbutus menziesii (madrone). This species is commonly found on cut-over areas with well drained soils (Fowells 1965; Soil Conservation Service 1958). Lonicera ciliosa (climbing honeysuckle) is also found only in these communities.

The soils of the two communities are similar. They are high in sand content and low in silt and clay, resulting in conditions of high drainage and low nutrient content.

Other studies conducted on the campus found similar Pseudotsuga communities (Brockway and Williams 1972; Acker et al. 1973; Winje and Otto 1972). Acker et al. divided Pseudotsuga into two communities, one with and one without Polystichum munitum.

Pseudotsuga menziesii—Gaultheria shallon community.—This community is found on the east side of the study area. It has a comparatively closed canopy and open understory and is the only community with representatives of all tree species. The highest importance values of Cornus nuttallii (common dogwood), Taxus brevifolia (western yew), Berberis nervosa, Vaccinium parvifolium, Galium triflorum (fragrant bedstraw), and Trientalis latifolia (star flower) are found here. Moisture indicators such as Sambucus racemosa, Montia siberica, and Rubus spectabilis (salmonberry) are absent. Thuja reproduction is more abundant than in other communities. These findings seem to indicate a successional trend

toward shade tolerant Thuja.

Acer macrophyllum—Polystichum munitum community.—Acer macrophyllum was the most frequently encountered species in the forest. Sites of intermediate moisture between communities dominated by Pseudotsuga and Alnus offer the most favorable growing conditions, resulting in this distinct community. This community occurs along the edge of the ravine where the largest trees are found. The most extensive stand is in a slight depression, where moisture is more abundant than in the adjacent Pseudotsuga menziesii—Pteridium aquilinum community. Acer forms a tight canopy, allowing little light to penetrate. Consequently, this community has the lowest number of other reproducing tree species. The understory is open and dominated by Polystichum munitum and Pteridium aquilinum. Gaultheria shallon is more abundant than in the Alnus dominated community, but less than in the two Pseudotsuga dominated communities.

There are seven individual Acer over 75 cm dbh; the largest is 223 cm. One of the smaller (83 cm dbh) was estimated to be approximately 110 yrs old. Other large individuals were hollow, making accurate measurements difficult. These data indicate that they are residuals of the old growth stand. Pseudotsuga stumps in the area reflect its original composition. Acer has become dominant in the absence of competition. Pseudotsuga regeneration is inhibited by the high Acer cover, resulting in a long-lived seral community that may eventually be dominated by a more tolerant conifer (Thuja plicata or Tsuga heterophylla).

Brockway and Williams (1972) had difficulty determining the community status of Acer macrophyllum. They decided to place it in a Thuja plicata community, commenting on its localized abundance. Winje and Otto (1972) did not define an Acer community in what is now our study area.

Alnus rubra—Polystichum munitum community.—This community is found primarily in the ravine, the wettest site in our area. It is characterized by an even-aged 30-40 yr old stand (as determined by increment borings) with P. munitum dominating the understory. Sambucus racemosa, Rubus spectabilis, Hydrophyllum tenuipes (waterleaf), and Oplopanax horridum are indicators of this community. Very little Berberis nervosa and Gaultheria shallon are found here.

Alnus is dependent on site disturbances for establishment (Trappe et al. 1968) Almost any amount of litter or other organic material apparently creates microenvironments drier than seedlings can tolerate (Trappe et al. 1968). In the ravine, logging practices may have exposed mineral soil, creating conditions allowing Alnus to dominate.

The 30-40 yr old stand of Alnus is in its prime. Trappe et al. (1968) state that an Alnus stand begins to stagnate (net growth = annual mortality) at age 45-60. Subsequently, the importance of Alnus will decline and a tolerant species will become established.

All the other studies done on campus have identified Alnus dominated communities. Acker et al. (1973), working on the south campus found two Alnus communities, based on the presence or absence of Rubus spectabilis. Winje and Otto (1972) identified an Alnus community in our study area.

Thuja plicata—*Polystichum munitum* community.—*Thuja plicata* was originally included in the *A. macrophyllum*—*P. munitum* community. However, the high importance value of this species in certain quadrats merited special attention. Close scrutiny of the ordination graph revealed that the *A. macrophyllum* grouping contained an area of quadrats with high *Thuja* values. When these quadrats were located on the map, they were found to be clumped in the northeast and southeast corners.

Thuja plicata is a slow growing, light tolerant climax species of the wetter areas of western Washington (Franklin and Dyrness 1973). Its dominance in this area denotes a more successionally advanced *Acer macrophyllum* community. *Tsuga heterophylla*, another climax species, also has a higher importance value in the *T. plicata*—*P. munitum* community (28 compared to 9 in the *Acer macrophyllum*—*P. munitum* community). *Alnus* reproduction is virtually absent. The large diameter of individual trees (up to 105 cm) indicates that some are remnants of the original forest. Three individuals of approximately 70 cm dbh were determined by coring to be 90-100 yrs old.

Soils in the community had low sand content and high silt and clay. This condition is characteristic of fertile soil with high moisture retention capability. This soil is an important agricultural soil in Thurston County (Soil Conservation Service 1958) and supports the highest overstory density of any of the communities described from this area.

CONCLUSIONS

Stumps remaining in the area indicate that an old growth forest consisting primarily of *Pseudotsuga* with some *Thuja* existed on what is now our study area. Since environmental conditions have not changed since the destruction of this original forest, other factors must have influenced the development of the present five communities. A knowledge of the methods of harvesting, slash disposal, and availability of seed is import in any attempt to analyze the development of successional relationships.

Increment borings revealed that three distinct logging operations have occurred. The *Thuja plicata*—*Polystichum munitum* and *Acer macrophyllum*—*P. munitum* communities contain residuals of the original stand and apparently have not been disturbed since the cutting approximately 100 yrs ago. Two communities, *Pseudotsuga menziesii*—*Gaultheria shallon* and *Alnus rubra*—*P. munitum* have developed on the site of a logging operation that took place about 40 yrs ago. Charred stumps, snags, and scarred trees provide evidence that slash burns occurred following these first two cuttings. The most recent logging, approximately 15 yrs ago, has apparently resulted in the development of the *P. menziesii*—*Pteridium aquilinum* community. Slash was left unburned, making regeneration difficult.

Availability of seed is another principle determinant of community formation. The role of rodents and birds as seed eaters and dispersers plays an import part. For example, among coniferous species, *Thuja plicata* seeds are the least palatable to rodents (Fowells 1965). This may account in part for the success of this species in our area.

Species aggregated around seed sources on the sites most suitable to their reproduction have developed into the present communities. The communities dominated by Thuja and Acer occupy areas with similar environmental characteristics. They have become dominant in their areas because the random distribution of old growth residuals provided a seed source. These factors, along with soil texture, drainage, and canopy closure, have resulted in the community composition of this seral forest.

The diversity of this forest and its proximity to the college offers students a unique opportunity for research projects. The area is large enough to support a viable population of mammals and birds, and more habitat diversity is provided than in an old growth system of similar size.

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APPENDIX I

Mammal species found in the study area

Presence established by trapping:

Clethrionomys occidentalis	western red-backed mouse
Eutamias townsendii	Townsend's chipmunk
Glaucomys sabrinus	northern flying squirrel
Neurotrichus gibbsii	shrew-mole
Peromyscus maniculatus	deer mouse
Sorex trowbridgeii	Trowbridge shrew
Tamiasciurus douglasii	Douglas squirrel
Zapus trinotatus	Pacific jumping mouse

Presence established by sightings:

Dama hemionus columbianus	black-tailed deer
Euarctos americanus	black bear

Presence established by previous study:

Aplodontia rufa	mountain beaver

APPENDIX II

Plant species found in the study area
(Nomenclature according to Hitchcock 1974.)

Trees

Abies grandis (Dougl.) Forbes	grand fir
Acer macrophyllum Pursh.	big-leafed maple
Alnus rubra Bong.	red alder
Arbutus menziesii Pursh.	madrone
Cornus nuttallii Aud.	common dogwood
Pseudotsuga menziesii (Mirbel) Franco.	Douglas-fir
Salix sp. L.	willow sp.
Taxus brevifolia Nutt.	western yew
Thuja plicata Donn.	western red cedar
Tsuga heterophylla (Raf.) Sarg.	western hemlock

Shrubs

Adiantum pedatum L.	maidenhair fern
Amelanchier alnifolia Nutt.	serviceberry
Berberis nervosa Pursh.	Oregon grape
Corylus cornuta Marsh.	western hazel
Cytisus scoparius (L.) Link	scotch broom
Gaultheria shallon Pursh.	salal
Holodiscus discolor (Pursh.) Maxim.	ocean spray
Ilex sp.	holly sp.
Lonicera ciliosa (Pursh.) DC.	climbing honeysuckle
Oplopanax horridum (Smith)	devil's club
Osmaronia cerasiformis (T. & G.) Greene.	Indian peach
Philadelphus lewisii Pursh.	mock orange
Polypodium glycyrrhiza D.C. Eat.	licorice fern
Polystichum munitum (Kaulf.) Presl	sword fern
Pteridium aquilinum (L.) Kuhn.	bracken fern
Rhamnus purshiana DC.	cascara
Ribes sanguineum Pursh.	red flowering currant
Rosa gymnocarpa Nutt.	wood rose
Rubus discolor Weihe & Nees	Himalayan blackberry
Rubus laciniatus Willd.	evergreen blackberry
Rubus leucodermis Dougl.	black-cap raspberry
Rubus parviflorus Nutt.	thimbleberry
Rubus spectabilis Pursh.	salmonberry
Rubus ursinus Cham. & Schlecht	wild blackberry
Sambucus racemosa L.	red elderberry
Vaccinium ovatum Pursh.	evergreen huckleberry
Vaccinium parvifolium Smith	red huckleberry

Herbs

Achlys triphylla (Smith) DC.	vanilla leaf
Actaea rubra (Ait.) Willd.	baneberry
Asarum caudatum Lindl.	wild ginger
Blechnum spicant (L.) Roth.	deer fern
Capsella bursa-pastoris (L.) Medic.	sheperd's purse
Corallorhiza maculata Raf.	spotted coral-root
Dicentra formosa (Andr.) Walp.	bleeding heart
Dryopteris austriaca (Jacq.) Woynar	wood fern
Epilobium angustifolium L.	fireweed
Equisetum arvense L.	common horsetail
Galium trifidum L.	swamp bedstraw
Galium triflorum Michx.	fragrant bedstraw
Goodyera oblongifolia Raf.	rattlesnake plantain
Hydrophyllum tenuipes Heller	waterleaf
Hypochaeris radicata L.	false dandelion
Lilium columbianum Hanson	tiger lily
Linnaea borealis var. longifolia Torr.	twinflower
Lysichitum americanum Hultén & St. John.	skunk cabbage
Maianthemun dilatatum (Wood) Nels. & Macbr.	false lily-of-the-valley
Monotropa uniflora L.	Indian pipe
Montia sibirica (L.) Howell	candy flower
Myosotis discolor Pers.	small blue forget-me-not
Myosotis micrantha Pall.	small white forget-me-not
Nemophila paryiflora Dougl.	wood nemophila
Osmorhiza chilensis H. & A.	common sweet cicely
Petasites frigidus var. palmatus (Ait.) Cronq.	sweet colt's foot
Plantago lanceolata L.	English plantain
Prunella vulgaris L.	heal-all
Pyrola aphylla Smith	leafless pyrola
Ranunculus uncinatus D. Don	woods buttercup
Rumex acetosella L.	red sorrel
Senecio jacobaea L.	tansy ragwort
Smilacina racemosa (L.) Desf.	large false Solomon's seal
Streptopus amplexifolius var. americanus Schult.	twisted stalk
Tiarella trifoliata var. trifoliata	three-leafed coolwort
Trientalis latifolia Hook.	star flower
Trillium ovatum Pursh.	trillium
Urtica dioica L.	stinging nettle
Vicia gigantea Hook.	giant vetch
Vicia hirsuta (L.) S.F. Gray	tiny vetch
Vicia sativa L.	common vetch
Viola sempervirens Greene	evergreen violet
Viola sp. L.	violet sp.
Woodsia oregana D.C. Eat.	Oregon woodsia