H. J. Andrews Experimental Forest Reference Stand System: Establishment and Use History

G. M. Hawk, J. F. Franklin, W. A. McKee, and R. B. Brown

Bulletin No. 12 • Coniferous Forest Biome • Ecosystem Analysis Studies

H. J. ANDREWS EXPERIMENTAL FOREST REFERENCE STAND SYSTEM: ESTABLISHMENT AND USE HISTORY

Glenn M. Hawk

School of Forestry, Oregon State University Corvallis, Oregon

Jerry F. Franklin

Forestry Sciences Laboratory, USDA Forest Service, Corvallis, Oregon

W. Arthur McKee

H. J. Andrews Experimental Ecological Reserve, Blue River, Oregon

Randall B. Brown

Department of Soil Science, Oregon State University, Corvallis, Oregon

Bulletin No. 12
Coniferous Forest Biome
Ecosystem Analysis Studies
U.S./International Biological Program

This research was supported by McIntire-Stennis Funds and by National Science Foundation grant no. GB-36810X to the Coniferous Forest Biome, Ecosystem Analysis Studies. This is contribution no. 301 from the Coniferous Forest Biome. Any portion of this publication may be reproduced for purposes of the U.S. Government. Copies are available from the Coniferous Forest Biome, University of Washington, AR-10, Seattle, WA 98195.

July 1978

ABSTRACT

Nineteen 1/4-hectare reference stands have been established in the central western Cascade Mountains of Oregon to represent widespread and important portions of the vegetation continuum. Their species diversity, cover, and structure are described here. The stands provide points of reference for visiting scientists and researchers who wish to design experiments around the natural stratification of vegetation provided by the differing habitat types. Several studies have tested theory about certain plant community-environment relations and given credence to the classification of habitat types in use in many northwest forests. This work reviews the methods for establishment, mapping, and collection of data on vegetation and the six-year history of use of the reference stands for 1972-1977.

TABLE OF CONTENTS

Introduction		1
Methods		4
Analysis		6
Soil Descriptions		15
Reference Stands		
Reference Stand 1:	*Pseudotsuga menziesii/Holodiscus discolor (Psme/Hodi)*	15
Reference Stand 8:	*Pseudotsuga menziesii-Tsuga heterophylla/Corylus cornuta* var. *californica (Psme/Tshe/Cococa)*	16
Reference Stand 6:	*Tsuga heterophylla/Castanopsis chrysophylla (Tshe/Cach)*	17
Reference Stand 16:	*Tsuga heterophylla/Castanopsis chrysophylla (Tshe/Cach)*	17
Reference Stand 10:	*Tsuga heterophylla/Rhododendron macrophyllum-Gaultheria shallon (Tshe/Rhma-Gash)*	18
Reference Stand 2:	*Tsuga heterophylla/Rhododendron macrophyllum-Berberis nervosa (Tshe/Rhma-Bene)*	19
Reference Stand 17:	*Tsuga heterophylla/Rhododendron macrophyllum-Berberis nervosa (Tshe/Rhma-Bene)*	19
Reference Stand 9:	*Tsuga heterophylla/Acer circinatum/Polystichum munitum (Tshe/Acci/Pomu)*	20
Reference Stand 15:	*Tsuga heterophylla/Polystichum munitum (Tshe/Pomu)*	21
Reference Stand 7:	*Tsuga heterophylla/Polystichum munitum-Oxalis oregana (Tshe/Pomu-Oxor)*	22
Reference Stand 19:	*Tsuga heterophylla/Polystichum munitum-Oxalis oregana (Tshe/Pomu-Oxor)*	22
Reference Stand 11:	*Pseudotsuga menziesii/Acer circinatum-Berberis nervosa (Psme/Acci-Bene)*	23
Reference Stand 5:	*Tsuga heterophylla-Abies amabilis/Rhododendron macrophyllum-Berberis nervosa (Tshe-Abam/Rhma-Bene)*	24
Reference Stand 3:	*Tsuga heterophylla-Abies amabilis/Linnaea borealis-Tsuga heterophylla-Abies amabilis/Rhododendron macrophyllum/Linnaea borealis (Tshe-Abam/Libo-Tshe-Abam/Rhma/Libo)*	25
Reference Stand 18:	*Pseudotsuga menziesii/Acer circinatum/Whipplea modesta (Psme/Acci/Whmo)*	26
Reference Stand 12:	*Abies amabilis/Vaccinium alaskaense/Cornus canadensis (Abam/Vaal/Coca)*	27

Reference Stand 13: *Abies procera/Clintonia uniflora (Abpr/Clun)* 27
Reference Stand 4: *Abies amabilis/Tiarella unifoliata (Abam/Tiun)* 28
Reference Stand 14: *Abies amabilis-Tsuga mertensiana/ Xerophyllum tenax (Abam-Tsme/Xete)* 29
History of Use 29
References 53
Appendix
Key to Stem Maps
Stem Maps of Reference Stands
Reference Stand 1 61
Reference Stand 2 62
Reference Stand 3 63
Reference Stand 4 64
Reference Stand 5 65
Reference Stand 6 66
Reference Stand 7 67
Reference Stand 8 68
Reference Stand 9 69
Reference Stand 10 70
Reference Stand 11 71
Reference Stand 12 72
Reference Stand 13 73
Reference Stand 14 74
Reference Stand 15 75
Reference Stand 16 76
Reference Stand 17 77
Reference Stand 18 78
Reference Stand 19 79

LIST OF FIGURES

Figure 1	1
Figure 2	2
Figure 3	5
Figure 4	31
Figure 5	34
Figure 6	35
Figure 7	36
Figure 8	36
Figure 9	46
Figure 10	48
Figure 11	49
Figure 12	50

LIST OF TABLES

Table 1	3
Table 2	6
Table 3	7
Table 4	11
Table 5	12
Table 6	30
Table 7	32
Table 8	37
Table 9	38
Table 10	40
Table 11	41
Table 12	42
Table 13	43
Table 14	44
Table 15	45
Table 16	45
Table 17	47
Table 18	52

INTRODUCTION

Reference stands within and around the H. J. Andrews Experimental Forest have been established to provide well-defined examples of many major plant communities commonly found in the *Tsuga heterophylla*, transition, and *Abies amabilis* zones of Oregon's central-western Cascade Mountains. The sites will serve as references for scientists of many disciplines in their future studies of these and similar forest communities.

The H. J. Andrews Experimental Forest is a 6,050-ha watershed located in the central-western Cascade Mountains of Oregon east of Eugene (Figure 1). The area was declared an experimental forest in 1948 and is representative of dense coniferous forests of Douglas-fir, western hemlock, and common true firs of the west slope of the Cascade Mountains. In 1969 the site was selected as one of the intensive study sites of the Coniferous Forest Biome Project of the International Biological Program. During the field seasons of 1971 and 1972, 19 reference stands were established as a part of the IBP studies.

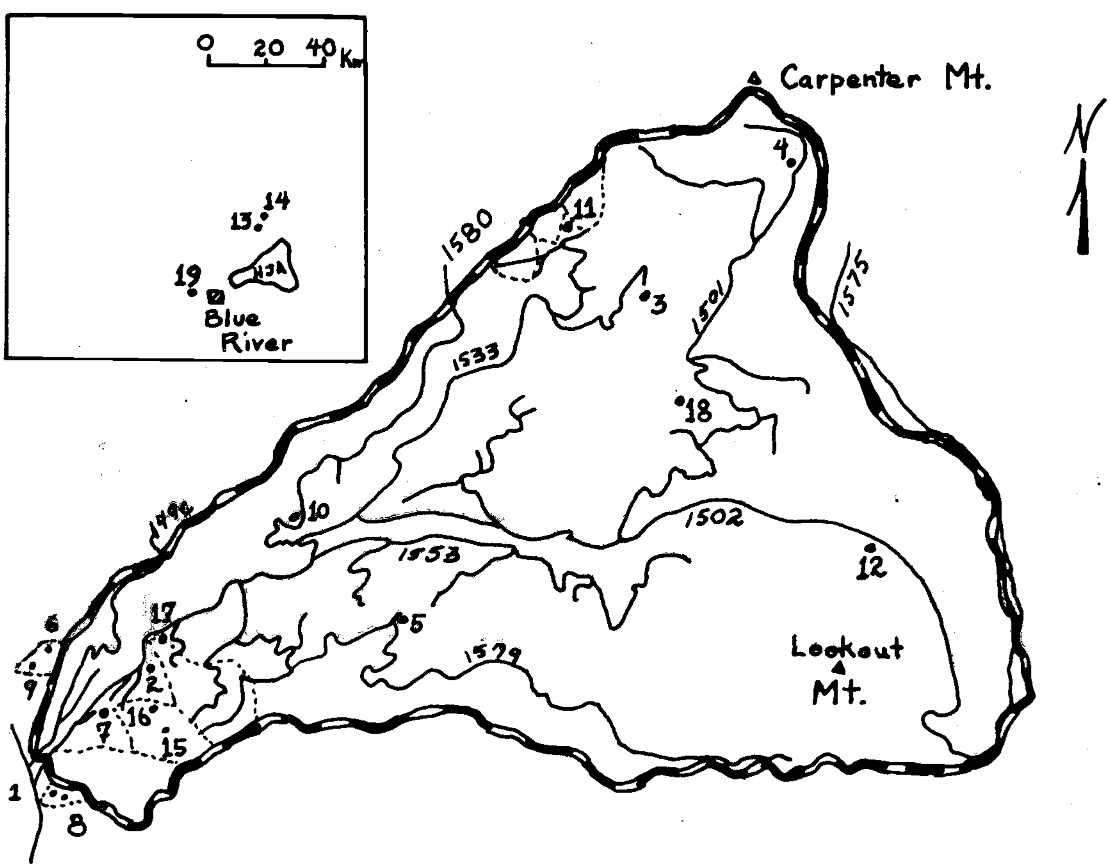


Figure 1. Location of 19 reference stands in and around the H. J. Andrews Experimental Forest. Major roads are numbered.

Phytosociological studies by Franklin et al. (1970) and Dyrness et al. (1974), based on a reconnaissance level sample of 300 plots in and near the H. J. Andrews Experimental Forest, identified 23 major forest communities (Figures 1 and 2). Of these 23 communities, 10 were in the *Tsuga heterophylla* zone, 4 within the transition zone, and 9 within the *Abies amabilis* zone. One of the goals of the study was to devise a workable classification system for the complex forest communities of Oregon's central-western Cascade Mountains. The study generated hypotheses concerning the causes of community distribution across a variety of gradients. Ordination showed the distribution of plant communities over gradients of temperature and moisture (Figure 2).

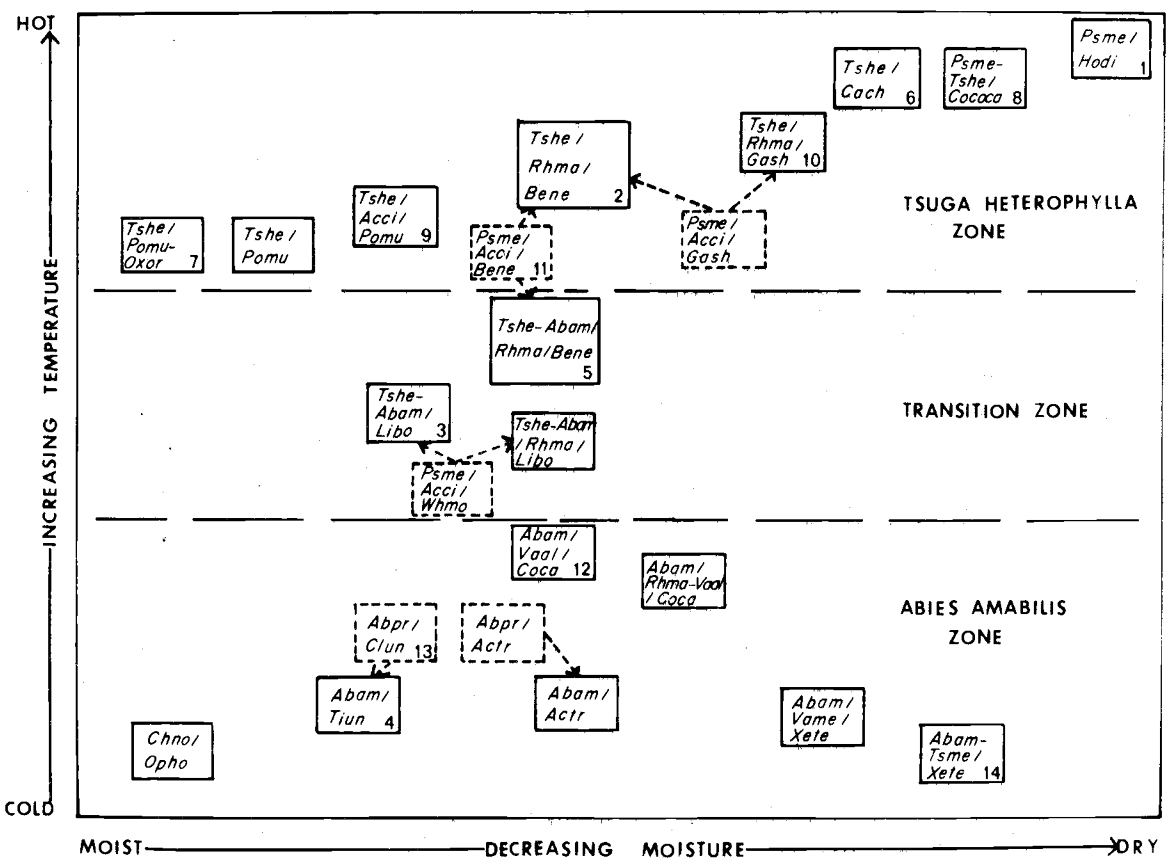


Figure 2. Diagrammatic representation of the vegetation ordination of Dyrness et al. (1974). Reference stands are numbered in the lower corner of community boxes (Zobel et al. 1976).

By the classification system of Dyrness et al. (1974), near modal representatives of major plant communities were established as reference stands (RS). Twelve reference stands are within the boundaries of the H. J. Andrews Experimental Forest, two are in the Wildcat Mountain Research Natural Area to the north (Figure 1), four are within Watersheds 9 and 10 adjacent to the southwestern tip of the Andrews Forest, and one is located 1 mile west of Blue River, Oregon. The reference stands include most vegetative and environmental gradient variation known to occur in the area represented (Table 1).

Table 1. Forest community represented in reference stands.

Ref. stand no.	Forest community name	Abbreviation
1	*Pseudotsuga menziesii/Holodiscus discolor*	*Psme/Hodi*
2, 17	*Tsuga heterophylla/Rhododendron macrophyllum Berberis nervosa*	*Tshe/Rhma-Bene*
3	*Tsuga heterophylla-Abies amabilis/ Linnaea borealis*	*Tshe-Abam/Libo*
4	*Abies amabilis/Tiarella unifoliata*	*Abam/Tium*
5	*Tsuga heterophylla-Abies amabilis/Rhododendron macrophyllum-Berberis nervosa*	*Tshe-Abam/Rhma-Bene*
6, 16	*Tsuga heterophylla/Castanopsis chrysophylla*	*Tshe/Cach*
7, 19	*Tsuga heterophylla/Polystichum munitum-Oxalis oregana*	*Tshe/Pomu-Oxor*
8	*Pseudotsuga menziesii-Tsuga heterophylla/ Corylus cornuta* var. *californica*	*Psme-Tshe/Cococa*
9	*Tsuga heterophylla/Acer circinatum/ Polystichum munitum*	*Tshe/Acci/Pomu*
10	*Tsuga heterophylla/Rhododendron macrophyllum-Gaultheria shallon*	*Tshe/Rhma-Gash*
11	*Pseudotsuga menziesii/Acer circinatum-Berberis nervosa*	*Psme/Acci/Bene*
12	*Abies amabilis/Vaccinium alaskaense/Cornus canadensis*	*Abam/Vaal/Coca*
13	*Abies procera/Clintonia uniflora*	*Abpr/Clun*
14	*Abies amabilis-Tsuga mertensiana/Xerophyllum tenax*	*Abam-Tsme/Xete*
15	*Tsuga heterophylla/Polystichum munitum*	*Tshe/Pomu*
18	*Pseudotsuga menziesii/Acer circinatum/ Whipplea modesta*	*Psme/Acci/Whmo*

Establishment of reference stands in these major vegetation communities focuses research in a limited area on species diversity, density, biomass, leaf area index, structure, and succession. The stands will also serve as reference points for other studies of ecosystem patterns and processes on similar sites.

METHODS

Reference stand sites were chosen as near modal examples of common plant communities. They often included areas originally sampled in the reconnaissance survey of Franklin et al. (1970).

Stands were of sufficient size to include 50- x 50-m plots with as large a buffer as possible. Each reference stand was surveyed and slope-corrected to a 1/4 ha area (Figure 3). Metal stakes were installed at 10-m intervals on the perimeter of each plot and at the corners of an interior 30- x 30-m plot. The entire reference stand was then divided into a 10- x 10-m grid, and all trees greater than 5 cm dbh (breast height = 1.37 m) were mapped and tagged with aluminum number tags.

Data recorded on each reference stand included location by X and Y coordinates, sequential tree tag number, species alpha code (Garrison et al. 1976), and dbh in cm. Vigor, crown condition, and bole condition were recorded for each tree with a three-digit code: vigor by 1--good, 2--moderate, 3--poor; crown by 1--broken, 2--forked, 3--dead top, 4--dying top, 5--half crowned, 6--suppressed; and bole by 1--swept butt, 2--leaning tree, 3--layering observed, 4--rot present, 5--split butt, 6--generally suppressed.

The location of downed logs and stumps was also included on maps of each stand. Stem mapping was completed by at least two men, and most trees were accurately mapped to $\pm$ 1 m (Appendix).

Saplings (> 0.5-m tall and < 5-cm dbh) were tallied within the 30- x 30-m interior plot by a total count or by a count of representative subsections of the interior plot. Seedlings (< 0.5 m tall) were tallied in a 120-m^2 area inside the 30- x 30-m plot in four 1- x 30-m strip transects (lines A, B, C, and D in Figure 3).

Cover and frequency of shrub species were tallied along 60 m of line intercept at the top and bottom of each 30- x 30-m plot (lines A and D in Figure 3). Cover and frequency of herb and moss species were tallied in 60 microplots (2 x 5 dm) placed at 1-m intervals along the inside of the two central lines.

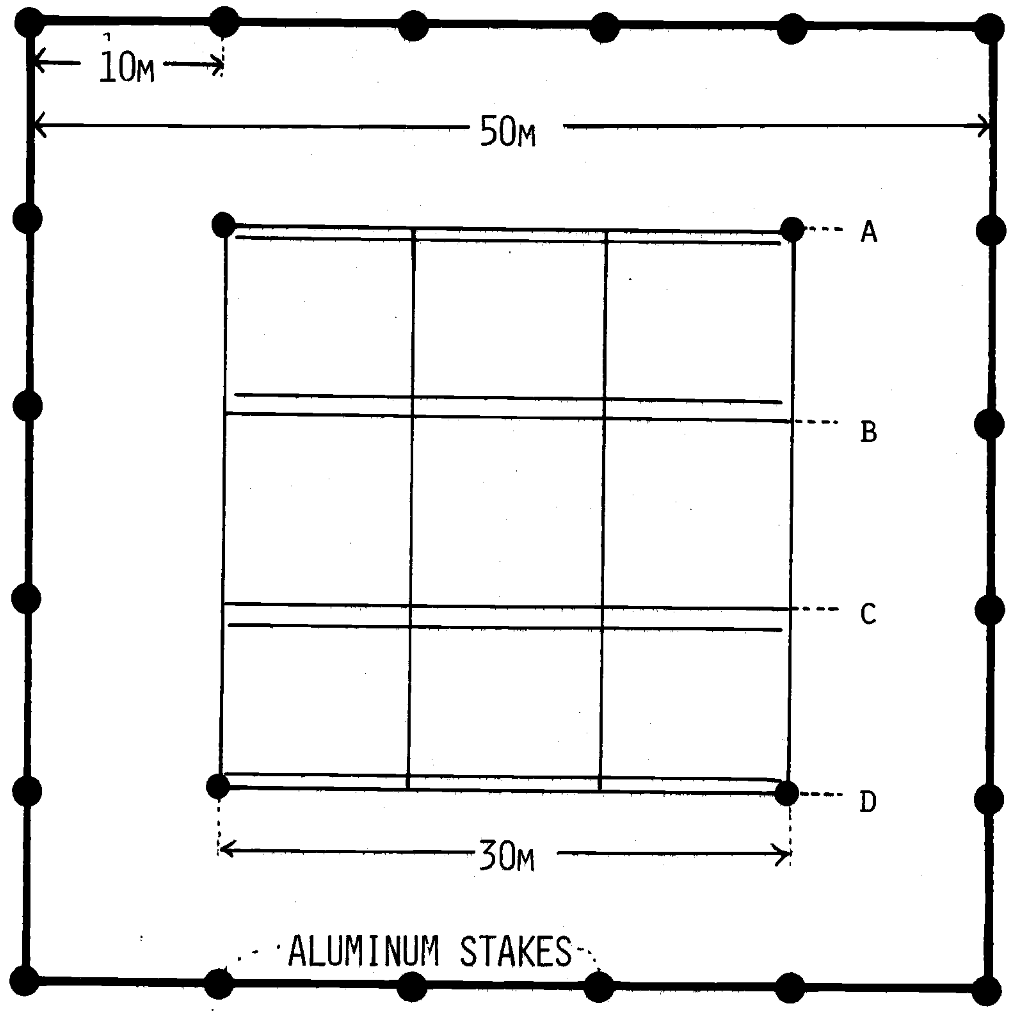


Figure 3. Plot diagram of 50 m x 50 m reference stand showing 10-m wide buffer strip; 30 m x 30 m central block; strip- and line- sample areas on lines A, B, C, and D; location of 60 microplots within lines B and C; and location of permanent aluminum stakes (●).

Data were collected for index estimates of understory biomass and leaf area. Not all understory species were sampled with equal intensity. The eight plant species sampled intensively were *Acer circinatum*, *Rhododendron macrophyllum*, *Castanopsis chrysophylla*, *Gaultheria shallon*, *Berberis nervosa*, *Polystichum munitum*, *Taxus brevifolia*, and *Xerophyllum tenax*. Data were also collected for many locally important understory species when growth-form similarity to one of the eight major species permitted good estimates. The measurements for this part of the study are listed in Table 2. Each of the species was sampled by total count within one or more of the representative 10- x 10-m sections within the inner 30- x 30-m plot.

Table 2. Parameters measured for estimating leaf area index and biomass of selected species within the H. J. Andrews Experimental Forest reference stands.

Species	Data collected
Polystichum munitum	number of fronds - average frond length (dm).
Berberis nervosa	number of plants - number of leaves (first digit = new; second digit = old) - average length of leaves (dm).
Gaultheria shallon	number of plants - average height of plants
Rhododendron macrophyllum	number of stems - average length (m) - average basal diameter (cm)
Taxus brevifolia	same as *Rhododendron macrophyllum*
Castanopsis chrysophylla	same as *Rhododendron macrophyllum*
Acer macrophyllum	same as *Rhododendron macrophyllum*
Vaccinium parvifolium	same as *Rhododendron macrophyllum*
Rosa gymnocarpa	same as *Rhododendron macrophyllum*
Rubus parviflorus	same as *Rhododendron macrophyllum*
Amelanchier alnifolia	same as *Rhododendron macrophyllum*
Rhus diversiloba	same as *Rhododendron macrophyllum*
Rhamnus purshiana	same as *Rhododendron macrophyllum*
Xerophyllum tenax	number of clumps - length of compacted leaf cone (dm) - basal diameter of cone (cm).

Each reference stand was monitored with a two-pen, 30-day thermograph equipped with air and soil probes. Air probes were located at 1 m above ground surface, or at 3 m or 5 m where snowpack is heavy during winter months. Soil probes were buried at a depth of 20 cm.

Analysis

Collected data have been analyzed for a baseline description of vegetation structure within each reference stand. A series of tables of vegetation cover and frequency within each reference stand was completed and reduced to a table including trees (mature and immature), shrubs, and herbs or mosses (Table 3). Table 4 includes other characteristics of each reference stand and a summary of cover values by stratum. Size-class distribution on each reference stand is given in Table 5.

Table 3. Cover table of species within reference stands of the H. J. Andrews Experimental Forest area associations.

Species		Reference stands: *Tsuga heterophylla* zone												Transition zone			*Abies amabilis* zone			
		1	8	6	16	10	2	17	9	15	7	19	11	5	3	18	12	13	4	14
Pseudotsuga menziesii	M[1]	40.0	50.0	35.0	55.0	55.0	50.0	50.0	25.0	30.0	25.0	60.0	75.0	35.0	20.0	70.0	55.0	45.0	45.0	----
	R[2]	10.0	20.0	5.0	15.0	20.0	----	----	1.0	----	----	5.0	7.0	----	----	3.0	5.0	----	----	----
Acer macrophyllum	M	3.0	15.0	----	----	----	3.0	2.0	5.0	20.0	----	20.0	----	----	----	----	----	----	----	----
Pinus lambertiana	M	2.0	----	3.0	2.0	1.0	----	----	----	----	----	----	----	3.0	----	----	----	----	----	----
	R	----	----	----	1.0	t	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Tsuga heterophylla	M	----	5.0	7.0	15.0	15.0	50.0	35.0	60.0	35.0	55.0	5.0	20.0	7.0	30.0	10.0	40.0	----	15.0	----
	R	2.0	3.0	5.0	5.0	30.0	3.0	25.0	30.0	25.0	30.0	35.0	30.0	20.0	30.0	20.0	10.0	----	20.0	----
Thuja plicata	M	----	1.0	3.0	----	8.0	----	5.0	----	20.0	30.0	----	----	3.0	45.0	----	----	----	----	----
	R	----	t	----	1.0	5.0	2.0	5.0	----	15.0	10.0	----	----	----	20.0	----	3.0	----	----	----
Calocedrus decurrens	M	----	1.0	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
	R	----	t	----	----	----	----	----	----	----	----	1.0	----	----	----	----	----	----	----	----
Abies amabilis	M	----	----	----	----	----	----	----	----	----	----	----	1.0	----	5.0	----	3.0	8.0	50.0	20.0
	R	----	----	----	----	----	----	----	----	----	----	----	5.0	----	20.0	----	10.0	20.0	30.0	25.0
Pinus monticola	M	----	----	----	----	----	----	----	----	----	----	----	1.0	----	----	----	----	----	----	----
	R	----	----	----	----	----	----	----	----	----	----	----	t	----	----	----	----	----	----	----
Abies procera	M	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	40.0	5.0	15.0
Tsuga mertensiana	M	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1.0	65.0
	R	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	2.0
Cornus nuttallii		0.2	3.9	3.6	4.1	13.1	t	5.6	17.6	3.3	2.9	4.2	7.0	----	----	t	----	----	----	----
Acer circinatum		21.2	28.2	11.1	15.9	25.8	7.3	17.0	36.2	4.1	8.3	30.9	12.3	33.3	t	57.4	13.4	5.4	t	----
Berberis nervosa		4.1	6.9	2.8	6.0	8.7	12.0	1.3	8.9	2.1	0.5	14.6	24.4	20.1	8.0	29.3	4.5	t	t	----
Rubus ursinus		0.2	1.2	0.4	0.3	0.1	0.2	0.4	0.1	0.1	2.3	1.9	5.3	0.3	0.7	1.9	0.6	0.2	t	----
Vaccinium parvifolium		1.3	1.1	----	0.1	0.6	3.4	0.9	1.0	t	1.8	4.7	1.3	t	4.2	1.6	0.9	----	t	----
Rhododendron macrophyllum		----	4.1	46.0	32.8	44.1	4.3	8.4	3.8	t	----	----	----	59.7	21.5	----	2.2	----	----	0.5
Taxus brevifolia		3.0	4.2	0.8	0.4	3.8	0.5	7.7	----	----	1.3	t	----	5.6	----	t	1.8	----	----	----
Castanopsis chrysophylla		----	0.7	31.7	21.6	2.6	0.1	t	1.8	0.1	----	0.3	t	2.4	t	----	----	----	----	----
Gaultheria shallon		----	0.2	26.3	26.8	18.8	2.3	0.3	3.3	3.7	1.5	16.5	10.7	1.5	----	----	----	----	----	----
Holodiscus discolor		2.7	t	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Rhus diversiloba		0.4	t	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Amelanchier alnifolia		0.1	0.1	t	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Lonicera ciliosa		----	t	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Ceanothus intergerrimus		----	t	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Symphoricarpos mollis		4.7	0.4	----	----	----	----	----	----	----	----	----	0.4	----	----	0.9	t	----	----	----
Corylus cornuta var. *californica*		6.5	13.0	----	----	----	----	----	----	t	----	t	----	----	----	----	----	----	----	----
Acer macrophyllum		2.1	t	t	----	----	----	t	----	----	t	0.4	----	----	----	----	----	----	----	----
Rosa gymnocarpa		0.5	t	t	t	----	----	----	t	----	----	----	t	----	----	t	1.0	t	0.3	----
Rhamnus purshaina		----	t	t	----	----	t	t	t	----	----	0.5	----	----	----	----	----	----	----	----
Pachistima myrsinites		----	----	----	----	----	t	----	----	----	----	----	t	----	1.2	t	t	t	----	----
Vaccinium membranaceum		----	----	----	----	----	----	----	----	----	----	----	0.2	----	0.7	t	1.5	4.2	8.3	2.3
Vaccinium alaskaense		----	----	----	----	----	----	----	----	----	----	----	----	----	0.2	----	28.7	----	----	----

Table 3. Continued.

	Reference stands																		
	Tsuga heterophylla zone												Transition zone			Abies amabilis zone			
Species	1	8	6	16	10	2	17	9	15	7	19	11	5	3	18	12	13	4	14
Rubus parviflorus	----	----	----	----	----	----	----	----	----	----	----	----	----	----	t	t	----	----	----
Sorbus sitchensis	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	t	t	t	t
Ribes lacustre	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	t	----
Linnaea borealis	3.9	3.5	2.3	3.3	1.9	9.4	26.1	3.3	0.2	5.1	2.2	1.7	0.7	6.0	3.7	3.8	----	0.4	----
Polystichum munitum	8.7	7.1	0.2	----	1.1	2.8	0.6	19.9	16.5	26.7	27.8	1.3	0.5	----	6.9	t	0.4	0.1	t
Goodyera oblongifolia	0.1	0.1	t	0.2	0.2	0.2	0.1	0.1	t	0.1	t	t	0.1	0.5	1.2	t	0.4	0.1	t
Viola sempervirens	----	0.5	0.3	t	t	2.9	0.6	3.2	t	0.6	0.2	4.5	----	3.3	0.6	1.8	0.4	0.5	t
Chimaphila umbellata	0.4	1.1	t	t	1.5	2.0	0.1	t	----	t	----	0.6	2.1	4.3	t	2.8	0.3	0.2	t
Anemone deltoidea	0.1	0.1	t	t	0.2	t	0.1	0.3	t	----	t	0.3	----	t	t	----	0.2	0.2	----
Hieracium albiflorum	0.4	0.4	t	t	----	----	t	----	----	t	t	t	----	----	0.2	t	t	0.1	----
Anemone lyallii	0.1	0.1	----	----	----	----	----	t	----	----	t	----	----	----	0.1	----	----	t	----
Trillium ovatum	----	----	----	t	t	0.1	t	0.6	0.1	t	0.1	t	t	0.1	t	t	0.3	0.1	t
Disporum hookeri	----	0.1	----	----	----	0.2	t	0.	t	t	0.2	----	----	t	t	t	----	t	----
Xerophyllum tenax	----	----	11.4	2.1	2.7	0.2	----	----	----	----	----	t	0.3	----	----	0.8	----	6.1	32.3
Achlys triphylla	----	2.3	t	0.6	t	0.1	t	t	0.6	t	t	0.1	----	t	t	1.0	5.4	11.5	0.1
Chimaphila menziesii	t	0.1	----	0.1	0.1	t	t	----	0.1	t	----	0.1	t	0.1	t	0.2	t	t	t
Galium oregana	----	0.9	----	----	----	----	----	----	----	----	----	0.1	----	----	----	----	0.1	t	----
Adenocaulon bicolor	t	t	----	----	----	----	t	0.5	----	----	0.5	t	----	----	----	----	----	t	----
Corallorhiza maculata	----	t	----	----	----	t	t	----	t	----	t	----	t	t	t	----	----	t	----
Whipplea modesta	12.8	4.1	----	0.2	0.1	----	----	0.1	----	----	----	1.1	----	----	0.1	----	----	----	----
Trientalis latifolia	0.5	0.6	t	t	t	t	t	0.1	----	t	t	t	----	----	0.7	----	----	----	----
Syntheris reniformis	4.5	3.2	----	----	----	----	t	0.9	----	----	----	----	----	----	1.0	----	----	----	----
Bromus sp.	1.0	0.1	----	t	----	----	----	----	----	t	t	t	----	----	t	----	----	t	----
Galium triflorum	0.1	0.6	----	t	----	----	t	0.1	t	0.1	t	t	----	----	0.8	----	----	----	----
Coptis laciniata	t	----	0.1	----	----	4.6	5.0	12.6	0.2	2.0	----	----	----	5.2	1.9	----	----	----	----
Fragaria vesca	1.3	t	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Lotus micranthus	0.6	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Luzula intermedia	0.3	0.1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Collomia heterophylla	0.2	----	----	----	----	----	----	----	----	----	----	t	----	----	----	----	----	----	----
Iris tenax	0.6	t	t	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Madia gracilis	0.1	0.1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Stellaria crispa	0.1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Lathyrus polyphyllus	t	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Bromus carinatus	t	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Montia sibirica	----	0.3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Epilobium angustifolium	t	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0.3	----	----	----
Epilobium paniculatum	t	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Epilobium watsonia	t	----	----	----	----	----	t	----	----	----	----	----	----	----	----	----	----	----	----
Vicia americana	t	0.3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Festuca occidentalis	t	t	t	----	----	t	----	----	----	----	----	----	----	----	----	----	----	----	----
Polystichum lonchitis	0.1	----	----	----	----	----	----	----	t	----	t	t	----	----	----	t	----	----	----
Oxalis oregana	----	----	----	----	----	0.4	3.7	1.8	----	24.4	20.4	----	----	----	----	----	----	----	----

Table 3. Continued.

Species	Reference stands: Tsuga heterophylla zone												Transition zone			Abies amabilis zone			
	1	8	6	16	10	2	17	9	15	7	19	11	5	3	18	12	13	4	14
Vancouveria hexandra	----	1.4	----	----	----	t	t	1.5	t	0.1	t	0.1	----	----	t	----	----	----	----
Blechnum spicant	----	----	----	----	----	----	----	0.6	----	----	----	----	----	----	----	----	----	----	----
Streptopus amplexifolius	----	----	----	----	----	t	----	t	----	t	t	----	----	----	----	----	----	----	----
Smilacina racemosa	----	----	t	----	----	----	----	t	t	----	t	----	----	----	----	----	----	----	----
Monotropa uniflora	----	----	----	----	----	----	----	----	----	t	----	----	----	----	----	----	t	----	----
Adiantum pedatum	----	t	----	----	----	----	----	t	----	----	----	----	----	----	----	----	----	----	----
Allotropa virgata	----	----	----	----	----	----	----	----	----	----	----	t	----	----	----	----	----	----	----
Eburophyton austineae	----	----	----	----	----	----	----	----	----	----	t	t	----	----	----	----	----	----	----
Pyrola aphylla	----	----	----	----	----	----	----	----	----	----	t	t	----	----	----	----	----	----	----
Smilacina stellata	----	t	----	----	----	0.1	t	0.6	----	t	t	0.1	----	0.1	t	2.5	15.8	0.2	----
Tiarella unifoliata	----	----	----	----	----	0.8	0.5	0.1	t	2.0	t	----	----	0.8	0.6	2.6	----	5.3	t
Rubus nivalis	----	----	----	----	----	----	1.4	----	----	t	----	0.1	1.8	0.4	1.0	----	----	----	----
Campanula scouleri	----	0.1	----	----	----	----	----	----	----	----	----	----	----	----	0.3	----	----	0.1	----
Pyrola picta	----	----	t	----	----	----	----	----	t	----	----	t	0.1	t	t	----	t	t	----
Aralia californica	----	t	----	----	----	----	----	0.7	----	t	----	----	----	----	----	----	----	----	----
Asarum caudatum	----	----	----	----	----	----	----	0.1	----	----	0.1	----	----	----	t	----	t	----	----
Pteridium aquilinum	----	----	t	----	t	----	----	----	----	----	1.7	t	----	----	----	----	0.6	t	----
Corallorhiza mertensiana	----	----	----	----	----	t	----	----	----	----	----	t	----	----	t	----	t	----	----
Osmorhiza chilensis	----	t	----	----	----	----	----	----	----	----	t	t	----	----	----	----	t	t	----
Athyrium felix-femina	----	----	----	----	----	----	----	----	----	----	t	----	----	----	----	----	----	----	t
Stellaria palustris	----	----	----	----	----	----	----	----	----	----	t	----	----	----	t	----	----	----	----
Cornus canadensis	----	----	----	----	----	----	----	----	----	2.0	----	----	----	3.5	----	10.2	1.3	6.6	----
Pyrola asarifolia	----	----	----	----	----	----	----	t	----	----	----	----	1.5	0.3	----	0.1	----	----	----
Rubus lasiococcus	----	----	----	----	----	----	----	----	----	----	----	----	----	0.5	----	0.8	2.4	0.4	0.4
Pyrola secunda	----	----	----	----	----	----	----	----	----	----	----	t	----	0.1	----	0.1	2.6	0.1	0.6
Clintonia uniflora	----	----	----	----	----	----	----	t	----	----	----	----	----	----	----	7.2	4.4	4.4	0.3
Valeriana sitchensis	----	----	----	----	----	----	----	0.3	----	----	----	----	----	----	----	----	----	2.5	----
Senecio harfordii	----	----	----	----	----	----	----	0.4	----	----	----	----	----	----	----	----	----	0.9	----
Pedicularis racemosa	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0.1
Viola glabella	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	0.2	----	----
Lilium columbianum	----	----	----	----	----	----	----	----	----	----	----	t	----	----	0.1	----	0.1	----	----
Listera caurina	----	----	----	----	----	----	----	----	----	----	----	t	----	----	----	----	0.2	t	t
Anemone oregana	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	t	----	----
Aranaria macrophylla	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	t	----	----
Arnica latifolia	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	t	----	----
Streptopus roseus	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	t	----
Veratrum viride	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	t	----	----
Eurhynchium oreganum	5.3	4.6	3.2	11.0	7.1	51.3	38.6	28.5	10.9	46.9	37.8	0.1	0.8	0.4	----	1.4	----	----	----
Dicranum fuscescens	0.1	1.0	0.2	0.1	0.8	0.2	t	0.2	t	1.3	t	----	----	0.1	----	0.2	----	t	0.1
Hypnum circinale	t	1.2	0.8	0.2	0.8	0.1	----	t	0.1	1.4	----	0.3	----	1.1	0.8	0.4	----	0.2	----
Isothecium stoloniferum	0.1	0.1	0.2	2.1	0.1	0.3	0.8	----	2.0	1.6	----	----	----	----	----	0.3	----	----	----
Polytrichum juniperinum	2.1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

Table 3. Continued.

Species	1	8	6	16	10	2	17	9	15	7	19	11	5	3	18	12	13	4	14
	Reference stands																		
	Tsuga heterophylla zone												Transition zone			Abies amabilis zone			
Tortella tortuosa	----	0.1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Antitrichia curtipendula	----	0.3	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Homalothecium megaptilum	2.6	----	----	0.4	0.4	0.1	----	----	----	----	----	----	----	----	----	t	----	----	----
Aulocomnium androgynum	0.1	----	0.1	t	----	----	----	----	t	----	----	----	----	----	----	----	----	----	----
Rhacomitrium heterostichum	----	0.1	0.1	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Dicranum tauricum	----	----	0.1	0.1	----	----	----	----	----	----	----	----	----	----	----	----	t	----	----
Dicranum howellii (or *scoparium*)	4.6	----	0.2	t	0.1	----	----	t	----	----	----	----	----	----	----	----	----	----	----
Rhytidiadelphus triquetrus	1.3	0.1	----	----	1.0	0.1	----	2.4	----	0.5	0.3	----	----	----	----	----	----	----	----
Hylocomium splendens	0.5	----	----	----	1.6	1.0	3.6	0.4	----	1.4	1.0	----	----	----	----	----	----	----	----
Leucolepis menziesii	0.2	----	----	----	----	----	----	0.6	----	----	2.6	----	----	----	----	----	----	----	----
Plagiothecium laetum	----	----	----	1.0	----	----	----	----	----	----	-----	0.1	----	0.1	0.1	----	t	0.5	----
Mnium sp.	----	----	----	----	t	----	t	0.2	t	1.7	t	----	----	0.1	t	----	----	----	----
Claopodium bolanderi	----	----	----	----	----	----	----	----	0.2	----	----	----	----	----	----	----	----	----	----
Plagiomnium insigne	----	----	----	----	----	----	----	----	----	t	t	t	----	----	----	----	----	----	----
Rhytidiadelphus loreus	----	----	----	----	----	----	----	----	----	----	0.3	----	----	----	----	----	----	----	----
Plagiothecium undulatum	----	----	----	----	----	----	----	----	----	----	t	----	----	----	----	----	----	----	----
Rhytidiopsis robusta	----	----	----	----	----	----	----	----	----	----	---	----	----	0.4	----	12.7	----	----	----
Bryum sandbergii	----	----	----	----	----	----	----	----	----	----	-----	----	----	----	----	----	t	0.1	t

Table 4. Characteristics of reference stands sampled. Percent cover is for a 50 x 50 m area at each stand. Specific epithet of plants in the community names are given in Table 1. (From Zobel et al. 1976).

Zone	Ref. stand no.	Community	Elevation (m)	Aspect	Slope (°)	Percent cover: Tree, Mature	Percent cover: Tree, Reproducing	Percent cover: Shrub	Percent cover: Herb
Tsuga heterophylla	1	*Pseudotsuga/Holodiscus*	510	SW	35	50	20	46	36
	2	*Tsuga/Rhododendron/Berberis*	520	NW	20	105	10	30	24
	6	*Tsuga/Castanopsis*	710	S	40	83	30	123	14
	7	*Tsuga/Polystichum-Oxalis*	490	NW	18	110	42	17	41
	8	*Pseudotsuga-Tsuga/Corylus*	500	W	40	81	25	64	27
	9	*Tsuga/Acer/Polystichum*	490	WNW	45	100	35	72	48
	10	*Tsuga/Rhododendron/Gaultheria*	670	SSW	5	89	60	118	7
	11	*Pseudotsuga/Acer/Berberis*	1,060	SSE	25	96	35	62	10
	15	*Tsuga/Polystichum*	720	NW	45	108	43	14	18
	16	*Tsuga/Castanopsis*	670	SW	40	107	48	108	7
	17	*Tsuga/Rhododendron/Berberis*	530	NNW	18	102	47	43	37
	19	*Tsuga/Polystichum-Oxalis*	380	WSW	17	85	55	76	54
Transition	3	*Tsuga-Abies/Linnaea*	950	SW	10	120	88	38	24
	5	*Tsuga-Abies/Rhododendron/Berberis*	920	N	8	90	27	125	5
	18	*Pseudotsuga/Acer/Whipplea*	1,080	SE	30	81	24	92	23
Abies amabilis	4	*Abies/Tiarella*	1,440	SW	10	116	50	9	39
	12	*Abies/Vaccinium/Cornus*	1,020	W	5	103	31	56	33
	13	*Abies/Clintonia*	1,480	S	15	93	20	12	32
	14	*Abies-Tsuga/Xerophyllum*	1,570	NW	15	100	27	3	33

Table 5. Size class distribution (10 cm increments) of major tree species found within reference stands of the H. J. Andrews Experimental Forest, Blue River, Oregon. (Trees per hectare.)

RS No.	Species	Seedling	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130	130-140	140-150	150-160	160+
1	*Pseudotsuga menziesii*	334	136	96	52	16	12	16	12	4	12	16	4	8	8	4	4	---	---
	Taxus brevifolia	334	103	40	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Castanopsis chrysophylla	---	100	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Acer macrophyllum	---	---	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Tsuga heterophylla[a]	---	34	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Pinus lambertiana	---	---	---	---	---	---	---	---	---	---	4	---	---	---	---	---	---	---
8	*Pseudotsuga menziesii*	1670	492	148	36	---	---	4	4	8	4	4	4	8	16	8	8	8	---
	Taxus brevifolia	90	27	16	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Acer macrophyllum	---	12	24	24	20	---	---	---	---	---	---	---	---	---	---	---	---	---
	Thuja plicata	---	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Libocedrus decurrens	---	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Tsuga heterophylla	340	---	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Castanopsis chrysophylla	---	34	8	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
6	*Pseudotsuga menziesii*	1670	885	24	8	8	---	8	4	---	20	12	20	12	4	4	---	---	---
	Tsuga heterophylla	2000	79	8	8	4	8	---	---	---	---	---	---	---	---	---	---	---	---
	Taxus brevifolia	930	90	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Pinus lambertiana	500	135	8	---	---	8	---	---	---	---	---	4	---	---	---	---	---	---
	Thuja plicata	260	56	---	---	---	4	---	---	---	---	---	---	---	---	---	---	---	---
	Castanopsis chrysophylla	---	---	116	96	4	---	---	---	---	---	---	---	---	---	---	---	---	---
16	*Pseudotsuga menziesii*	340	92	12	---	---	4	---	4	8	4	4	4	12	4	4	12	4	4
	Tsuga heterophylla	1260	8	12	16	32	8	---	---	---	---	---	---	---	---	---	---	---	---
	Taxus brevifolia	1260	8	32	12	4	---	---	---	---	---	---	---	---	---	---	---	---	---
	Pinus lambertiana	---	---	---	---	4	---	---	---	---	---	---	---	---	---	---	---	---	---
	Thuja plicata	---	20	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Castanopsis chrysophylla	---	284	140	32	4	---	---	---	---	---	---	---	---	---	---	---	---	---
10	*Pseudotsuga menziesii*	---	4	108	96	80	112	44	20	---	---	---	---	---	4	---	---	---	---
	Tsuga heterophylla	1000	260	28	8	12	8	---	---	---	---	---	---	---	---	---	---	---	---
	Taxus brevifolia	500	119	8	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Pinus lambertiana	---	---	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Thuja plicata	---	72	8	4	8	---	---	---	---	---	---	---	---	---	---	---	---	---
	Castanopsis chrysophylla	---	334	---	12	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Abies grandis	---	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
2	*Pseudotsuga menziesii*	---	---	---	---	---	---	---	4	8	12	4	12	12	8	12	4	4	---
	Tsuga heterophylla	422	134	96	80	80	20	4	4	4	---	---	---	---	---	---	---	---	---
	Taxus brevifolia	422	256	---	12	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Thuja plicata	166	---	16	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Table 5. Continued.

RS No.	Species	Seedling		0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130	130-140	140-150	150-160	160+
	Castanopsis chyrsophylla	---	34	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
	Acer macrophyllum	---	---	8	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
17	*Pseudotsuga menziesii*	---	---	---	---	---	---	---	---	4	---	---	8	20	12	4	4	4	4	
	Tsuga heterophylla	1500	133	28	24	36	12	8	---	4	---	8	4	---	---	---	---	---	---	
	Taxus brevifolia	260	276	164	36	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
	Thuja plicata	---	34	---	---	4	---	4	---	---	---	---	---	---	---	---	---	---	---	
	Acer macrophyllum	---	---	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
9	*Pseudotsuga menziesii*	120	---	---	---	---	---	---	---	25	---	---	---	---	13	---	13	---	---	
	Tsuga heterophylla	1450	388	125	138	75	13	---	---	---	---	---	---	---	---	---	---	---	---	
	Taxus brevifolia	450	76	25	---	13	---	---	---	---	---	---	---	---	---	---	---	---	---	
	Castanopsis chrysophylla	---	56	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
	Acer macrophyllum	---	---	13	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
15	*Pseudotsuga menziesii*	---	---	---	4	---	4	4	---	---	---	---	---	---	4	---	12	---	12	
	Tsuga heterophylla	760	199	88	68	20	12	20	4	4	8	---	---	---	---	---	---	---	---	
	Taxus brevifolia	170	31	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
	Acer macrophyllum	---	---	4	48	4	8	---	---	---	---	---	---	---	---	---	---	---	---	
	Thuja plicata	1180	193	12	20	12	---	4	4	---	4	---	---	---	---	---	---	---	---	
	Castanopsis chrysophylla	---	23	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
7	*Pseudotsuga menziesii*	---	---	---	---	---	---	---	---	---	8	---	---	20	---	4	8	---	4	
	Tsuga heterophylla	2500	320	48	44	44	8	---	---	---	---	---	---	---	---	---	---	---	---	
	Taxus brevifolia	---	39	16	8	4	---	---	---	---	---	---	---	---	---	---	---	---	---	
	Thuja plicata	760	248	4	4	8	---	4	4	8	4	---	---	---	---	---	---	---	---	
	Castanopsis chrysophylla	---	67	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
19	*Pseudotsuga menziesii*	---	4	28	40	32	20	16	28	8	---	---	---	---	---	---	---	---	---	
	Tsuga heterophylla	1170	333	24	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
	Taxus brevifolia	90	---	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
	Castanopsis chrysophylla	---	23	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
	Acer macrophyllum	---	4	40	44	12	---	---	---	---	---	---	---	---	---	---	---	---	---	
	Librocedrus decurrens	---	---	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
11	*Pseudotsuga menziesii*	340	---	---	40	32	104	48	44	36	32	20	---	---	4	---	---	---	---	
	Tsuga heterophylla	840	516	112	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
	Taxus brevifolia	90	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
	Castanopsis chrysophylla	---	126	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
	Abies amabilis	500	34	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	
	Abies grandis	---	23	---	---	---	4	---	---	---	---	---	---	---	---	---	---	---	---	
	Pinus monticola	90	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	

Table 5. Continued.

RS No.	Species	Seedling	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130	130-140	140-150	150-160	160+
5	*Pseudotsuga menziesii*	---	---	---	---	---	---	4	---	---	4	12	12	8	32	---	24	4	---
	Tsuga heterophylla	590	116	12	12	12	4	---	4	---	4	8	---	4	---	---	---	---	---
	Taxus brevifolia	255	74	48	28	20	8	---	---	---	---	---	---	---	---	---	---	---	---
3	*Pseudotsuga menziesii*	---	---	---	---	---	---	---	---	---	---	---	8	---	8	4	---	---	---
	Tsuga heterophylla	1088	486	132	24	---	4	8	8	8	4	4	---	4	---	---	---	---	---
	Taxus brevifolia	89	72	52	12	4	---	---	---	---	---	---	---	---	---	---	---	---	---
	Thuja plicata	1088	87	4	8	---	---	12	16	4	16	12	8	8	---	---	---	---	---
	Abies amabilis	3422	376	16	4	---	---	---	4	---	---	---	---	---	---	---	---	---	---
18	*Pseudotsuga menziesii*	---	---	16	32	8	52	48	48	32	28	12	---	4	---	4	---	---	---
	Tsuga heterophylla	760	151	12	8	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Taxus brevifolia	170	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Abies grandis	---	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
12	*Pseudotsuga menziesii*	90	---	4	8	8	---	---	---	---	---	4	4	12	16	12	4	4	4
	Tsuga heterophylla	1260	28	---	4	4	16	16	16	24	8	8	8	---	---	---	---	---	---
	Taxus brevifolia	590	94	8	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Thuja plicata	90	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Abies amabilis	2000	65	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
13	*Pseudotsuga menziesii*	---	---	---	---	8	12	28	28	36	20	8	---	---	---	---	---	---	---
	Abies amabilis	1090	107	4	4	---	---	---	---	---	---	---	---	---	---	---	---	---	---
	Abies procera	---	---	---	---	---	16	4	16	16	52	8	8	---	---	---	---	---	---
4	*Pseudotsuga menziesii*	---	---	---	---	---	8	8	20	44	32	32	12	8	---	---	---	---	---
	Tsuga heterophylla	100	161	4	---	8	---	4	4	---	4	---	---	---	---	---	---	---	---
	Abies amabilis	4922	1146	282	48	24	8	4	4	---	---	---	---	---	---	---	---	---	---
	Abies procera	---	---	---	---	---	---	---	---	---	4	---	---	4	---	---	---	---	---
	Tsuga mertensiana	---	---	---	---	---	4	---	---	---	---	---	---	---	---	---	---	---	---
14	*Abies amabilis*	9170	200	8	---	12	20	24	8	---	---	---	---	---	---	---	---	---	---
	Abies procera	---	---	---	---	---	---	4	44	4	12	---	---	---	---	---	---	---	---
	Tsuga mertensiana	590	---	---	32	76	108	44	4	---	---	---	---	---	---	---	---	---	---

[a]All *Tsuga heterophylla* found at original sampling were dead by 1976 summer season.

Soil Descriptions

Field work was conducted from June through September, 1972. The reference stands were part of a larger study to describe and interpret soil-landscape patterns on the Andrews Forest. The soil survey techniques included air photo-interpretation and description of preliminary shallow pits. No walking or digging was done in the reference stands, but from preliminary reconnaissance, pedons were selected at or near the periphery of the stands in positions thought best to characterize the soils underlying them. At least one pedon was selected for morphologic study and sampling at each reference stand. Sometimes, in order to characterize the range of soil variability, two to four pedons were selected. A total of 32 pedons were chosen to characterize the soils of 19 reference stands. Field methods, laboratory chemical and physical methods, classification scheme, and profile descriptions are further described in Brown and Parsons (1973).

REFERENCE STANDS

The soils and vegetation of each of the 19 reference stands are described in this section in the order of their position along environmental gradients of dry to moist and warm to cool. The low-elevation xeric stands are described first, the cool high-elevation stands last.

Reference Stand 1: Pseudotsuga menziesii/Holodiscus discolor (Psme/Hodi)

RS 1 occupies a portion of the interfluve on the northwest boundary of Watershed 9 (Figure 1). Pediment backslope grades upward to the double-convex shoulder of a ridge spur. Slope aspect is generally southwest, and slope gradients vary from 30% to more than 65%. Soils on the pediment backslopes are deep, well drained, very gravelly loams and sandy loams developed in colluvium from breccia and basalt. A dark brown to dark reddish-brown A horizon overlies a brown to reddish-brown B horizon. Highly fractured bedrock underlies these Dystrochrepts at depths of 1.5 to 2.5 m. Soil on the interfluve is a shallow, somewhat excessively drained Xerochrept. Depth to bedrock on the interfluve is 50 cm or less, and rock outcrops are common.

The tree canopy of this reference stand is typically open. The stand is dominated by *Pseudotsuga menziesii* in both mature and immature size classes (Table 5). Size-class distribution data taken in 1972 show *Tsuga heterophylla* saplings, all of which had died by the 1976 summer season. *Taxus brevifolia* is an abundant understory tree species which maintains a shrubby growth habit in this and most other Andrews Forest plant communities throughout their succession.

The shrub layer is dominated by *Acer circinatum* and *Pseudotsuga menziesii*. *Corylus cornuta* is secondary in the tall shrub layer. *Symphoricarpos mollis* and *Berberis nervosa* are the most abundant low shrubs. A diagnostic shrub species of the community, *Holodiscus discolor*, occurs with >2% cover (Table 3).

The herb layer, with high species diversity, is dominated by *Whipplea modesta* and *Polystichum munitum*. *Synthyris reniformis* and *Linnaea borealis* are common to abundant in patches.

This stand contains 4 tree, 15 shrub, 30 herb, and 8 moss species. The bryophytes are good indicators of site character. *Eurhynchium oreganum* is the dominant moss in most other communities but is greatly reduced here and of about the same cover as typical dry-site *Dicranum* spp. Other dry-site moss indicators are *Polytrichum juniperinum* and *Homalothecium megaptilum*. This reference stand conforms to most of the parameters of Dyrness et al. (1974) in site characteristics, vegetation species, cover, and dominance.

Reference Stand 8: Pseudotsuga menziesii-Tsuga heterophylla/Corylus cornuta *var.* californica (Psme/Tshe/Cococa)

RS 8 is on a pediment backslope and ridge shoulder near the headwall of Watershed 9 (Figure 1). The slope is generally convex, with a westerly aspect and gradients ranging from 60% to 75%. Soils are shallow, well-drained, dark brown and dark reddish-brown very gravelly loams and very gravelly sandy loams developed in colluvium from breccia and basalt. Depths to bedrock vary from 15 to 50 cm, and the soils are classified in Lithic subgroups of Dystrochrepts and Haplumbrepts.

RS 8 has a partially open canopy which varies markedly in height and depth due to the dominance of old-growth *Pseudotsuga menziesii* over emergent *Pseudotsuga menziesii, Tsuga heterophylla, Taxus brevifolia, Calocedrus decurrens*, and *Acer macrophyllum* in large openings. Immature trees are dominated by *Pseudotsuga menziesii*. *Tsuga heterophylla* is second in importance.

In addition to the immature conifers, the shrub layer contains an abundance of the dominant shrub, *Acer circinatum* and *Corylus cornuta* var. *californica* and moderate amounts of *Rhododendron macrophyllum, Cornus nuttallii*, and *Taxus brevifolia*. Low shrubs are also well represented. *Berberis nervosa* is the most abundant species.

The richness of the herb layer, with 30 species, is second only to that of RS 4. *Polystichum munitum, Whipplea modesta, Linnaea borealis, Synthyris reniformis, Achlys triphylla*, and *Vancouveria hexandra* make up most of the cover. The other 24 species are far less abundant.

This reference stand, like RS 1, is a good representative of the habitat type described by Dyrness et al. (1974). Both RS 8 and RS 1 differ from an "average" habitat type in development of the low shrub species. *Gaultheria shallon* has less cover in both the reference stands than in descriptions of the habitat type based on the reconnaissance plots. *Berberis nervosa* is also less developed here than usual for the community from previous descriptions. In both instances, however, these stands fit within the range of variation given by Dyrness et al. (1974).

Reference Stand 6: Tsuga heterophylla/Castanopsis chrysophylla (Tshe/Cach)

RS 6 is on a shoulder and pediment backslope below the ridge spur forming the northern boundary of Watershed 10 (Figure 1) which was clearcut in 1975 as part of the IBP/Coniferous Forest Biome research. Slope gradients on this generally convex landform vary from 55% to 80%. Slope aspect is south. Soils are predominantly deep, well-drained, dark yellowish-brown to dark brown gravelly loams developed in alluvium-colluvium from breccia, tuff, and andesite. The A horizon has numerous small rounded pebbles, and depth to saprolite is generally about 90 cm. Most of the stand is underlain by this Dystrochrept, but a localized pocket of a deeper, redder Paleudalf underlies the extreme southwest corner.

The tree layer of this stand was diverse but relatively open. Old-growth *Pseudotsuga menziesii, Pinus lambertiana*, and occasional *Castanopsis chrysophylla* dominated the overstory of more open areas. Understory tree species indicative of the climax included not only *Tsuga heterophylla* and *Castanopsis*, but also *Pseudotsuga menziesii* and *Pinus lambertiana*.

The shrub layer was dominated by the tall shrubs *Rhododendron macrophyllum, Castanopsis chrysophylla*, and *Acer circinatum*, which formed often impassable shrub thickets. The dense low shrubs were dominated by *Gaultheria shallon*. *Berberis nervosa* was present in minor amounts.

The herb stratum was moderately developed for a submesic site and was dominated by *Xerophyllum tenax* which is characteristic of low-elevation xeric to submesic forests in the Andrews Forest region. Mosses were common but not abundant in the stand. *Eurhynchium oreganum* was the most abundant representative species of this layer with 3.2% cover (Table 3).

RS 6 conforms closely in landform and vegetation to the *Tshe/Cach* habitat type described by Dyrness et al. (1974). The stand was more representative of this habitat type than is RS 16.

Reference Stand 16: Tsuga heterophylla/Castanopsis chrysophylla (Tshe/Cach)

RS 16 is on a slightly convex shoulder/backslope below the ridge crest on the northeast side of Watershed 2 (Figure 1). Slopes vary from 60% to 70% and aspects from south to southwest. This Hapludalf has a surface horizon of brown to dark brown gravelly silt loam over an argillic horizon of dark yellowish-brown silty clay loam. The depth to saprolite is 120 cm. Parent materials are mostly colluvium derived from breccia and andesite.

This stand replicates the RS 6 community (*Tshe/Cach*). It is dominated by old-growth *Pseudotusga menziesii*, with occasional *Pinus lambertiana*. *Tsuga heterophylla* makes up part of the tree canopy and most of the immature tree layer. *Pseudotsuga menziesii* also occurs in the smaller size classes in the more open portions of the stand.

The shrub layer, dense and often impassable, is dominated by *Castanopsis chrysophylla, Rhododendron macrophyllum, Acer circinatum, Taxus brevifolia*, and *Pseudotsuga menziesii* in the tall shrub layer. The low shrub layer, also dense, is dominated by *Gaultheria shallon. Berberis nervosa* is quite common.

The herb layer is sparse. *Linnaea borealis* cover is 3.3% and *Xerophyllum tenax* cover is much less than on RS 6. Moss cover is lower than on other reference stands but is higher than that on RS 6.

Several attributes indicate that RS 16 is not a good representative of the *Tshe/Cach* habitat type. Tree cover is denser than usual, shrub cover is lighter than usual, *Xerophyllum tenax* is greatly reduced in the herb cover, and moss cover is three times greater than in the more modal RS 6. Fungi collections indicate a more mesic site (R. Fogel, personal communication), old-growth *Pseudotsuga menziesii* are unusually tall (W. Emmingham, personal communication), and soil development is more advanced than in a typical *Tshe/Cach* community such as RS 6. Almost all species characteristically dominant in the *Tshe/Cach* habitat type are abundant in RS 16 except for *Xerophyllum tenax*. The stand appears to be a mesic variety of the *Tshe/Cach* type.

Reference Stand 10: Tsuga heterophylla/Rhododendron macrophyllum-Gaultheria shallon (Tshe/Rhma-Gash)

RS 10 is located on a pediment surface associated with a gently to moderately sloping ridge spur (Figure 1). The contour is convex on the upper portion and concave on the lower portion; slope gradients range from 10% to 25%. The surface is radially convex, with an aspect generally south-southeast. The soil is well drained and deep. A surface horizon of dark brown gravelly silt loam with numerous rounded pebbles overlies an argillic horizon of brown to dark brown and dark reddish-brown clay loam. The parent material of this Glossoboralf was alluvium-colluvium from breccia and basalt. Depth to the saprolitic substratum is 1.5 m.

The canopy of RS 10 is dominated by old-growth *Pseudotsuga menziesii*. Emergent *Pseudotsuga, Tsuga heterophylla*, and *Thuja plicata* are secondary. The only conifer species abundant in the understory, however, is *Tsuga heterophylla*. The contribution of *Tsuga heterophylla, Taxus brevifolia*, and *Castanopsis* to the tall shrub layer is large.

The shrub stratum is exceptionally well developed. A tall shrub layer is dominated by *Rhododendron macrophyllum* and *Acer circinatum*. Cover of *Cornus nuttallii* is relatively high for this habitat type. The low shrub layer is also well developed and is dominated by *Gaultheria shallon* with smaller amounts of *Berberis nervosa*.

The number of species and cover of the herb layer is greatly reduced as a result of the dense shrub cover. *Xerophyllum tenax, Chimaphila umbellata, Linnaea borealis*, and *Polystichum munitum* are the most common herb species. The moss layer, moderately well developed but patchy in distribution, is dominated by *Eurhynchium oreganum* (Table 3).

This reference stand is an example of a young stand in the *Tshe/Rhma-Gash* habitat type described by Dyrness et al. (1974), but it differs slightly in having unusually high tree cover by immature *Pseudotsuga menziesii*. RS 10 could thus be interpreted as marginal *Tshe/Rhma-Gash* tending toward the *Tshe/Cach* habitat type described by Dyrness et al. (1974).

Reference Stand 2: Tsuga heterophylla/Rhododendron macrophyllum-Berberis nervosa (Tshe/Rhma-Bene)

RS 2 is on a pediment surface between backslope and footslope (Figure 1). The north side of the stand occupies part of a fan terrace emanating from a draw on the hillslope. Slope gradient is about 35%. Slope aspect is west-northwest. The soil is a deep, well-drained, brown to dark brown loam over silt loam developed in colluvium and alluvium from tuffs and breccias. Pebbles in the A horizon are rounded, and the pumice content of the soil matrix increases strikingly with depth. Depth to the saprolitic C horizon ranges from 90 to 100 cm. The soil is classified as a Dystrochrept.

The tree stratum is dominated by a mixture of old-growth *Pseudotsuga menziesii* and emergent *Tsuga heterophylla*, a late seral species. Climax is evident in the density and the cover of understory conifers, both dominated by *Tsuga heterophylla*. The site is mesic, and *Thuja plicata* will undoubtedly be codominant in the mature forest.

The tall shrub layer is dominated by *Taxus brevifolia, Acer circinatum*, and *Rhododendron macrophyllum*. *Berberis nervosa* dominates the low shrub layer. *Vaccinium parvifolium* is also common.

The herb stratum consists primarily of patches of large amounts of *Linnaea borealis, Coptis laciniata, Viola sempervirens, Polystichum munitum*, and *Chimaphila umbellata*, and a scattered variety of other herbs. The moss layer is extremely well developed. More than 50% of the cover is *Eurhynchium oreganum*.

RS 2 appears representative of the *Tshe/Rhma-Bene* habitat type of Dyrness et al. (1974) with a well-developed canopy, little shrub layer development, and moderate herb cover. Characterisitic species of each stratum comply with the descriptions of Dyrness et al. (1974). This reference stand replicates the *Tshe/Rhma-Bene* habitat type. RS 17, the other stand of this type, is more moist and much less modal than RS 2.

Reference Stand 17: Tsuga heterophylla/Rhododendron macrophyllum-Berberis nervosa (Tshe/Rhma-Bene)

RS 17 is located on a concave pediment footslope (Figure 1). Slope gradients vary from 20% to 40% and slope aspects from northwest to north. The soil is a deep, well-drained, dark brown loam, with many small rounded pebbles over brown to dark brown gravelly silty clay loam. Depth to the saprolitic C horizon is approximately 100 cm. This Dystrochrept has developed in alluvium-colluvium from breccia, tuff, and andesite.

RS 17 is the same habitat type represented by RS 2. The tree canopy is mature and dominated by several old-growth *Pseudotsuga menziesii* and abundant large *Tsuga heterophylla* and *Thuja plicata*. *Tsuga heterophylla* is the only abundant immature conifer in the understory of this mesic habitat type.

Tsuga heterophylla, Taxus brevifolia, and *Acer circinatum* dominate the well-developed tall shrub layer. *Rhododendron macrophyllum* and *Cornus nuttallii* are also important. The low shrub layer is sparse.

The herb layer, dominated by *Linnaea borealis*, is unusually well developed for this habitat type. *Coptis lacinitata* and *Oxalis oregana* are common. Mosses are abundant in RS 17 and are dominated by *Eurhynchium oreganum*. *Hylocomium splendens* is also common.

RS 17 appears to be a more mesic site than RS 2. Both represent the *Tshe/Rhma-Bene* habitat type, but the size-class distribution in RS 17 indicates a more youthful community than RS 2, and typically seral species such as *Acer circinatum, Cornus nuttallii*, and *Rhododendron macrophyllum* cover more of RS 17. The diversity and abundance of herb species also indicate a more mesic site (*Linnaea borealis* cover is 26% and *Oxalis oregana* cover is >3%).

RS 17 may thus differ from RS 2 merely in seral stage. RS 17, a younger stand, has a more developed shrub layer. This same relation is seen between subclimax and climax stands of the northwestern Siskiyou Mountains of southwestern Oregon (Franklin et al. 1972, Hawk 1977) and between the two reference stands which represent the *Tshe/Pomu-Oxor* habitat type in this study.

Reference Stand 9: Tsuga heterophylla/Acer circinatum/Polystichum munitum (Tshe/Acci/Pomu)

RS 9 is on a slightly convex pediment surface on the northwest-facing slope near the mouth of Watershed 10 (Figure 1). Slope gradients vary from 70% to 80%. Soil is well-drained, dark brown, very gravelly loam. Upslope, the soil is underlain by gravelly clay loam saprolite at a depth of 1 m, but rock outcrops occur, and the soil becomes shallower on the lower portions of the stand near the creek. Small rounded pebbles are numerous in the A horizon and occur in moderate amounts down through the solum and into the underlying saprolite.

This reference stand was completely logged in 1975 with the rest of Watershed 10.

The tree stratum of RS 9 was well developed. *Tsuga heterophylla* and a few old-growth *Pseudotsuga menziesii* were dominant. Immature trees were dominated by *Tsuga heterophylla*, and occasional *Pseudotsuga* occurred in openings left by larger trees falling out of the canopy.

The shrub stratum was also well developed. *Acer circinatum* and *Cornus nuttallii* were dominant in the tall shrubs and *Berberis* *nervosa* and *Gaultheria shallon* were common and abundant in the low shrubs. *Taxus brevifolia* and *Rhododendron macrophyllum* were important within portions of the stand.

The herb layer, clearly dominated by *Polystichum munitum*, also had large patches and high cover of *Coptis laciniata*. Many other herb species typically associated with moist Pacific Northwest forests were common: *Blechnum spicant, Oxalis oregana, Aralia californica, Vancouveria hexandra*, and *Smilacina racemosa*. The moss layer was well developed and was dominated again by *Eurhynchium oreganum*.

RS 9 occupied typical landform and aspects for this habitat type but was an example of a variant after disturbance. As the stem map shows, the stand was smaller than others (only 20 x 40 m). It was disturbed by existing trail systems, investigator perturbations, and instability of the streamside location which caused massive trees to fall into and out of the stand. Vegetation conformed to descriptions of the habitat type by Dyrness et al. (1974).

Reference Stand 15: Tsuga heterophylla/Polystichum munitum (Tshe/Pomu)

RS 15 is on a slightly concave pediment backslope on the northwest side of Watershed 2 (Figure 1). Slope gradients are 60% to 80% and slope aspect is north. The soil is deep, well-drained, dark brown to black gravelly loam over dark brown gravelly silt loam, which developed on alluvium-colluvium from andesite. Depths to the very gravelly silt loam C horizon range from 70 to 80 cm, and pumice is very evident throughout the profile. The A horizon contains many small rounded pebbles, but larger angular pebbles, stones, and cobbles dominate the lower solum and substratum. Fine earth is insufficient to fill all interstices between coarse fragments, therefore, this Dystrochrept is placed in a fragmental family.

RS 15 is an old-growth community dominated by *Pseudotsuga menziesii*, with *Tsuga heterophylla* and *Thuja plicata* emergent or codominant in the canopy. *Tsuga heterophylla* and *Thuja plicata*, abundant in immature size classes, indicate that the habitat type is mesic.

The shrub layer is dominated by immature trees. Moderate amounts of *Taxus brevifolia, Acer circinatum*, and *Cornus nuttallii* are in the tall shrub layer. The low shrub layer is dominated by *Gaultheria shallon* and *Berberis nervosa*.

The herb stratum is dominated by 16.5% cover of *Polystichum munitum*. Other species have low frequency. *Eurhynchium oreganum* is dominant among the relatively common mosses.

This reference stand is similar to the *Tshe/Pomu* habitat type, described by Dyrness et al (1974), in having a less prominent shrub layer and a greater *Polystichum munitum* cover than the less moist *Tshe/Acci/Pomu* habitat type. The tree canopy also contains considerable cover of *Thuja plicata*, which is characteristic of moist stands at low to middle elevations in the Cascade Mountains (Franklin and Dyrness 1973).

Reference Stand 7: Tsuga heterophylla/Polystichum munitum-Oxalis oregana (Tshe/Pomu-Oxor)

RS 7 is on a generally concave pediment backslope having a complex pattern of local relief (Figure 1). Slope aspect is north. Gradients vary from 50% to 60%. The soil is deep, well-drained, dark brown gravelly loam overlying brown to dark brown clay loam. The A horizon, with numerous small rounded pebbles, thickens toward locally concave areas. Parent material was alluvium-colluvium derived from breccia, tuff, and andesite. Depth to saprolite varies from 80 to 130 cm. The high base status of the lower B horizon causes this soil to be classified as a Eutrochrept rather than Dystrochrept.

This is one of the two most moist reference stands among low-elevation communities of the Andrews region. The tree canopy is dominated by old-growth *Pseudotsuga menziesii*. *Tsuga heterophylla* is emergent and *Thuja plicata* is common throughout. *Tsuga heterophylla* and *Thuja plicata* comprise the great majority of immature trees and most of the tall shrub stratum in this reference stand.

The tall shrub stratum contains 8.3% *Acer circinatum* as well as abundant *Taxus brevifolia* and *Cornus nuttallii*. The low shrubs are poorly developed and scattered.

The herb layer is dominated by wide patches of *Oxalis oregana* and scattered clumps of *Polystichum munitum*. *Linnaea borealis, Coptis laciniata*, and *Tiarella unifoliata* are also common. The moss layer, extremely well developed, has seven species and more than 50% cover dominated by *Eurhynchium oreganum*.

This community is also represented in a seral stage by RS 19, located west of the town of Blue River, Oregon. RS 7 is well representative of the *Tshe/Pomu-Oxor* habitat type of Dyrness et al. (1974). Reduction in the shrub layer is characteristic of low-elevation communities with abundant moisture in this area. High cover by the two herbs, *Polystichum munitum* and *Oxalis oregana*, conclude the classification of this reference stand. The *Tshe/Pomu-Oxor* community at the warm-moist end of the existing gradients remains fairly constant throughout the Pacific Northwest, though the overstory vegetation may change (Franklin and Dyrness 1973, Bailey 1966, Bailey and Poulton 1968, Hawk and Zobel 1974, Hawk 1977).

Reference Stand 19: Tsuga heterophylla/Polystichum munitum-Oxalis oregana (Tshe/Pomu-Oxor)

RS 19 is on a convex/concave pediment backslope/footslope bisected by an east-flowing stream. Slope gradients vary from 45% to 60% and aspects from east to east-southeast. The deep, well-drained soil is classified as a Hapludalf. Dark brown gravelly loam with rounded pebbles overlies an argillic horizon of dark reddish-brown and reddish-brown clay loam. Depths to the saprolitic C horizon vary from 120 to 130 cm. Parent material is alluvium-colluvium from breccia and andesite.

Size-class distribution of trees on RS 19 indicates that the stand is much younger than RS 7 in the same habitat type. More heterogeneity of landform, aspect, and age classes of trees yields a less dense tree canopy dominated by middle-sized *Pseudotsuga menziesii*. Small amounts of *Tsuga heterophylla* are emergent. *Acer macrophyllum* is also common in the tree layer. *Tsuga heterophylla* dominates reproducing conifers of the understory.

The shrub layer, denser than that in RS 7, is dominated by tall *Acer circinatum*, low *Gaultheria shallon*, and *Berberis nervosa*. These species have greater cover on RS 19 than on RS 7.

The herb layer is basically the same as on RS 7, but most species are more abundant. Mosses are well developed. *Eurhynchium oreganum* dominates the more than 40% cover.

This stand has greater species diversity than the more mature RS 7 in all but the tree stratum. Whether this is the product of successional or site differences is difficult to tell. However, other northwest climax communities have been preceeded by much shrubbier associates in their seral development. Though RS 19 is shrubby and may not be representative as a mature forest, it meets the criteria for classification as a *Tshe/Pomu-Oxor* community. As on RS 7, the dominance of the herb layer by *Polystichum munitum* and *Oxalis oregana* precludes other classification of the stand.

Reference Stand 11: Pseudotsuga menziesii/Acer circinatum-Berberis nervosa (Psme/Acci-Bene)

RS 11 is on a complex pediment backslope in Watershed 7 (Figure 1). Slope gradients on the upper, concave area of the stand and on the lower shoulders are 40% to 50% but diminish to 20% to 30% on convex portions in the southeast corner. Slope aspects vary from south-southeast to south. Soils are deep and well drained. A very dark brown gravelly sandy loam A horizon with rounded pebbles overlies a dark brown gravelly sandy loam B horizon. Depths of solum range from 90 to 110 cm. The soils have developed in alluvium-colluvium from andesite, flow breccia, and a significant component of volcanic ash. Soils on the steeper portions appear to be more strongly influenced by coarse fragments than by ash, and they are classified as Dystrochrepts. The reverse is true of the soils on the gentler, more stable portions, which are classified as Dystrandepts.

This reference stand represents a high-elevation (transitional) example of the second-growth community *Psme/Acci-Bene*. The overstory is dominated by middle-size classes of *Pseudotsuga menziesii* (with occasional remnant old-growth). *Tsuga heterophylla* is subemergent.

Immature conifers are dominated by *Tsuga heterophylla* but include *Abies amabilis* and *Abies concolor (Abies grandis* or *A. concolor*, Zobel 1973, 1974, 1975).

The tall shrub layer is dominated by scattered patches of *Acer circinatum* and occasional *Vaccinium parvifolium* and *V. membranaeceum*. The low shrubs are well developed and are dominated by *Berberis nervosa*. *Gaultheria shallon* and *Rubus ursinus* are also common.

The herb stratum is diverse but sparse. The most abundant herb (4.5% cover) is *Viola sempervirens*. The other species cover 1% or less and are found in most other reference stands as well, such that this habitat type has no diagnostic herb (Table 3). The moss layer is poorly represented, which is typical of upper elevation stands.

RS 11 represents an upper elevation example of the *Psme Acci-Bene* community of Dyrness et al. (1974), but contains abundant cover of *Abies amabilis* in both mature and immature tree strata. The shrub layer has more than the usual cover of *Gaultheria shallon* for the habitat type, but *Acer circinatum* and *Berberis nervosa* are dominant. *Rhododendron macrophllym* is lacking (Dyrness et al. 1974). Though RS 11 is probably near modal for high elevations, it is not representative of the *Psme/Acci-Bene* community in general because elevation influences the vegetation composition. The wide elevational range of this community makes location of a modal site difficult.

Reference Stand 5: Tsuga heterophylla-Abies amabilis/Rhododendron macrophyllum-Berberis nervosa (Tshe-Abam/Rhma-Bene)

RS 5 is on a broad, undulating bench with a complex pattern of gently to moderately sloping ridge spurs, saddles, and pediment surfaces (Figure 1). Slope gradients vary from 0% to 30%, and slope aspect is generally northwest. The soil pattern is complex, with both Dystrochrepts and Haplumbrepts in proximity to the reference stand. Depth variations of coarse-fragment content, and the absence of coarse fragments below 1 m on the east side of the stand, show the complex geomorphic history of this bench area. Parent material appears to have been andesitic alluvium-colluvium overlying a layer of silty material. Soils are deep, well-drained, dark brown gravelly loams over silt loams and gravelly silt loams, except on the high southern portion of the stand where the texture is loam throughout. The A horizon, except in the high area, contains numerous rounded pebbles. Pumice and charcoal fragments vary unpredictably with depth.

The tree canopy of this stand is composed of old-growth *Pseudotsuga menziesii* and emergent *Tsuga heterophylla*. Immature trees are dominated by *Tsuga heterophylla* and the ever-present *Taxus brevifolia*. Both species contribute greatly to the cover of the tall shrub layer.

The tall shrub layer is dominated by *Rhododendron macrophyllum* and *Acer circinatum*, which combine to create a nearly impassable shrub layer. Beneath the tall shrubs is a well developed low shrub layer dominated by *Berberis nervosa*.

The herb stratum is poorly developed. Cover is only about 4%, and no species is dominant. *Chimaphila umbellata* is the most abundant herb species. The moss layer is nearly nonexistent.

This reference stand has fewer species than all other stands except for the *Abam-Tsme/Xete* community (RS 14) with which it is tied. Each has only 23 plant species in all layers combined. The stand is a fair representative of the *Tshe-Abam/Rhma-Bene* habitat type of Dyrness et al. (1974). It is shrubbier than indicated by the vegetation tables, but overlap of species yields a less dense shrub layer in the field. Most of the characteristic species of the habitat type are within the limits discussed by Dyrness et al. (1974). However, *Acer circinatum* is more abundant than in the descriptions. The tree layer in RS 5 lacks *Abies amabilis*, but the species has been recorded in plots adjacent to the stand within the same habitat type.

Reference Stand 3: Tsuga heterophylla-Abies amabilis/Linnaea borealis-Tsuga heterophylla-Abies amabilis/Rhododendron macrophyllum/ Linnaea borealis (Tshe-Abam/Libo-Tshe-Abam/Rhma/Libo)

RS 3 is on an extensive, slightly concave pediment footslope (Figure 1). Slope gradients vary from 15% to 25%, and slope aspect is west-northwest. The solum is a deep, well-drained, dark brown gravelly loam over a C horizon of cobbly silt loam. Parent material was alluvium-colluvium or glacial till, derived from andesite. Depth of the solum is about 1 m. Pumice is abundant throughout the A_3, B, and C horizons of this Dystrochrept.

The overstory canopy of this community is nearly closed and is dominated by mixed old-growth *Pseudotsuga menziesii* and emergent *Tsuga heterophylla* and *Thuja plicata*. These overlie a layer containing the smaller *Abies amabilis*. Reproductive trees of all three emergent species are abundant, which shows that this community is transitional in the vegetation gradient.

The shrub stratum is dominated by immature individuals of *Tsuga, Abies*, and *Thuja* but includes large amounts of *Taxus brevifolia* and *Rhododendron macrophyllum* in the tall shrub layer. The low shrubs are dominated by *Berberis nervosa*.

The herb layer consists of patches dominated by *Coptis laciniata, Linnaea borealis, Chimaphila umbellata, Cornus canadensis*, and *Viola sempervirens*. The moss layer is poorly developed, as it is in most other high-elevation stands.

RS 3 is representative of the *Tshe-Abam/Libo* and the *Tshe-Abam/Rhma/Libo* communities. Different workers have used both designations as a result of confusion over the degree of difference between the two communities. The two typically occur in a mosaic of shrubby and nonshrubby phases (the major shrub determinant is *Rhododendron macrophyllum*). This reference stand is classified by the dichotomous key of Dyrness et al. (1974) as *Tshe-Abam/Rhma/Libo* because of the high *Rhododendron* cover (21.5%). The herb layer is less dense than that common for the *Libo* or the *Rhma/Libo* communities. However, most of the characteristic species of the *Libo* and the *Rhma/Libo* communities are abundant in this stand. Dyrness et al. (1974) state that further climatic measurements may reveal clearer differences between the two communities. At present, RS 3 is thought to be near modal for the two community types.

Reference Stand 18: Pseudotsuga menziesii/Acer circinatum/Whipplea modesta (Psme/Acci/Whmo)

RS 18 is on a concave pediment backslope/footslope (Figure 1). Slope gradients vary from 20% to 50%, and aspect is generally south. The soil is moderately deep, well-drained, very dark brown gravelly silt loam over very dark brown and dark brown gravelly silt loam. The A, B, and C horizons contain rounded pebbles. This Dystrochrept has developed in alluvium-colluvium derived from andesite with a significant component of volcanic ash. Depth to a saprolitic bedrock is approximately 70 cm.

This stand represents a transition-zone seral community. Its canopy is dominated by a dense stand of *Pseudotsuga menziesii* over immature size classes of dense *Tsuga heterophylla*.

The tall shrub layer is dominated by *Acer circinatum* which covers over half of the reference stand. *Tsuga heterophylla* follows in importance in the tall shrub layer. Low shrubs are dominated by *Berberis nervosa*. Other shrub species have low cover and low frequency.

The herb layer is well developed. Patches of *Linnaea borealis*, clumps of *Polystichum munitum*, and several other species are frequent. Mosses are generally lacking.

The youth of this community, which is seral in most instances to the *Tshe-Abam/Libo* or *Rhma/Libo* communities, is shown by the dense *Pseudotsuga menziesii* overstory and the size-class distribution of all trees. This stand is exemplary of the *Psme/Acci/Whmo* community because of the high cover of *Acer circinatum* and *Berberis nervosa* and the exclusion of *Rhododendron macrophyllum*. Most characteristic species of all strata are present and abundant, with the exception of *Whipplea modesta*.

This stand appears seral to the typical *Tshe-Abam/Libo* community as described by Dyrness et al. (1974). The *Psme/Acci/Whmo* community is regarded as seral to different transition-zone communities, depending on site characteristics. Southerly aspects will probably develop a *Tshe-Abam/Acci Bene* habitat type (previously represented by older reconnaissance stands of the *Psme/Acci/Bene* community of Dyrness et al. (1974). Westerly slopes and protected south slopes appear to develop the *Tshe-Abam-Rhma Libo* or *Tshe-Abam Libo* habitat type, and more northerly slopes develop the *Tshe-Abam/Rhma/Bene* habitat type of Dyrness et al. (1974).

Reference Stand 12: Abies amabilis/Vaccinium alaskaense/Cornus canadensis (Abam/Vaal/Coca)

RS 12 is on an undulating, slightly concave pediment footslope varying from 15% to 30%, with an aspect generally west (Figure 1). The surface is somewhat dissected by draws trending west or northwest. The soil has developed in deep alluvium-colluvium, and possible glacial till, derived from andesite. A dark reddish-brown, sandy loam A horizon with varying amounts of coarse fragments is underlain to a depth of 80 cm by dark brown to darker reddish-brown loam and sandy loam with a mixture of stones, cobbles, pebbles, and boulders. The C horizon is a very stony silt loam with a similar mixture of coarse fragments. This soil is well drained and contains varying amounts of pumice. It is classified as a Dystrochrept.

The tree layer of this dense stand is composed of mature, old-growth *Pseudotsuga* and *Tsuga heterophylla*. The understory trees are dominated by a mixture of *Tsuga*. *Abies amabilis* is next in importance and some *Thuja plicata* is also present.

The tall shrubs are dominated by *Acer circinatum*, medium shrubs by *Vaccinium alaskaense*, and low shrubs by *Berberis nervosa*. Diversity is relatively high with 18 shrub species, but the cover of the layer is low for species other than those mentioned.

The herb stratum is dominated by *Cornus canadensis* and *Clintonia uniflora*. *Linnaea borealis, Chimaphila umbellata, Smilacina stellata, Tiarella unifoliata, Viola sempervirens, Achlys triphylla*, and *Xerophyllum tenax* are also common. *Rhytidiopsis robusta* is the dominant moss with a frequency of 56%. It covers an average of 12.7% in microplots.

RS 12 is near modal for the *Abam/Vaal/Coca* habitat type. A roadside location has led to some disturbance, but most of the strata agree with those discussed by Dyrness et al. (1974) for the *Abam/Vaal/Coca* habitat type.

Reference Stand 13: Abies procera/Clintonia uniflora (Abpr/Clun)

RS 13 is on a concave pediment backslope with gradients between 30% and 45% and a southwest aspect (Figure 1). The soil is deep, well-drained, very dark brown silt loam over dark brown silt loam and gravelly silt loam. Depth to the very gravelly silt loam C horizon is 120 cm. Parent material was colluvium derived from pink and gray porphyritic flow rocks and a significant mixture of volcanic ash and pumice. The soil is a Dystrandept.

The tree canopy is dominated by almost equal numbers of 135-year-old *Pseudotsuga* and *Abies procera*. The only common understory tree species is *Abies amabilis*, which has not yet attained diameters greater than 25 cm.

The shrub layer is poorly developed. Major species are *Acer circinatum*, *Vaccinium membranaceum*, and *Rubus lasiococcus*. The herb layer is patchy but well developed. It is dominated by *Smilacina stellata* and contains high cover of *Achlys triphylla* and *Clintonia uniflora*. The moss layer is virtually absent.

This reference stand is a good fit with the *Abpr/Clun* community discussed by Dyrness et al. (1974). Seral relationships of overstory and understory trees evident in this stand are characteristic of the habitat type and indicate the probable direction of development towards the climax *Abam/Tiun* community. The dense tree canopy dominated by early seral species of medium-large diameter, the sparse shrub cover, the high herb cover and its frequency as well as richness are characteristic of the *Abpr/Clun* community. Density and size class of the *Abies amabilis* indicate a middle seral stage in which *Abies amabilis* has yet to penetrate the tall tree canopy.

Reference Stand 4: Abies amabilis/Tiarella unifoliata (Abam/Tiun)

RS 4 is on a smooth pediment backslope near the origin of McRae Creek (Figure 1). Slope gradient is 50% and aspect is west. The soil is deep, well-drained, dark brown to brown gravelly silt loam over cobbly silt loam. This Haplumbrept has developed in alluvium-colluvium or glacial till derived from andesite. Thickness of the solum is 110 to 120 cm. Pebbles in the A horizon are rounded, and the solum and substratum contain moderate amounts of pumice.

This stand has a moderately dense overstory canopy of old *Pseudotsuga* and *Abies procera*. *Abies amabilis* and *Tsuga heterophylla* are emergent. The stand also harbors an occasional understory *Tsuga mertensiana*. Immature trees are dominated by *Abies amabilis* and *Tsuga heterophylla* is secondary.

Most of the cover within the shrub layer is immature conifers. Tall shrubs are rare and unimportant. *Vaccinium membranaceum*, an abundant low shrub, dominates the shrub layer that exists.

The well-developed herb stratum is rich in species and cover. No single herb is dominant, but *Achlys triphylla, Cornus canadensis, Xerophyllum tenax, Tiarella unifoliata, Clintonia uniflora*, and *Valeriana sitchensis* make up most of the cover. The other 27 species in the layer are more scattered and less important. The moss layer is poorly developed.

RS 4 is representative of the *Abam/Tiun* habitat type and is an excellent site for comparison with its early seral associates in RS 13 (the *Abpr/Clun* community). The decreased cover by mature *Abies procera* and increased mature cover by *Abies amabilis* again show the succession of tree species of high-elevation forests in the Andrews region and in most of the western Cascade Mountains of Oregon and Washington. The shrub layer remains poorly developed, but in RS 4 *Pachistima myrsinites* is exceptionally well developed. However, the herb layer shows the characteristic decrease in *Rubus lasiococcus* and *Pteridium aquilinum* and increase in *Tiarella unifoliata* in transition from the *Abpr/Clun* to the *Abam/Tiun* communities described by Dyrness et al. (1974).

Reference Stand 14: Abies amabilis-Tsuga mertensiana/Xerophyllum tenax (Abam-Tsme/Xete)

RS 14 is a predominantly concave backslope beneath the crest of a ridge spur (Figure 1). Slumping appears to be an active factor on this surface, and most of the stand seems to constitute a slump headwall. The south corner of the plot is a convex shoulder from a minor ridge spur extension. Slope gradients range from 35% to 55% and slope aspects from northwest to north-northwest. Soils are shallow, well-drained, dark brown sandy loams developed in alluvium-colluvium from gray and pink porphyritic flow rocks, and a significant but varying mixture of volcanic ash and pumice. Depth to bedrock ranges from 50 to 70 cm. Size-range distributions and total-volume percentages of coarse fragments vary laterally and down through the solum. The soils are classified as Cryandepts and Cryochrepts.

The tree layer of this stand is closed. It is composed of old *Abies procera* and middle-aged to young *Tsuga mertensiana* and *Abies amabilis*. The understory tree layer is dominated by *Abies amabilis*, though *Tsuga mertensiana* seedlings are abundant.

The composition of the tall shrub layer is patchy, with the exception of *Abies amabilis* reproduction, and of low diversity. *Vaccinium membranaceum* is the only common species.

The most distinctive vegetation in this reference stand is the herb layer. It is dominated by a dense cover of *Xerophyllum tenax*. Other species are scattered, scarce, and unimportant. As is typical for high-elevation stands, the moss layer is nearly lacking. Total plant diversity in this stand is lower than in most other reference stands.

RS 14 is a good example of the *Abam-Tsme/Xete* habitat type. Species of all strata conform to the description of Dyrness et al. (1974). *Xerophyllum tenax* is the dominant plant of all understory species, though it is less abundant in RS 14 than in the stands described by Dyrness et al.

HISTORY OF USE

Environmental and vegetational data from the buffer strip around the reference stands of the H. J. Andrews Experimental Forest or in the adjacent stands of the same habitat type have been widely used. The reference stands have functioned as bench mark areas.

Abee and Lavender (1972) completed a comparative study of nutrient concentrations (nitrogen, phosphorus, potassium, calcium, and magnesium) found in canopy throughfall and litterfall in six oldgrowth *Pseudotsuga menziesii* stands. The stands were representative of common forest communities spanning much of the temperature-moisture gradient of Dyrness et al. (1974) in the central-western Oregon Cascade Mountains. The reference stands and communities sampled by Abee and Lavender are listed in Table 6. Their study yielded the following conclusions: (1) Nutrient concentrations of all elements in throughfall samples are essentially the same for low-elevation stands 1 through 4 (their numbering) for each season. (2) Water sample concentrations are highest in summer months when precipitation is highest. Throughfall nutrient concentration is high in the fall months at the beginning of the precipitation season. (3) No difference apprears in net kg ha^{-1} yr^{-1} among low-elevation stands 1 through 4 for each element, with the exception that stand 3 has more potassium and less calcium than stands 1, 2, and 4. (4) Total litter production, which averages 5.98 MT ha^{-1} yr^{-1} (1970-71 year), varies little among stands. Most litter falls in the winter months, but different components peak at different times. (5) Nutrient concentration of litterfall components varies greatly among plots and by seasons. (6) Nutrient return through litterfall is greatest in the needle component. (7) More nitrogen, phosphorus, and calcium are transferred to the soil from litterfall than from throughfall, though more potassium and magnesium are added from throughfall.

Table 6. Reference stands used by Abee and Lavender (1972) for nutrient cycling study.

Abee Lavender no.	Ref. stand no.	Community name[a]
1	1	*Pseudotsuga menziesii/Holodiscus discolor*
2	2	*Tsuga heterophylla/Rhododendron macrophyllum/Berberis nervosa*
3	7[b]	*Tsuga heterophylla/Polystichum munitum*
4	10	*Tsuga heterophylla/Rhododendron macrophyllum-Gaultheria shallon*
5	3	*Tsuga heterophylla-Abies amabilis/ Linnaea borealis*
6	4	*Abies amabilis/Tiarella unifoliata*

[a]Abbreviations in Table 1.
[b]1970, now void.

Fogel et al. (1974) studied terrestrial decomposition immediately east of RS 2. The objectives of their study were to estimate frequency and distribution of major fungal populations and to develop decomposition models for further research in decomposition.

The area studied was identical to and adjacent to RS 2 (*Tshe/Rhma-Bene*). The standing crop of the forest floor (excluding large woody litter) was estimated to be 55.65 MT ha^{-1}. This estimation ignores the heterogeneity of forest floor depth, which increases greatly at the base of larger *Pseudotsuga menziesii* boles (Figure 4, Table 7).

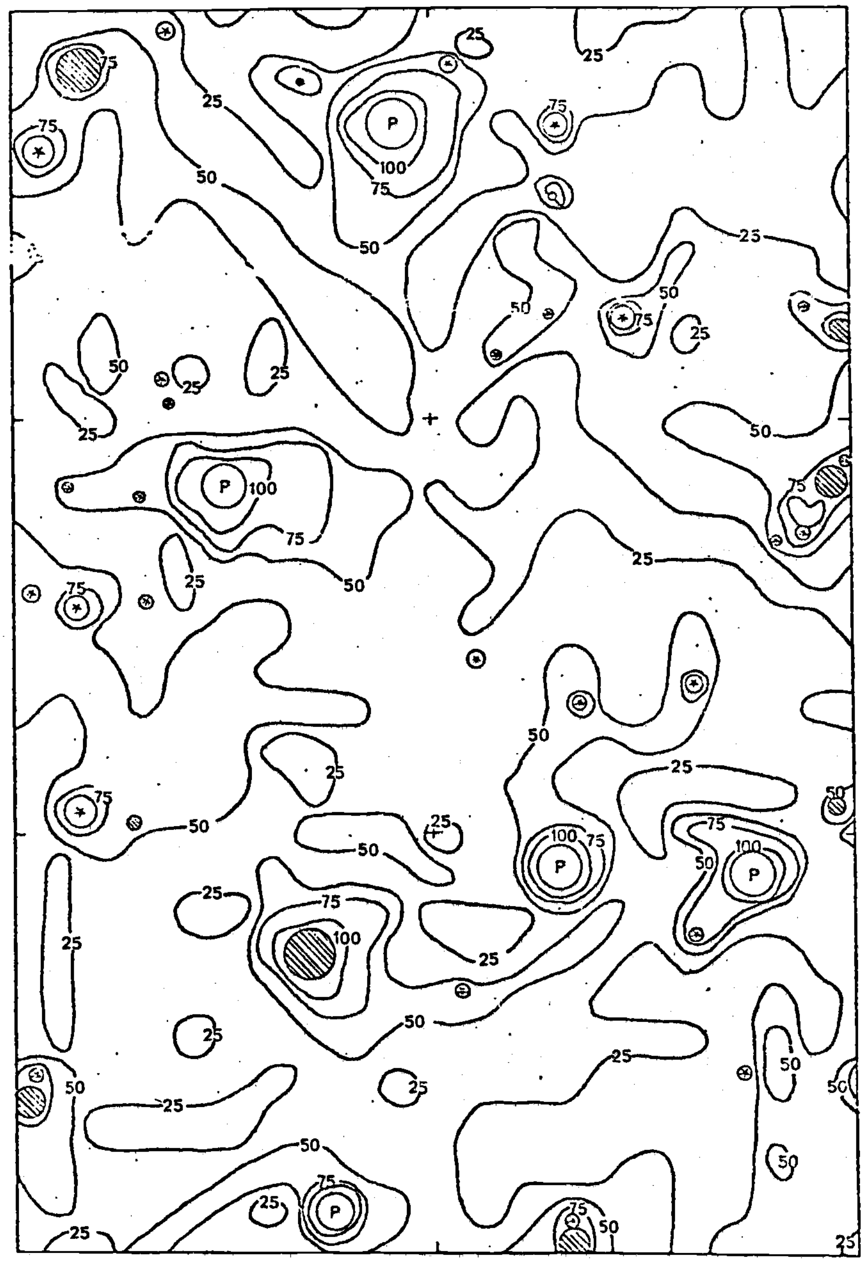


Figure 4. Classification of forest floor depth on a 20 m x 30 m area near Reference Stand 2 (*Tshe/Rhma/Bene* community): 0-25 mm, 25-50 mm, and 100+ mm. P = *Pseudotsuga menziesii*. * = *Tsuga heterophylla*. ◍ = standing dead tree (Fogel et al. 1974).

Table 7. Dry weight of forest floor on reference stand 2.

Depth class (mm)	% cover	$m^2\ ha^{-1}$	$kg\ m^{-2}$	$MT\ ha^{-1}$
0 to 25	21.3	2130	3.54	7.54
25 to 50	56.3	5620	5.60	31.47
50 to 75	18.0	1800	7.60	13.68
75 to 100	1.8	180	10.40	1.87
100 +	0.7	70	16.00	1.09

Fogel et al. (1974) found more than 3,321 epigeous fungal sporocarps in their established grid, 356 probably produced by mycorrhizal fungi (4.9 kg ha^{-1} yr^{-1}, including the 3.87 kg ha^{-1} yr^{-1} for fruiting bodies of probable mycorrhizal fungi). A preliminary estimate of the hyphal biomass of soil fungi was 4.04 MT ha^{-1} dry weight. Root biomass was 41.11 MT ha^{-1}, excluding roots less than 0.5 mm in diameter.

In a series of papers, Zobel (1972) and Zobel et al. (1973a, 1973b, 1974, 1976) discuss the relation to forest communities of variation in soil and air temperature, plant moisture stress, phenology, foliar nutrition, and snowpack. Climatic and physiological data were taken on reference stands beginning in 1970.

In their studies, plant moisture stress of coniferous saplings 1 to 2 m tall was measured. The measured value is the pressure potential of the xylem sap, which in most instances is close to the water potential of the xylem sap. Values of sap-pressure potential are negative, and as moisture stress of the plant increases, the values further decrease.

Throughout the growing season, stress determinations were made between midnight and dawn (when plant moisture stress most closely approaches the moisture condition of the soil) in order to estimate minimum stress for a given date. At some sites, daily stress patterns were obtained also. Early studies included reference stands 1 through 10, with the exception of 4. Later studies included all reference stands and two other sites in the Andrews Forest area. Three to seven saplings of the most important understory conifers were used at each site. Overstory species were preferred, but if they were sparse in the reproductive layer, *Taxus brevifolia* was sampled.

The locations of two reference stands were changed between the 1970 and 1971 sampling periods. Reference stands 6 (*Tshe/Cach*) and 7 (*Tshe/Pomu-Oxor*) were newly established in 1971; data for RS 6 and RS 7 were obtained at different locations in 1970. The first RS 7 (*Tshe/Pomu*) was located at the junction of the upper road to Watershed 3 with the Lookout Mountain road in the Andrews Forest. RS 7 corresponds to Abee's and Lavender's site 3 (1972).

The yearly maximum of predawn moisture stress for communities of the *Tsuga heterophylla* zone is highly correlated with their vegetational composition, especially in the drier years 1970 and 1972. In Figure 5, maximum yearly predawn stress is plotted against the median X-axis coordinate of each community from the Dyrness et al. (1974) ordination of the *Tsuga heterophylla* zone. The correlation is best in the two drier years. One transition-zone community (RS 3) fit the relationship only in 1972. The change of its position from 1970-71 is perhaps due to a spring 1972 salvage cutting within 70 m of the stand, which increased north-northwest exposure and, somewhat, the west exposure.

The only replicated community in measured stands, *Tshe/Rhma-Bene*, is represented by RS 2 and RS 17. In 1972, a dry year, maximum values of plant moisture stress in those stands were similar, 8.9 and 8.1 bars.

Except for RS 4, communities in the *Abies amabilis* zone (Figure 6: RS 4, 12, 13, and 14) were seldom sampled. At RS 4, greater stress developed than at some communities of the *Tsuga heterophylla* zone, specifically RS 3 and 7 in 1970 and 1971, and RS 7 in 1972. In two comparisons, RS 14 was drier by 1 and 3 bars than RS 4, which agrees with community ordination (Dyrness et al. 1974). These four stands were compared only in August 1971. All had stresses of 3.6 to 4.5 bars, which allows no useful comparison of moisture stress and vegetation type.

In the *Tsuga heterophylla* zone, the correlation of maximum plant moisture stress with the "moisture" axis of the vegetation ordination was excellent in the drier years 1970 and 1972, and fairly strong in 1971. There is little doubt that vegetation variation on the X axis of the ordination of Dyrness et al. (1974) is related to moisture stress.

Most plant species occur over a wide range of temperature and moisture; many occupy a wider range of environments in the western Cascade Mountains than they do in the eastern Siskiyou Mountains of southwest Oregon. Differences between vegetation zones are reflected in a temperature index; within zones, communities are distinguished by moisture stress and, to a lesser extent, by temperature. In two instances vegetation differences appear to be related to low nitrogen content in needles.

Species diversity (total number of vascular species) increases and dominance (Simpson's Index) decreases with change from moderate environments to warmer-drier and colder environments (Figures 7 and 8). Diversities of different strata are unrelated. Dominance appears in fewer strata of the vegetation on the colder sites (Figure 8). However, some discontinuities in the relation of diversity to environment are not related to major differences in our measured environmental indexes. Evergreen shrubs are more prevalent in stands with the lowest foliar nitrogen levels.

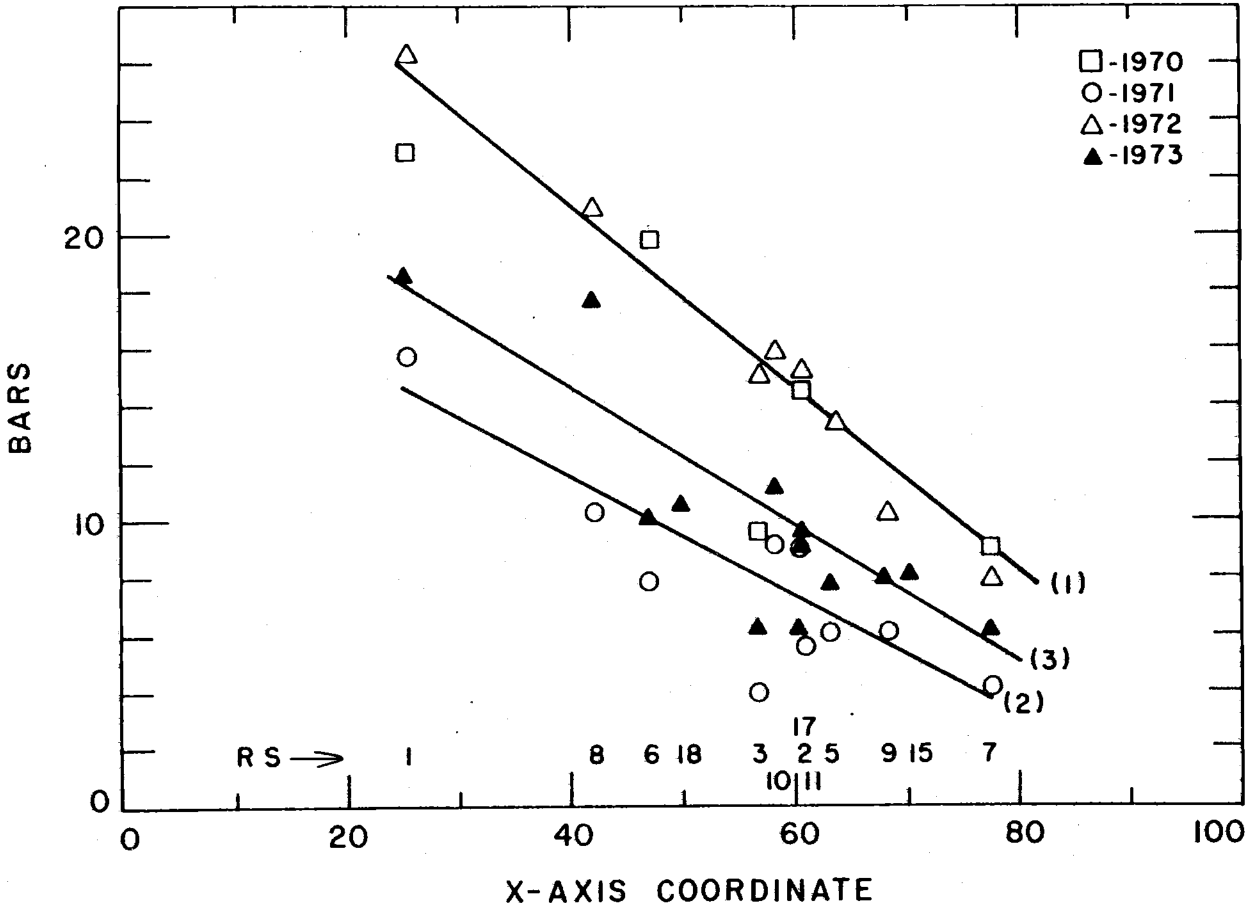


Figure 5. Relationship of maximum yearly predawn moisture stress to position of the *Tsuga heterophylla* and transition zone communities on the x-axis of the vegetation ordination of Dyrness et al. (1974). The community represented by each reference stand (RS) is listed in Table 1. Linear regressions: (1) 1970 + 1972 - $Y = -33.96 + 0.319\ X$, $r^2 = 0.95$; (2) 1971 - $Y = -20.00 + 0.207\ X$, $r^2 = 0.83$; (3) 1973 - $Y = -24.31 + 0.241\ X$, $r^2 = 0.82$. (Data from Reference Stand 3 were excluded from the regression equations.) (Zobel et al. 1976).

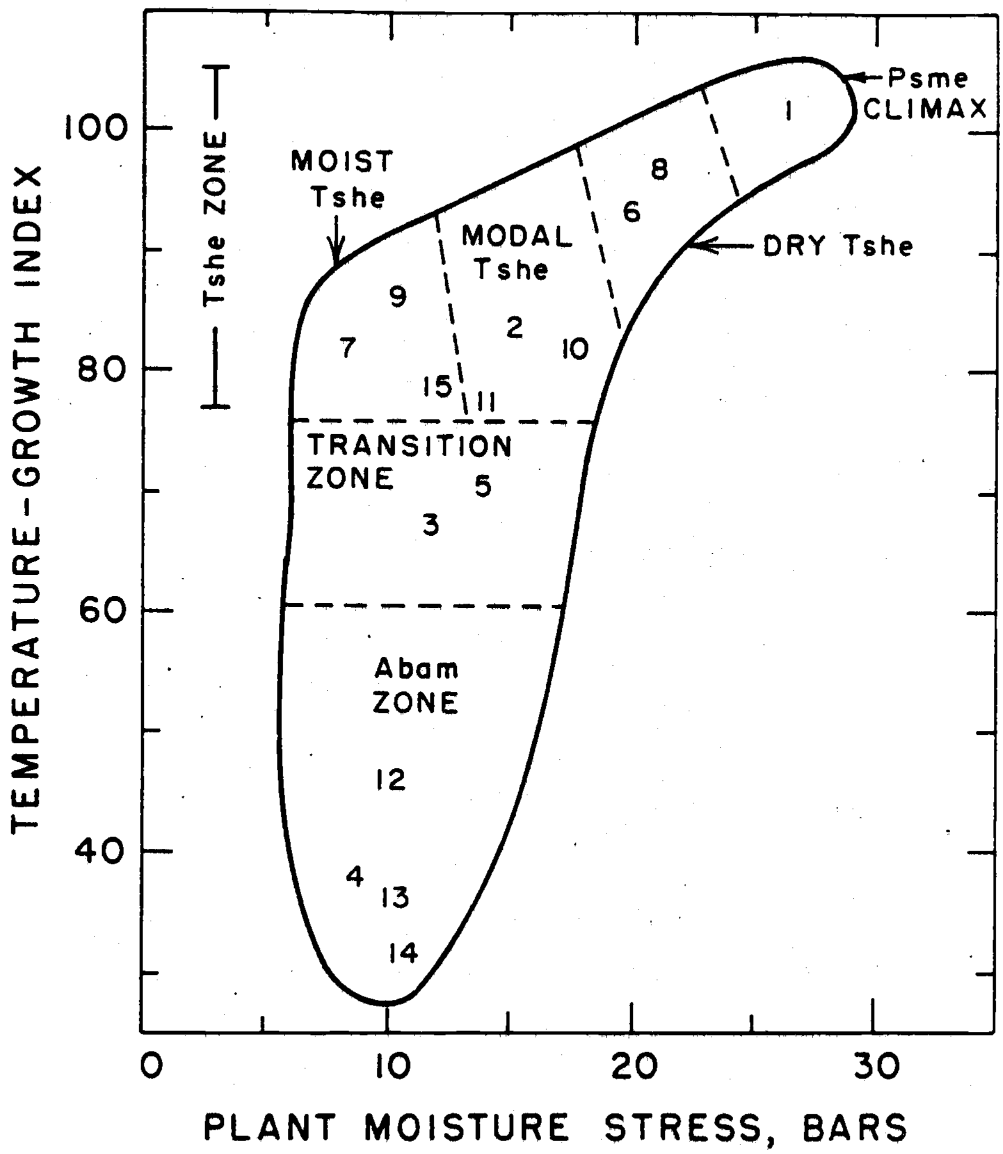


Figure 6. Position of reference stands in a two-dimensional environmental field. Temperature Growth Index is computed by the method of Cleary and Waring (1969). Moisture is assessed as the late-summer predawn moisture stress on conifer saplings. Most data are for 1972. The community represented by each reference stand is listed in Table 1: Psme = *Pseudotsuga menziesii*, Tshe = *Tsuga heterophylla*, Abam = *Abies amabilis* (Zobel et al. 1976).

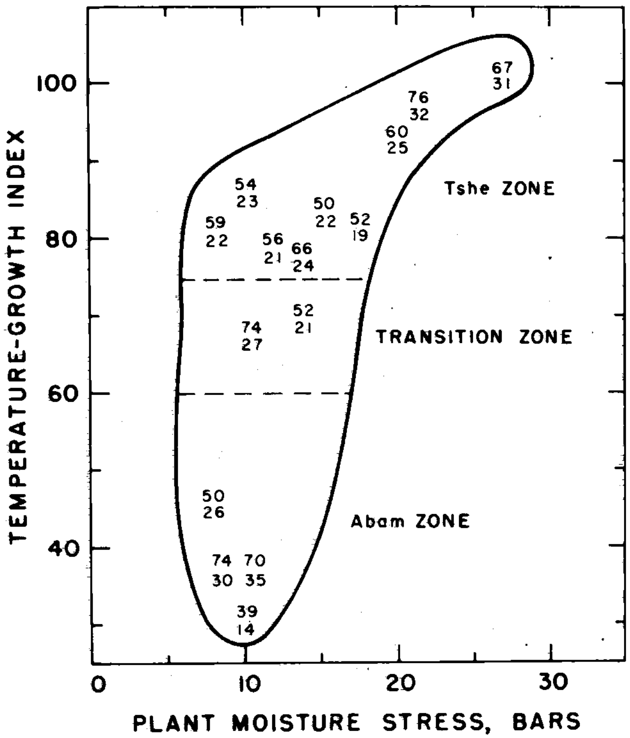


Figure 7. Diversity of vascular species in relation to temperature and moisture conditions of the stands representing each community. Number of species in the composite sample is above; average number of species per stand is below. The reference stand at each position is identified in Figure 6 (Zobel et al. 1976).

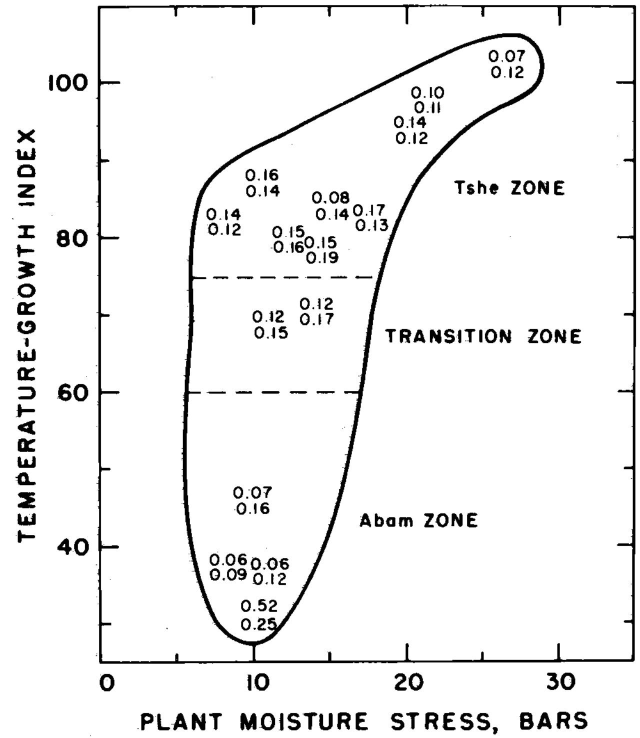


Figure 8. Dominance (Simpson's index) in relation to temperature and moisture conditions of the stands representing each community. The figure calculated for all vascular species is above; the figure calculated for shrubs and herbs is below. Percent cover is the measure of importance (Zobel et al. 1976).

McKee (1973) used the reference stands (1 through 14) for sampling the phenological character of vegetation in the Andrews Forest region. The phenology program began with two objectives. The first was to examine the possible relation between easily observed phenophases and more obscure but interesting phenophases. The second objective was to provide additional data for the ordination of communities.

Stands were visited weekly during May and June, less frequently thereafter. Phenophases, such as initiation of vegetative activity and flowering, were noted and recorded with the hope that a correlation could be established with other more important phenophases, such as initiation of root growth or cambial activity. Conspicuous correlations between such phases were noted. The study also permitted an examination of the potential suitability for phenological analysis of a wide range of species.

Table 8. Suitable and suitable but restricted-use species observed in phenology study (McKee 1973).

Suitable	Suitable but restricted
Understory trees and tall shrubs	
Taxus brevifolia	*Libocedrus decurrens*
Thuja plicata	*Abies grandis*
Abies amabilis	*Pinus lambertiana*
Pseudotsuga menziesii	*Corylus cornuta* var. *californica*
Tsuga heterophylla	*Castanopsis chrysophylla*
Acer circinatum	*Holodiscus discolor*
Cornus nuttallii	
Rhododendron macrophyllum	
Low shrubs and herbs	
Chimaphila umbellata	*Oxalis oregana*
Vaccinium membranaceum	*Cornus canadensis*
Vaccinium parvifolium	*Vaccinium alaskaense*
Linnaea borealis	

McKee concluded that 12 species appear to be suitable for phenological analysis. These species (Table 8) are found on a wide range of sites and have distinct and easily recognized phenophases. Species that are suitable for phenological analysis but restricted to a few sites are valuable for comparing sites within the community types. *Cornus canadensis* is an example of a species that would be valuable for comparing communities at high elevations. It has clearly definable phenophases and is locally abundant. A wide range of species has been examined, and the suitability of species for phenological studies can be stated with some confidence. *Chimaphila umbellata, Linnaea borealis, Rhododendron macrophyllum* and the conifers offer promise of the most information return for hours invested.

Table 9. Stands ordered by phenophases.[a]

Species	Phenophase	Order (earliest to latest)
Libo	First pair leaves expanded, parallel to stem; initiation of flowering	(1, 8), Δ[b], 2, (6, 9), (10, 7), 5, 11, 3, 12 (1, 8, Δ), (7, 9, 2, 6), 10, (5, 11), 3, 12
Chum	Leaves fully expanded, perpendicular to stem	1, (8, 2), 7, (5, 12), 10, 11, 3), 4, 13
Acci	First pair leaves out of bud, still folded	(1, 8, 2, 9), (6, 10), 5, 11
Conu	Vegetative bud break	(1, 8, Δ, 2), (6, 9, 10, 7), 11
Rhma	Vegetative bud break, leaves 1/4 to 1/2 expanded	8, (2, 6, 10), 5, 3, 12, 14
Tshe	Budbreak	(8, Δ), 7, 6, 10), (2, 9), (5, 11), 3, 12, 4
Psme	Budbreak	(1, 6, 8), 7
Abam	Budbreak	3, 12, 4
Thpl	Budbreak	6, (7, 10, 9)
Tabr	Budbreak	7, (2, 10), 9, 3
Vapa	Initiation of flowering	(1, 8, Δ), (2, 6, 9), 7, (11, 3), 12

[a]Stands enclosed in parentheses show no differences in time or the phenophase.
[b]Δ (Delta) represents a stand on the McKenzie River terraces.

The value of the data for ordinating communities is yet to be examined. Table 9 gives some information on the potential for separating stands by different species' phenophases; the degree of resolution is an artifact of the number of data collected. Field experience suggests that stands may be ordered from specific phenophases.

Zobel et al. (1974) established the correlation between forest communities and environment and phenology of the H. J. Andrews Experimental Forest through McKee's (1973) phenology study and data from Zobel (1972) and Zobel et al. (1973a, 1973b).

Air and soil temperature, leaf nutrient content, plant moisture stress in late summer, and phenology were measured on 14 of the 23 forest communities recognized in the study area by Dyrness et al. (1974). The three vegetation zones identified (Franklin and Dyrness 1973) differ considerably in a temperature index (Cleary and Waring 1969). Comparisons of an existing vegetation ordination with ordinations made in the Zobel et al.(1974) study showed that the X axis of the vegetation ordination of Dyrness et al. (1974) represents a moisture axis. Although both temperature and nutrition correlate to some extent with the Y axis of their ordination, they are not simply a response to any one or two factors studied. The yearday of selected phenological stages correlates well with the temperature-growth index used, but not with ordination axes.

The maximum predawn moisture stress and the calculated temperature index effectively separate the previously classified communities in the study area. The range of the environmental indexes measured in this area is similar to that in the eastern Siskiyou Mountain forests studied by Waring (1969).

Wiens and Nussbaum (1975) used a simulation model developed in the Grassland Biome Program of the US/IBP to estimate the magnitudes and patterns of energy flow in breeding bird populations of coniferous forests of the Northwest.

Data gathered in their study were taken at five reference stands (RS 1, 2, 3, 13, 14) and at an alluvial landform community (Delta) on the McKenzie River. These stands support breeding avifaunas of 7 to 15 species and standing crops of 223 to 526 g ha^{-1} (Tables 10 and 11).

Total energy flow through these avifaunas during the April to October breeding season was estimated at roughly 10 kcal m^{-2} $season^{-1}$ in the low-elevation, moderately xeric stands; 12 kcal m^{-2} $season^{-1}$ in the high-elevation stands; 17 kcal m^{-2} $season^{-1}$ in a mesic floodplain stand; and 21 kcal m^{-2} $season^{-1}$ in a middle-elevation (transition) stand (Tables 12 and 13).

Table 10. Some features of the coniferous forest stands considered by Wiens and Nussbaum (1975).

Site code	Community type[a]	Elevation (m)	Vegetive bud break, 1972	
			Understory conifers[b]	*Linnaea borealis*
1	*Pseudotsuga menziesii/Holodiscus discolor*	488	19 May	15 March
2	*Tsuga heterophylla/Rhododendron macrophyllum/Berberis nervosa*	488	7 June	29 March
Δ[c]	*Tsuga heterophylla/Acer circinatum/Polystichum munitum-Oxalis oregana*	360	13 May	absent
3	*Tsuga heterophylla-Abies amabilis/Linnaea borealis*	945	17 June	16 May
13	*Abies procera/Clintonia uniflora*	1,311	7 July	19 June
14	*Abies amabilis-Tsuga mertensiana/Xerophyllum tenax*	1,433	13 July	absent

[a]Tree dominant/shrub dominant/herbaceous understory dominant.
[b]Includes *Pseudotsuga menziesii, Tsuga heterophylla, Abies amabilis*, and *Abies grandis*; individuals < 3 m tall.
[c]Δ (Delta) represents a stand on the McKenzie River terraces.

Table 11. Avifaunal characteristics of six coniferous forest stands. Species diversity $(H') = -\Sigma p_i \ln_e p_i$, where p_i = the proportion of all individuals belonging to the *i*th species. Equitability = $H'/\ln S$, where S = number of species. (Wiens and Nussbaum 1975).

Stand	Number of species[a]			Total density (individuals km^{-2})	Standing crop biomass (g ha^{-1}) on 1 July	Species diversity (H')	Equitability
	Permanent	Seasonal	Σ				
1	7	5	12	1,779	262.8	2.0	0.82
2	8	4	12	1,380	275.8	2.21	0.89
Δ[b]	8	4	12	2,619	424.3	2.13	0.86
3	10	5	15	2,887	526.1	1.89	0.70
13	6	1	7	1,910	223.3	1.64	0.84
14	7	6	13	1,229	361.9	2.22	0.87

[a] "Permanent" and "Seasonal" refer to residency.
[b] Δ (Delta) represents a stand on the McKenzie River terraces.

Table 12. Magnitudes and patterns of energy flow through the breeding bird populations of six coniferous forest stands, from model output (Wiens and Nussbaum 1975).

	Stand					
	1	2	Δ[a]	3	13	14
Seasonal energy demand ($kcal\ m^{-2}$)						
Egg production	0.01	0.01	0.02	0.02	0.01	0.01
Nestlings	0.27	0.23	0.35	0.43	0.27	0.21
Fledgings	1.10	1.10	1.66	2.03	1.23	1.02
Adults and juveniles	9.35	9.15	14.62	18.28	10.75	10.91
Total	10.73	10.49	16.65	20.76	12.26	12.15
Peak daily energy demand ($kcal\ m^{-2}\ day^{-1}$)						
Amount	0.08	0.08	0.13	0.15	0.10	0.09
Dates	14 July	9-19 July	24-29 June	29 June-3 July	4-9 July	4 July
Seasonal energy allocation ($kcal\ m^{-2}$)						
Production	0.11	0.10	0.19	0.23	0.14	0.12
Excretion	3.21	3.12	4.94	6.17	3.64	3.61
Respiration	7.49	7.28	11.54	14.39	8.49	8.43
Allocation to thermoregulation ($kcal\ m^{-2}$)						
Amount	1.41	1.40	2.43	3.09	2.34	2.10
Percent of seasonal Σ	13.1	13.3	14.6	14.9	19.1	17.3
Percent of seasonal Σ allocated to reproduction						
Egg production	0.1	0.1	0.1	0.1	0.1	0.1
Nestlings	2.5	2.2	2.1	2.1	2.2	1.7
Fledglings	10.3	10.5	10.0	9.8	10.0	8.4
Total	12.9	12.8	12.2	12.0	12.3	10.2

[a]Δ (Delta) represents a stand on the McKenzie River terraces.

Table 13. Energy flow (kcal m^{-2} $season^{-1}$) from animal and plant (seed) resource pools into permanent and seasonal (migratory) resident bird populations in six coniferous forest stands (Wiens and Nussbaum 1975).

Stand	Residency[a]		Energy source: Animal (kcal)	(%)	Plant (kcal)	(%)
1	P		7.21	86	1.19	14
	S		1.78	76	0.56	24
		Σ	8.99	84	1.75	16
2	P		6.02	68	2.82	32
	S		1.46	88	0.19	12
		Σ	7.48	71	3.01	29
Δ[b]	P		12.00	84	2.37	16
	S		1.91	84	0.36	16
		Σ	13.91	84	2.73	16
3	P		14.44	76	4.59	24
	S		1.15	66	0.58	34
		Σ	15.59	75	5.17	25
13	P		9.63	83	1.95	17
	S		0.58	85	0.10	15
		Σ	10.21	83	2.05	17
14	P		4.32	51	4.10	49
	S		2.65	71	1.08	29
		Σ	6.97	57	5.18	43

[a]P = permanent, S = seasonal.
[b]Δ(Delta) represents a stand on the McKenzie River terraces.

About 1% of the seasonal energy flow was channeled into production, and reproduction-related processes accounted for 15% to 16% of the total energy intake. Thermoregulation required 13% to 19% of the seasonal total. The higher costs were associated with cooler, higher elevation stands. Foliage-gleaning species accounted for the greatest proportion of the energy intake at most stands. The importance of granivorous species generally increased through the stand sequence (RS 1, 2, Delta, 3, 13, 14) as the growing season became shorter and environmental conditions more severe.

In a study of the comparative rates of CO_2 production from the forest floor in the Douglas-fir ecosystem, Phillips (1976) found seasonal and yearly totals of mineralized carbon were similar for three habitat types. First year totals for the *Tshe/Rhma-Bene* (RS 2), *Tshe/Cach* (RS 6), and *Tshe/Pomu-Oxor* (RS 7) associations were 77.36, 75.67, and 78.86 mg C g^{-1} litter (Table 14). Spring and fall mineralization accounted for approximately 62% of this total on all three reference stands. The lowest rates occurred during the winter months. Carbon mineralization rates for the second fall of the study were similar to those of the first year. However, carbon mineralization during the second winter of the study increased unexpectedly to 88%, 123%, and 142% for reference stands 2, 6, and 7. Presumably, this was due to warmer temperatures during the second winter.

Table 14. Carbon mineralization (mg C g^{-1} litter) from the forest floor (01 + 02) of old-growth forest communities (Phillips 1976).

Date	Reference stand no.		
	2	6	7
08/16/73 - 11/30/73	24.67	25.05	26.62
12/01/73 - 02/28/74	12.53	9.97	12.09
03/01/74 - 05/31/74	24.94	22.29	23.15
06/01/74 - 08/15/74	15.22	18.36	17.00
Yearly totals	77.36	75.67	78.86

Peaks in CO_2 production on all sites closely followed increases in moisture content, particularly during the early fall months. Clearcutting increased the rate of carbon mineralization, the magnitude of the increase related in part to the age of the clearcut. Broadcast burning after clearcutting reduced the rate of carbon mineralization of residual litter. The reduction was probably due in part to an increase in resistant substances, particularly lignin and charcoal. Carbon mineralization under snow cover was higher than on uncovered sites, possibly due to a stabilized litter temperature that might stimulate the growth of fungal populations.

Decomposition was significantly correlated with litter moisture content or litter temperature on a seasonal basis. In general, litter moisture content was the dominant factor during the summer and fall months. Litter temperature was the dominant factor in the winter and spring months. Inadequate means of estimating litter temperature under snowpack may be the reason for fewer significant correlations during these periods.

In their study of leaf area differences associated with old-growth forest communities in the western Oregon Cascade Mountains, Gholz et al. (1976) had two objectives: to develop techniques to assess foliage areas for a wide variety of common plant species in the Cascade Mountains of western Oregon, and to ascertain whether leaf-area differences among major vegetational units are associated with measured moisture and temperature gradients (Dyrness et al. 1974, Zobel et al. 1974).

To assess possible differences in leaf area, six reference stands representing a broad spectrum of environments were selected (Table 15). In all stands, *Pseudotsuga menziesii* was the major overstory tree, constituting from 55% to 98% of the total tree foliage biomass. Easily measurable independent variables were selected for each shrub species. Destructive sampling was conducted in the neighborhood of reference stands 5 and 7, data were plotted, and an appropriate function was selected to relate foliage weight and the given measurement (Table 16).

An average tree sampling procedure was followed for other species in one or two reference stands where similar growth forms and sizes appeared over the range of sites investigated.

Table 15. Description of reference stands used by Gholz et al. (1976) for leaf area study.

Ref. stand no.	Community	Elevation (m)	Description
1	*Pseudotsuga menziesii/Holodiscus discolor (Psme/Hodi)*	490	hot, dry, Douglas-fir climax
2	*Tsuga heterophylla/Rhododendron macrophyllum/Berberis nervosa (Tshe/Rhma/Bene)*	490	modal, hemlock climax
4	*Abies amabilis/Tiarella unifoliata (Abam/Tiun)*	1310	subalpine, silver-fir climax
5	*Tsuga heterophylla-Abies amabilis/Rhododendron macrophyllum/Berberis nervosa (Tshe-Abam/Rhma-Bene)*	885	mid-elevation, hemlock-silver-fir climax
6	*Tsuga heterophylla/Castanopsis chrysophylla (Tshe/Cach)*	610	dry, hemlock climax
7	*Tsuga heterophylla/Polystichum munitum-Oxalis oregana (Tshe/Pomu-Oxor)*	490	very wet, hemlock climax

Table 16. Understory foliage biomass equations (from Gholz et al. 1976).

Species	Sample size	Equation[a]	r^2
Acer circinatum[b]	132	$X = 9.03\ (D_2L_{max})$	0.90
Berberis nervosa	32	$X = 14.218 + 1.984$ (% cover)	0.80
Rhododendron macrophyllum	40	$\ln(X) = 0.067177 + 0.60981 \ln (D_2L_{max})$	0.90
Gaultheria shallon	32	$\ln(X) = 1.5137 + 0.70263 \ln$ (% cover)	0.83
Xerophyllum tenax	22	$X = 18.873 + 0.02798\ (D_2L_{avg})$	0.94
Polystichum munitum	41	$X = -2.5695 + 0.06429\ (L_{avg} \cdot \#\ \text{fronds})$	0.90
Oxalis oregana	10	$X = 0.4625$ (% cover)	$S\bar{x} = 2.2$

[a]All equations are significant at the 0.99 level. D, diameter at litter surface (cm); L, length (cm, except Acer = m).
[b]From Russel (1973).

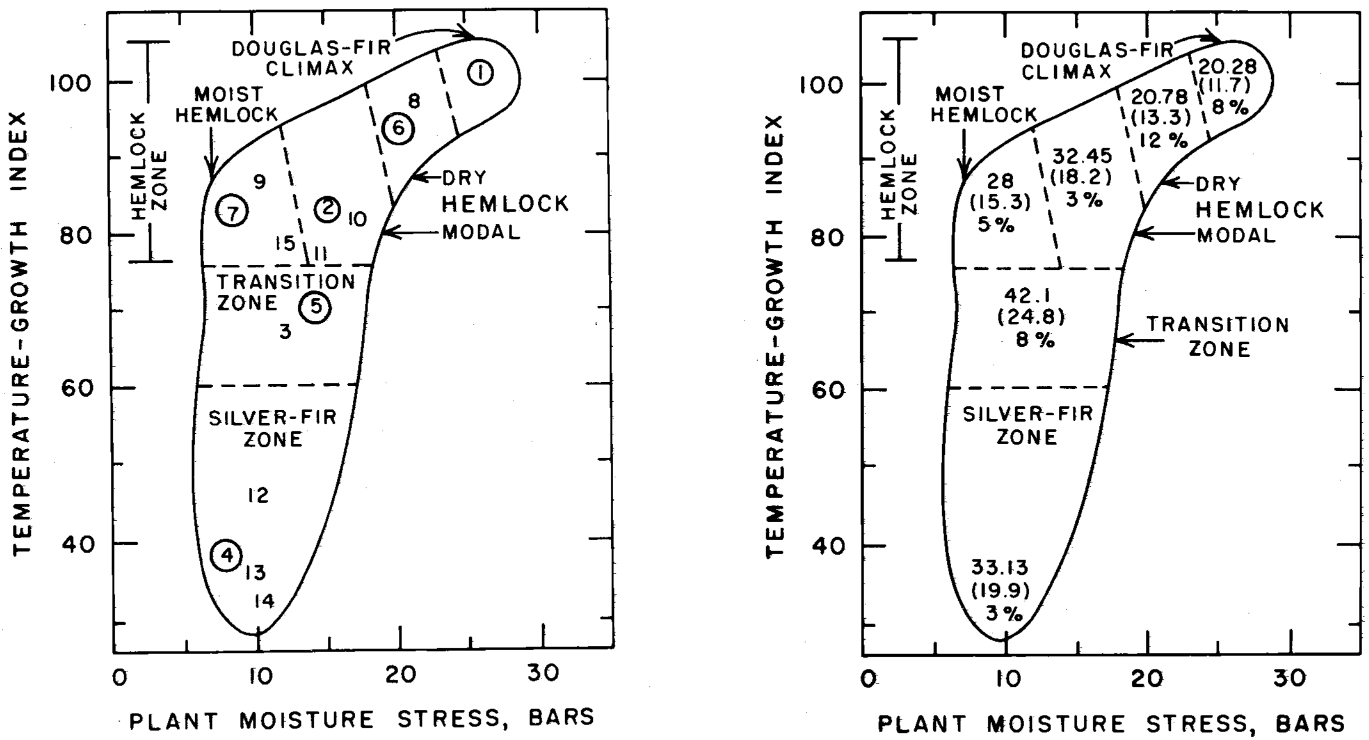


Figure 9. Right: total leaf area (m^2 m^{-2}, upper values), total foliage biomass (MT ha^{-1}, parenthetical values), and percentage of the total surface area in the shrubs and herbs (lower values) for the six reference stands. Projected leaf areas, one side with no cross-section corrections, are as follows for reference stands circled on the left: RS 1, 8.7 m^2 m^{-2}; RS 2, 14.3; RS 4, 14.4; RS 5, 18.6; RS 6, 9.1; RS 7, 12.0. Sugar pine (*Pinus lambertiana* Dougl.) would add about 0.4 MT ha^{-1} to RS 1 and 0.9 MT^{-1} to RS 6 but is not included because no surface area conversion is available (Gholz et al. 1976).

Herbaceous cover was assumed to be directly related to foliage surface area, so that 10% cover on a 1 m^2 plot was equivalent to a one-sided surface area of 0.1 m^2. This assumption appeared invalid only at high cover values not commonly encountered.

Total foliage biomass, surface area, and percentage of the surface area in the shrub and herb layers for each of the six stands studied are shown in Figure 9. Their locations in this figure correspond to the locations within the environmental framework discussed by Zobel et al. (1974, 1976). Surface area coefficients of conifer needles show that area per gram of needle decreased with increasing age. Substantial error may be made by not treating age classes separately; however, leaf areas were computed by age classes for only a few species other than *Pseudotsuga*. *Abies amabilis* and *A. procera* had a greater surface area per gram in the understory than in the overstory. This suggests that a variety of coefficients may be obtained from different crown areas of taller overstory trees. Broadleaved species show a greater range of coefficients than do coniferous species, and often a wide range exists even within one species. Thus comparison of leaf areas of old-growth forests in six communities show differences that have been attributed primarily to variations in the environment.

In the study of the influence of vegetation type and decomposition on cation exchange properties of forest litter, Warner (1977) looked at a variety of forest floor materials from different forest types in eastern North America and Oregon. L, F, and H layers were used to determine the effect of decomposition on cation exchange capacity (Table 17). Samples from Oregon showed significantly increased cation exchange capacity magnitudes with increased decomposition, and litter samples from the various forest types differed significantly in cation exchange capacity between vegetation types. Litter from more productive timber sites had greater cation exchange values for L and F layers than did litter from less productive sites (Figure 10).

Table 17. Cation exchange capacity values for reference stands ranked by sums of L, F, and L + F layers (CEC meq 100 g^{-1}).

Vegetation type[a]	Ref. stand no.	L	F	L + F
Tshe/Pomu-Oxor	7	66.3	74.8	140.6
Tshe/Rhma-Bene	2	53.1	60.5	113.6
Tshe/Rhma-Gash	10	51.9	56.2	107.8
Tshe/Abam/Libo	3	50.7	54.6	104.4
Tshe/Cach	16	46.8	53.7	98.6
Tshe-Abam/Rhma-Bene	5	44.9	50.0	95.6

[a]See Table 1 for full community names.

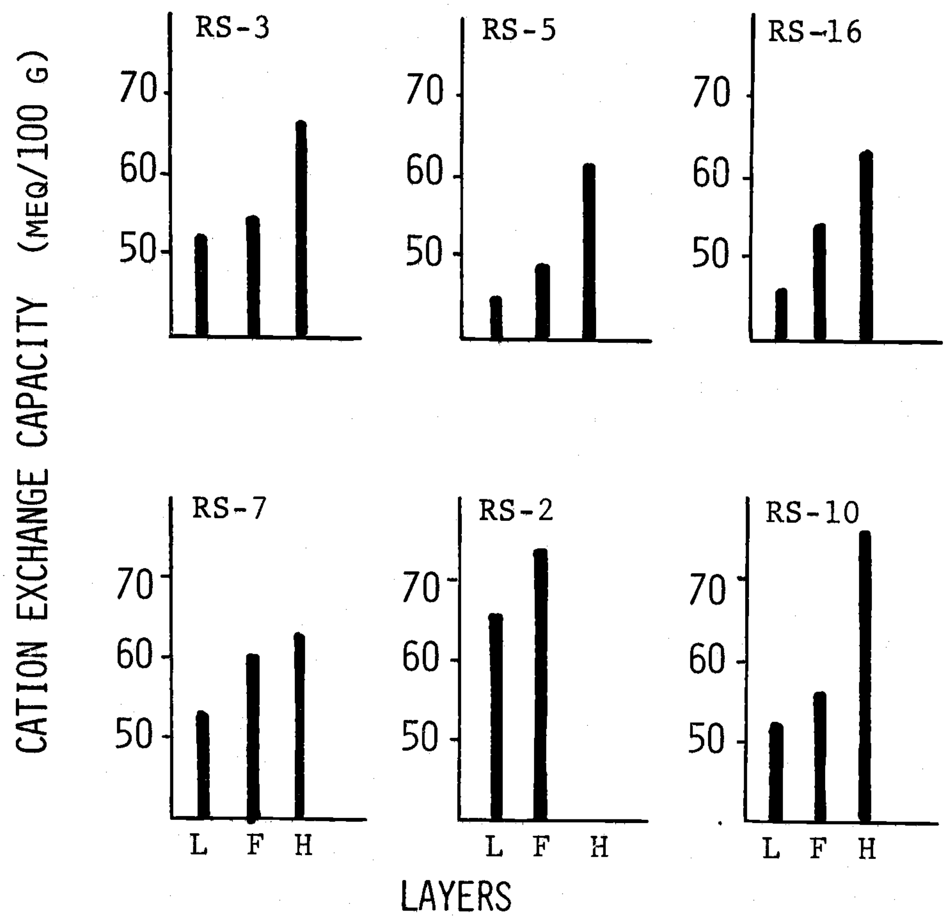


Figure 10. Cation exchange capacity (mg 110 g^{-1}) of L, F, and H layers of the forest floor at six reference stands (Warner 1977).

Warner's samples included those from reference stands 2, 3, 5, 7, 10 and 16 within the H. J. Andrews Experimental Forest. The ranking of cation exchange capacity in the L, F, or L + F layers was in decreasing order: 7, 2, 10, 3, 16, and 5 (Table 17). Warner also has provided figures of the cation exchange capacities, pH values, and base saturation by layer (L, F, and H) for each reference stand (Figures 10, 11, and 12).

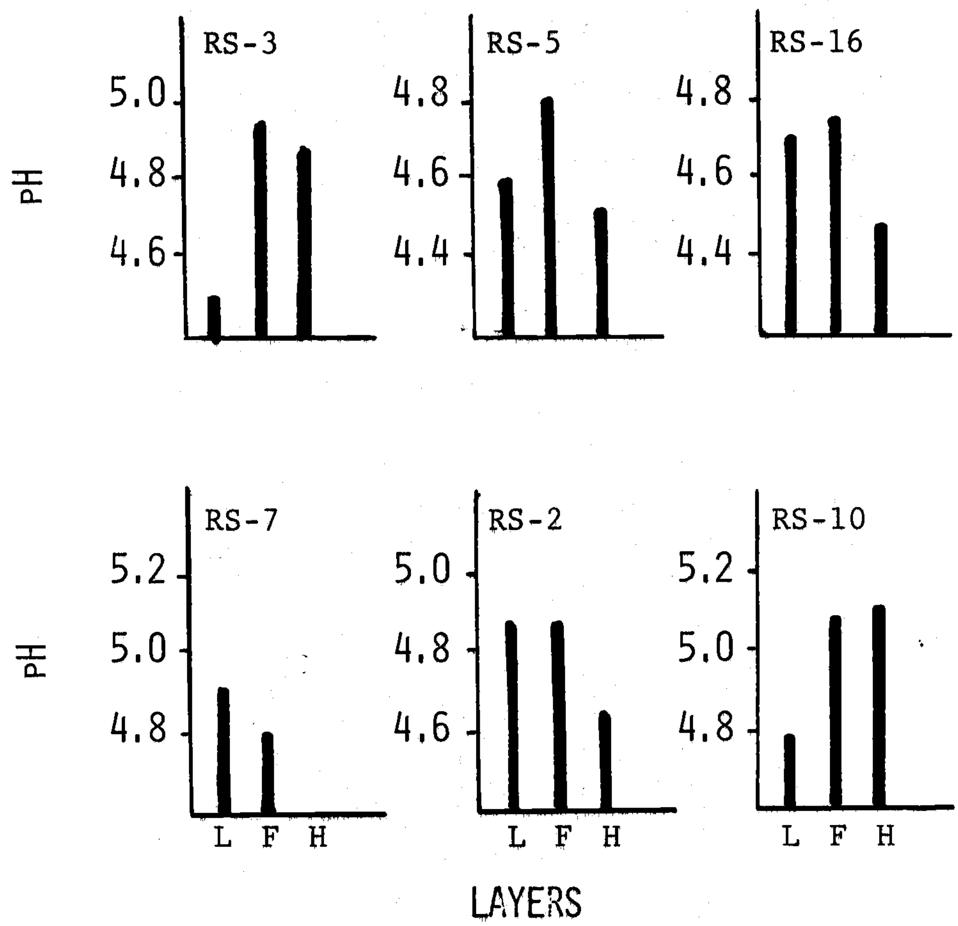


Figure 11. Reaction (pH) of L, F, and H layers of the forest floor at six reference stands (Warner 1977).

Fogel and Cromack (1977) used reference stands in their study of the effects of habitat and substrate quality on Douglas-fir litter decomposition in western Oregon. They studied decomposition of Douglas-fir needles, female cones, branch, and bark segments within mature stands of four habitat types of western Oregon. In addition to determining the effects of environment and substrate quality on decomposition, they estimated the turnover time of Douglas-fir needles, cones, branches, and bark. Habitat differences were recognized by changes in vegetation

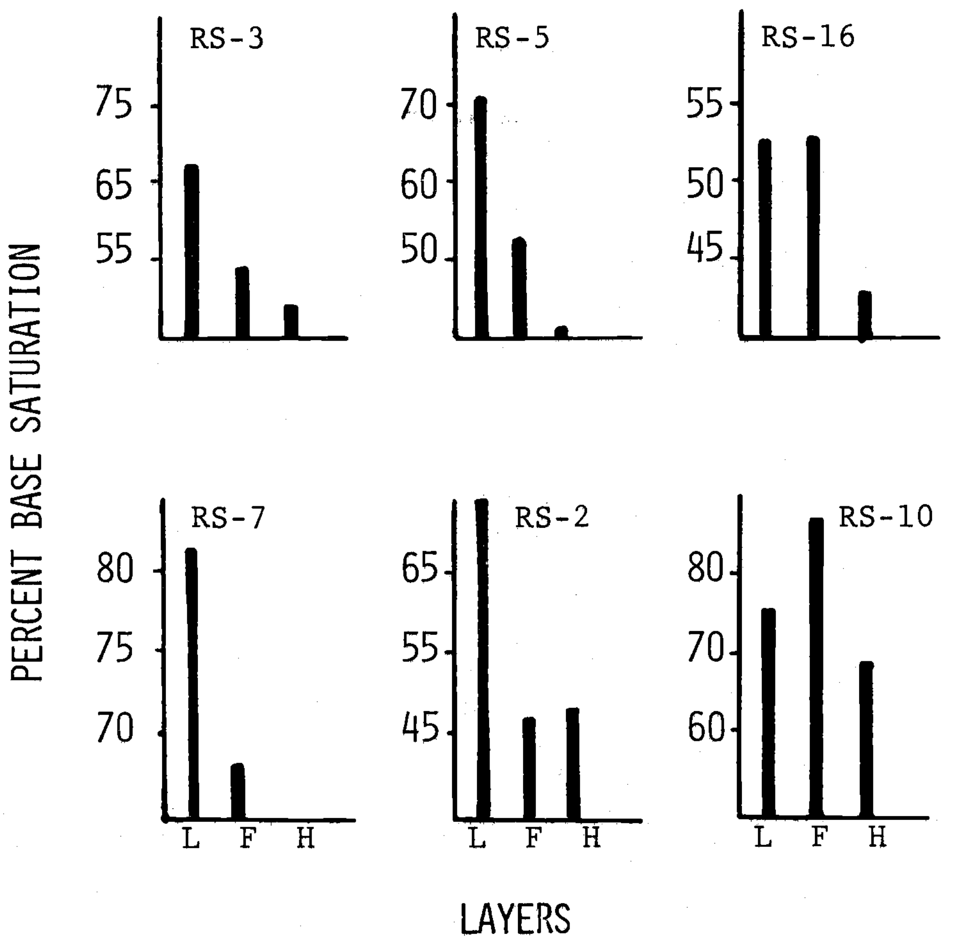


Figure 12. Percent base saturation of L, F, and H layers of the forest floor in six reference stands (Warner 1977).

that reflect the relative depletion of soil water reserves during the summer dry period.

The habitat types that were studied include: *Psme/Hodi* (RS 1), *Tshe/Cach* (RS 16 and RS 6), *Tshe/Rhma-Bene* (RS 2 and RS 17), and *Tshe/Pomu-Oxor* (RS 7). This choice of stands includes the driest and most mesic of the low-elevation habitat types as well as the climatic climax community.

Linear regression models were developed for decomposition of substrates. The decomposition constant had a negative linear correlation, significant at the 1% level, with maximum plant moisture stress and temperature growth index of the seven stands sampled. They also compared substrate quality of needle and woody litter components and found that potassium was more closely correlated with lignin content than with carbon/nitrogen ratio.

Some other studies that have been or are now being conducted in or near the reference stands of the H. J. Andrews Forest are given in Table 18. Many studies have supplied supportive data for studies not yet published, and many that have continued for the last several years are only now being prepared for publication.

Table 18. Other completed and ongoing studies using reference stands of the H. J. Andrews Forest.

1. An index of photosynthesis for comparing forest sites in western Oregon (Emmingham and Waring).

2. Ecological indexes as a means of evaluating climate, species distribution and primary production (Emmingham).

3. Effect of environment on litter decomposition in six western Oregon sites (Cromack, Fogel, and Emmingham).

4. Comparison of litter decomposition in coniferous forest environments in the western United States (Cromack and Emmingham).

5. Dew point comparisons across a 6000 hectare watershed in the Cascade Mountains of western Oregon (Emmingham and Lundburg).

6. Comparison of microclimate of clearcut and virgin forests in the Cascade Mountains of western Oregon (Emmingham and Lundburg).

7. Ecosystem process modeling as a means of evaluating distribution of primary productivity (Emmingham).

8. Climatic and physiological data summaries for the H. J. Andrews reference stand network. (Emmingham and Lundburg).

9. Comparison of cambial growth as measured by conventional dendrometer bands and by xylem pinning methods (Tesch and Emmingham).

10. Analytic verification of reconnaissance survey of central western Oregon Cascade Mountain plant communities (Hawk and Franklin).

11. Assessing stress in *Rhododendron macrophyllum* through an analysis of leaf physical and chemical characteristics. (Gholz).

12. Environmental control on the accumulation of leaf area by coniferous forests in Oregon (Waring, Emmingham, Gholz, and Grier).

13. Evaluating stem conducting tissue as an estimator of leaf area in four wood angiosperms. (Waring, Gholz, Grier, and Plummer).

14. Mapping and structure description of Watershed 10 plant communities (Hawk).

15. Organic litterfall in Watershed 10, 1971-1972 (Denison and Rossman).

16. Litter decomposition rates in Watershed 10 (Denison and Rossman).

17. Sapwood water storage: its contribution to transpiration and effect upon water conductance through the stems of old-growth Douglas-fir (Waring and Running).

18. Leaf area differences associated with old-growth forest communities in the western Oregon Cascades. (Gholz, Fitz, and Waring).

REFERENCES

ABEE, A., and D. LAVENDER. 1972. Nutrient cycling in throughfall and litterfall in 450-year-old Douglas-fir stands. IN: Proc.--Research on Coniferous Forest Ecosystems--A Symposium, p. 133-143. USDA For. Serv. Pacific Northwest Forest and Range Exp. Stn., Portland, Oregon.

BAILEY, A. W. 1966. Forest associations and secondary plant succession in the southern Oregon Coast Range. Ph.D. thesis, Oregon State Univ., Corvallis. 164 p.

BAILEY, A. W., and C. E. POULTON. 1968. Plant communities and environmental interrelationships in a portion of the Tillamook Burn, northwestern Oregon. Ecology 49:1-13.

BROWN, R. B., and R. B. PARSONS. 1973. Soils of the reference stands, Oregon IBP. Coniferous Forest Biome Internal Report 128. Coll. For. Resources, Univ. Washington, Seattle. 76 p.

CLEARY, B. D., and R. H. WARING. 1969. Temperature: Collection of data and its analysis for the interpretation of plant growth and distribution. Can. J. Bot. 47:167-173.

DYRNESS, C. T., J. F. FRANKLIN, and W. MOIR. 1974. A preliminary classification of forest communities in the central portion of the western Cascades in Oregon. US/IBP Coniferous Forest Biome Bulletin No. 4. Coll. For. Resources, Univ. Washington, Seattle. 123 p.

FOGEL, R., and K. CROMACK, JR. 1977. Effect of habitat and substrate quality on Douglas-fir litter decomposition in western Oregon. Can. J. Bot. 55(12): 1632-1640.

FOGEL, R., M. OGAWA, and J. M. TRAPPE. 1974. Terrestrial decomposition: a synopsis. Coniferous Forest Biome Internal Report 135. Col. For. Resources, Univ. Washington, Seattle. 12 p.

FRANKLIN, J. F., and C. T. DYRNESS. 1973. Natural vegetation of Oregon and Washington. USDA For. Serv. Gen. Tech. Rep. PNW-8. 417 p.

FRANKLIN, J. F., C. T. DYRNESS, and W. H. MOIR. 1970. A reconnaissance method for forest site classification. Shinrin Richi 12(1), Meguro, Tokyo, Japan. 14 p.

FRANKLIN, J. F., F. C. HALL, C. T. DYRNESS, and C. MASER. 1972. Federal research natural areas in Oregon and Washington. USDA For. Ser., Pacific Northwest Forest and Range Exp. Stn., Portland, Oregon. 9 p.

GARRISON, G. A., J. M. SKOVLIN, and C. E. POULTON. 1976. Northwest plant names and symbols for ecosystem inventory and analysis. USDA For. Serv. Gen. Tech. Rep. PNW-46. 263 p.

GHOLZ, H. L., F. K. FITZ, and R. H. WARING. 1976. Leaf area differences associated with old-growth forest communities in the western Oregon Cascades. Can. J. For. Res. 6(1):49-57.

HAWK, G. M. 1977. Comparative study of temperate *Chamaecyparis* forests. Ph.D. thesis, Oregon State Univ., Corvallis. 195 p.

HAWK, G. M., and D. B. ZOBEL. 1974. Forest succession on alluvial landforms of the McKenzie River Valley, Oregon. Northwest Sci. 48: 245-265.

MCKEE, W. A. 1973. Phenological observations on reference stands in the H. J. Andrews Experimental Forest in 1971. Coniferous Forest Biome Internal Report 41. Col. For. Resources, Univ. Washington, Seattle. 10 p.

PHILLIPS, M. J. 1976. Comparative rates of CO_2 production from the forest floor in the Douglas-fir ecosystem. M.S. thesis. Oregon State Univ., Corvallis. 114 p.

WARING, R. H. 1969. Forest plants of the eastern Siskiyous: their environmental and vegetational distribution. Northwest Sci. 43:1-17.

WARNER, S. A. 1977. Cation exchange properties of forest litter as influenced by vegetation type and decomposition. M.S. thesis. Oregon State Univ., Corvallis. 102 p.

WEINS, J. A., and R. A. NUSSBAUM. 1975. Model estimation of energy flow in northwestern coniferous forest bird communities. Ecol. 56:547-561.

ZOBEL, D. B. 1972. Relation of biologically defined environmental measurements to distribution and productivity of forest ecosystems in the central Oregon Cascades. Coniferous Forest Biome Internal Report 6. Col. For. Resources, Univ. Washington, Seattle. 2 p.

ZOBEL, D. B. 1973. Local variation in intergrading *Abies grandis-Abies concolor* populations in the central Oregon Cascades: Needle morphology and periderm color. Bot. Gaz. 134(3):209-220.

ZOBEL, D. B. 1974. Local variation in intergrading *Abies grandis-Abies concolor* populations in the central Oregon Cascades. II. Stomatal reaction to moisture stress. Bot. Gaz. 135:200-210.

ZOBEL, D. B. 1975. Local variation in intergrading *Abies grandis-Abies concolor* populations in the central Oregon Cascades. III. Timing of growth and stomatal characteristics in relation to environment. Bot. Gaz. 136(1):63-71.

ZOBEL, D. B., G. M. HAWK, W. A. MCKEE, and C. T. DYRNESS. 1973a. Variation in plant moisture stress associated with forest communities in the H. J. Andrews Experimental Forest. Coniferous Forest Biome Internal Report 78. Col. For. Resources, Univ. Washington, Seattle. 15 p.

ZOBEL, D. B., W. A. MCKEE, G. M. HAWK, and C. T. DYRNESS. 1973b. Variation in air and soil temperature in forest communities on the H. J. Andrews Experimental Forest, 1970-1972. Coniferous Forest Biome Internal Report 127. Col. For. Resources, Univ. Washington, Seattle. 43 p.

ZOBEL, D. B., W. A. MCKEE, G. M. HAWK, and C. T. DYRNESS. 1974. Correlation of forest communities with environment and phenology on the H. J. Andrews Experimental Forest, Oregon. IN: Integrated Research in the Coniferous Forest Biome, p. 48-56. Coniferous Forest Biome Bulletin No. 5. Col. For. Resources, Univ. Washington, Seattle.

ZOBEL, D. B., W. A. MCKEE, G. M. HAWK, and C. T. DYRNESS. 1976. Relationships of environment to composition, structure and diversity of forest communities of the central western Cascades of Oregon. Ecol. Monogr. 46:135-156.

APPENDIX

Stem Maps of Reference Stands, H. J. Andrews Experimental Forest Area

(A Sequential Listing by Reference Stand Number)

KEY TO STEM MAPS

Pseudotsuga menziesii

Tsuga heterophylla

Tsuga mertensiana

Thuja plicata

Pinus monticola

Pinus lambertiana

Calocedrus decurrens (Libocedrus decurrens)

Abies grandis (or *Abies concolor)*

Abies procera

Abies amabilis

Abies lasiocarpa

Taxus brevifolia

*Acer circinatum (*changed to *Alnus rubra* in 1977*)*

Acer macrophyllum

Cornus nuttallii

Castanopsis chrysophylla

Arbutus menziesii

Quercus garryana

Rhamnus purshianus

0 - 25 cm dbh

25 - 50 cm dbh

50 - 100 cm dbh

greater than 100 cm dbh

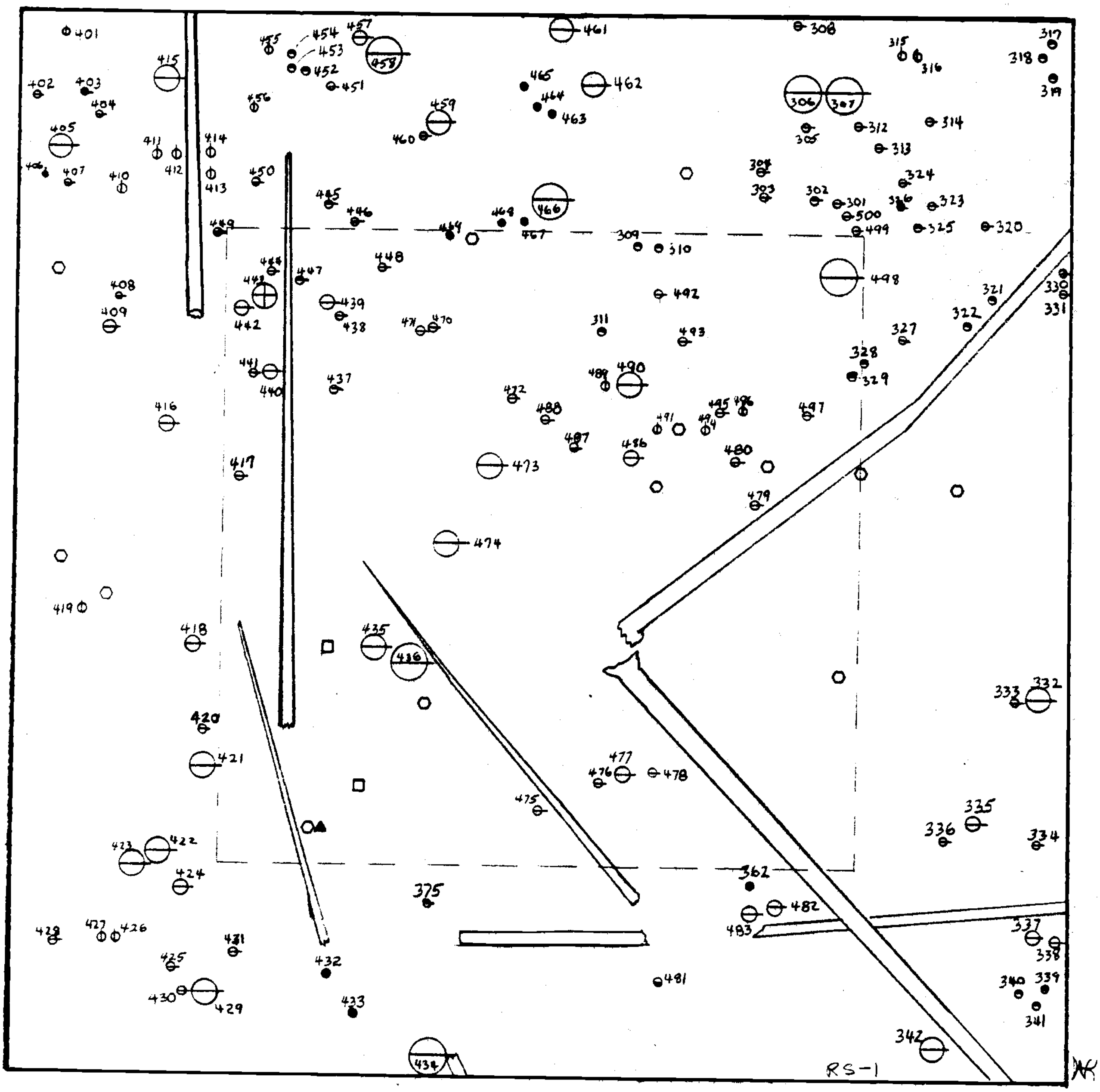
Litter trap

Stump

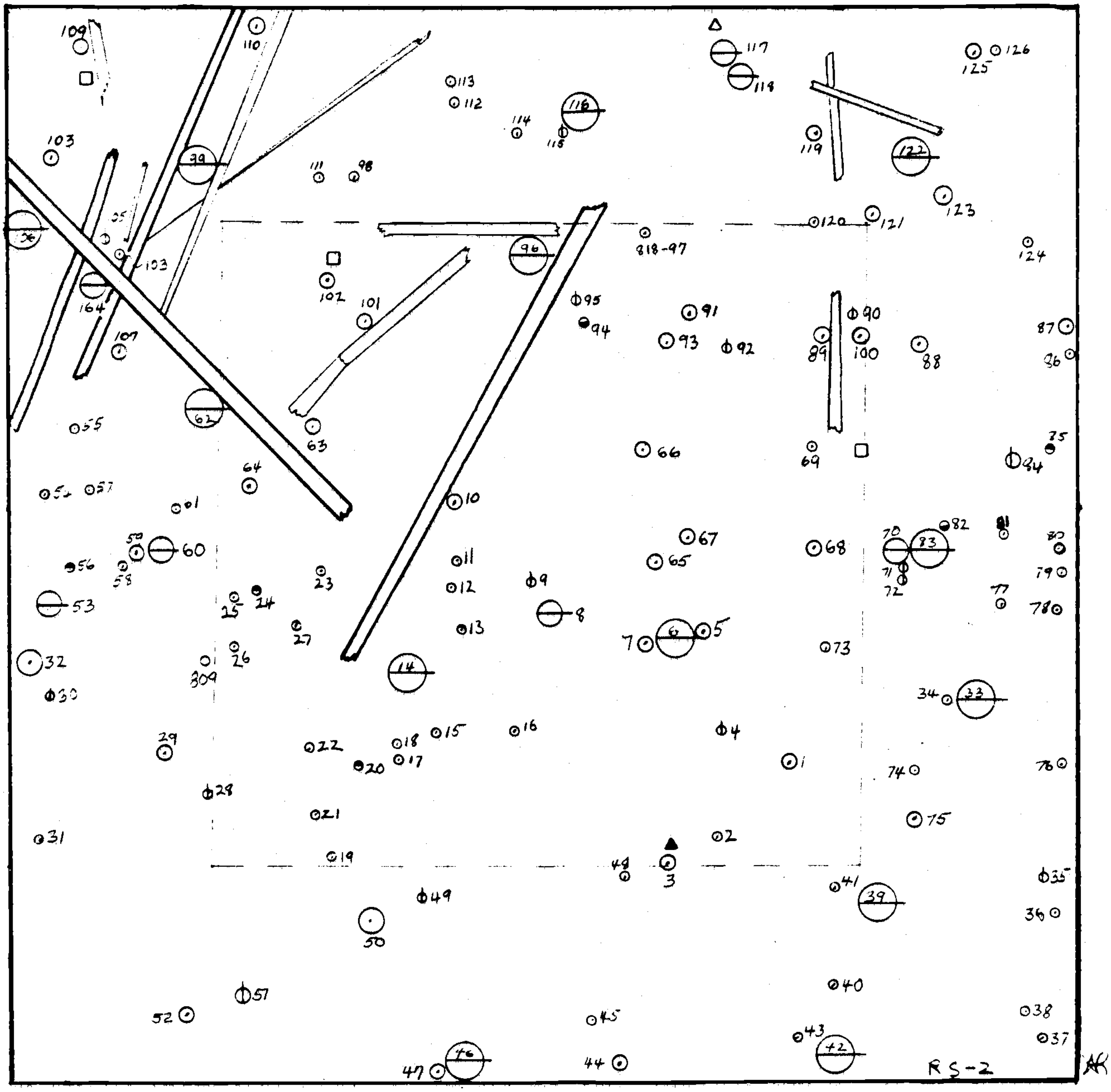
Rain gauge

Thermograph

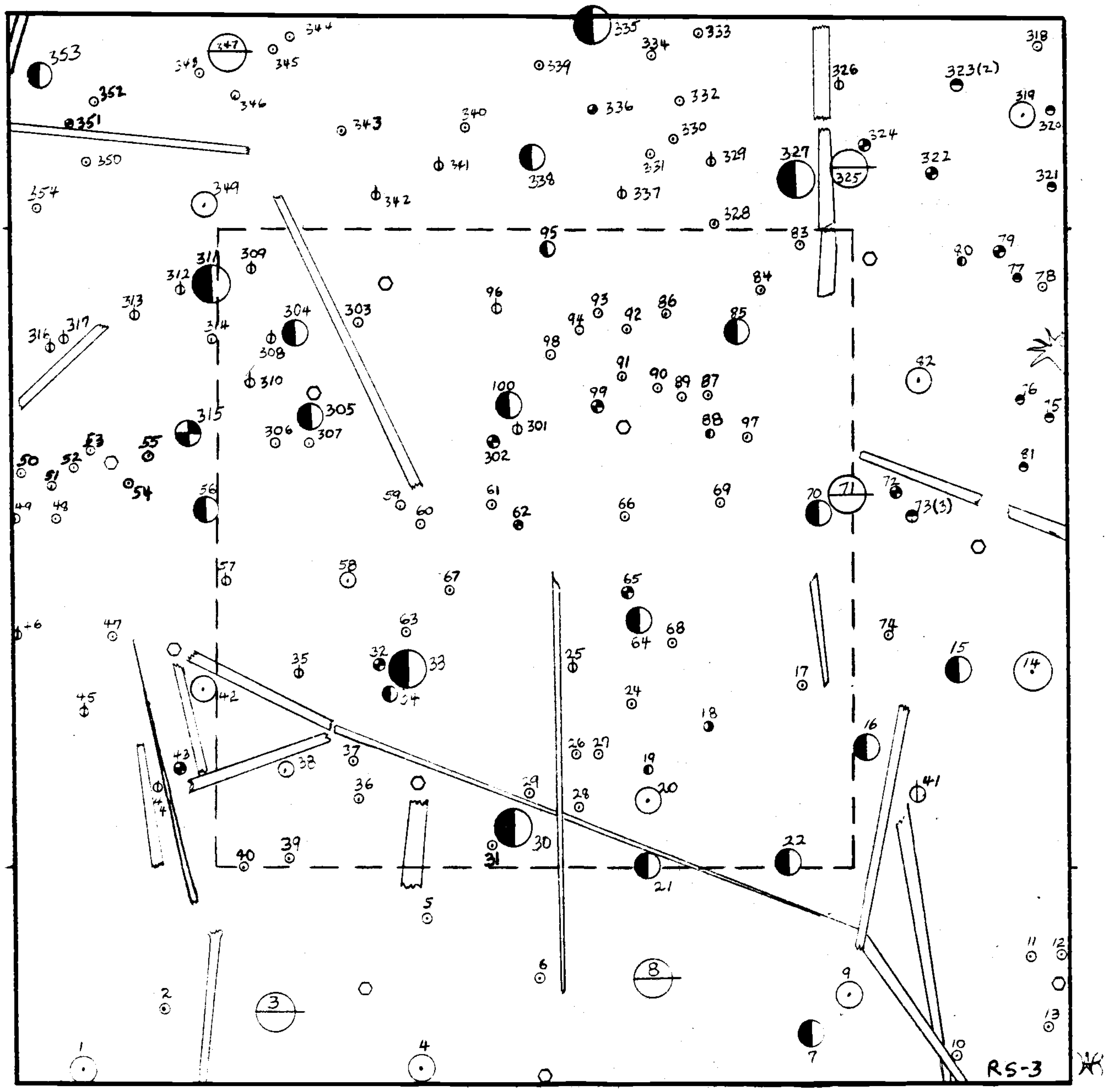
Log



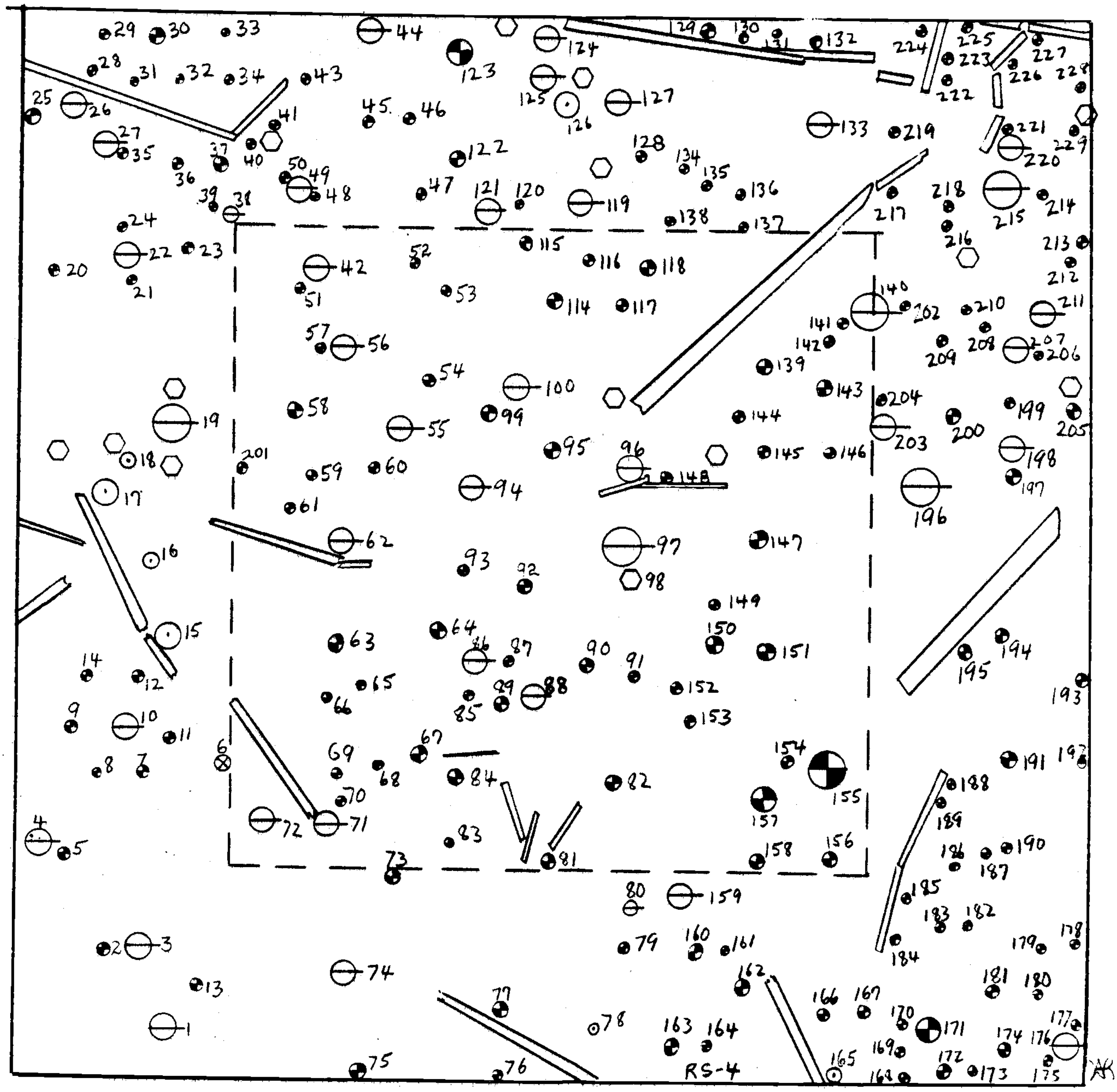
REFERENCE STAND 1



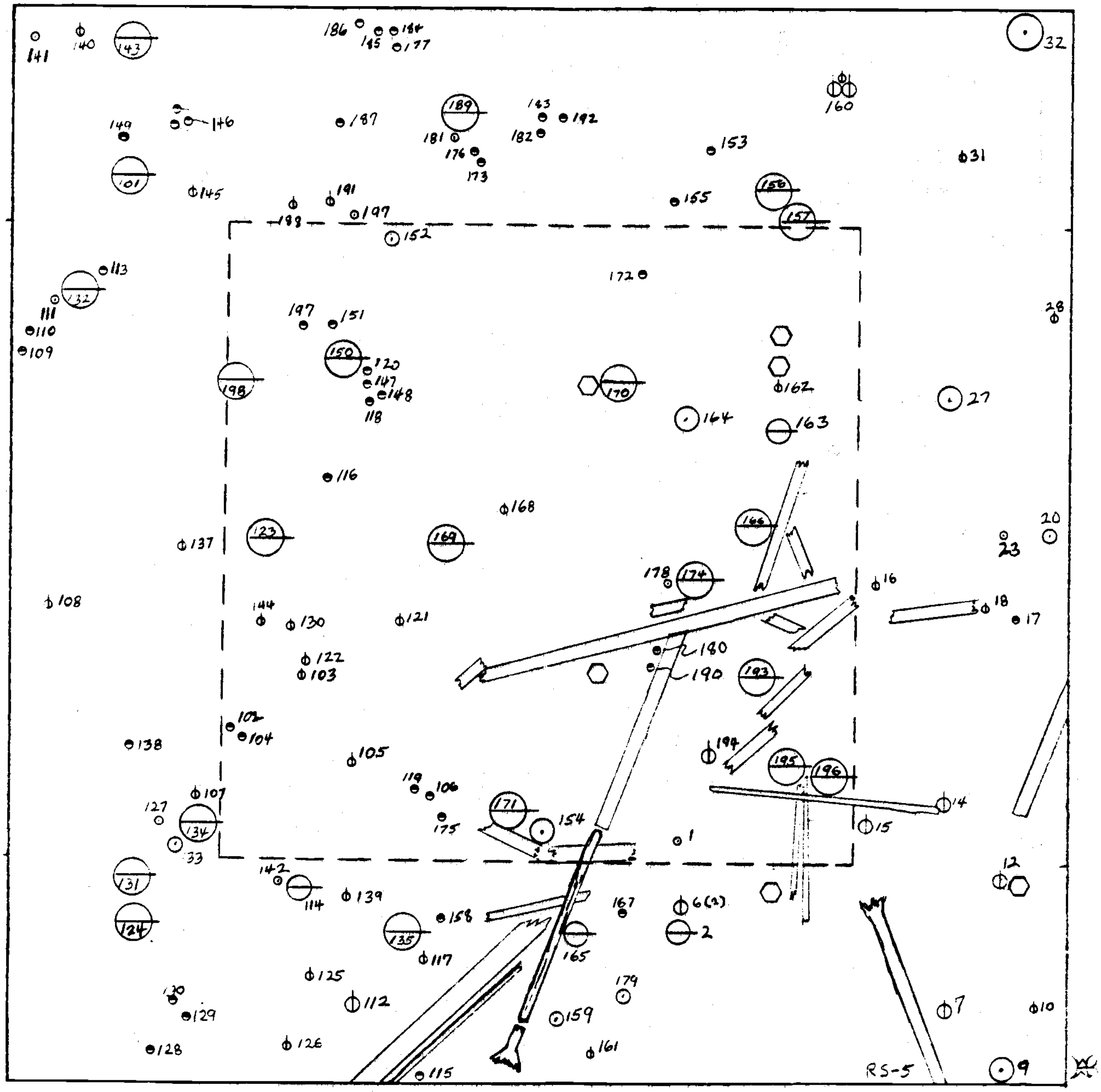
REFERENCE STAND 2



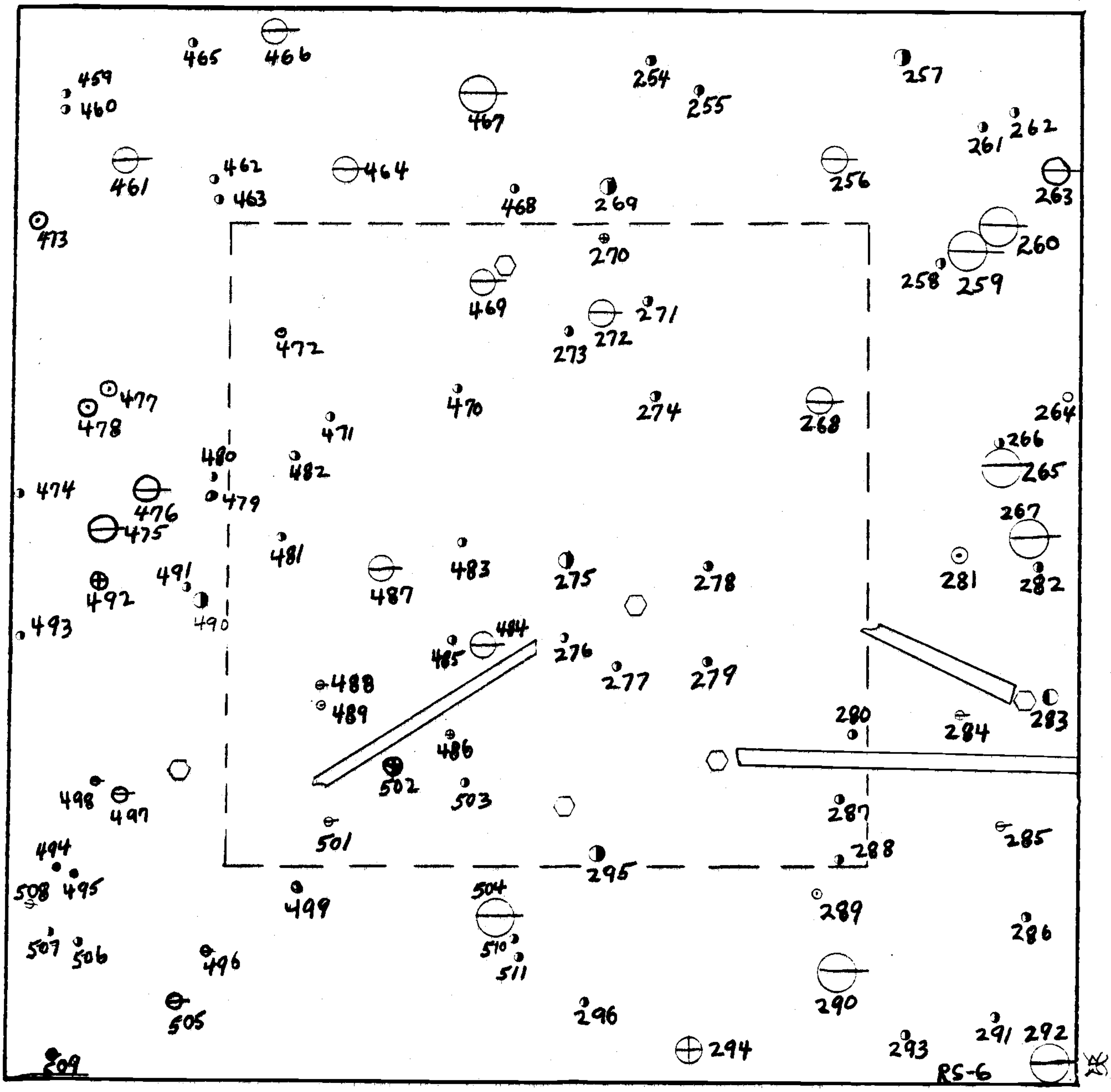
REFERENCE STAND 3



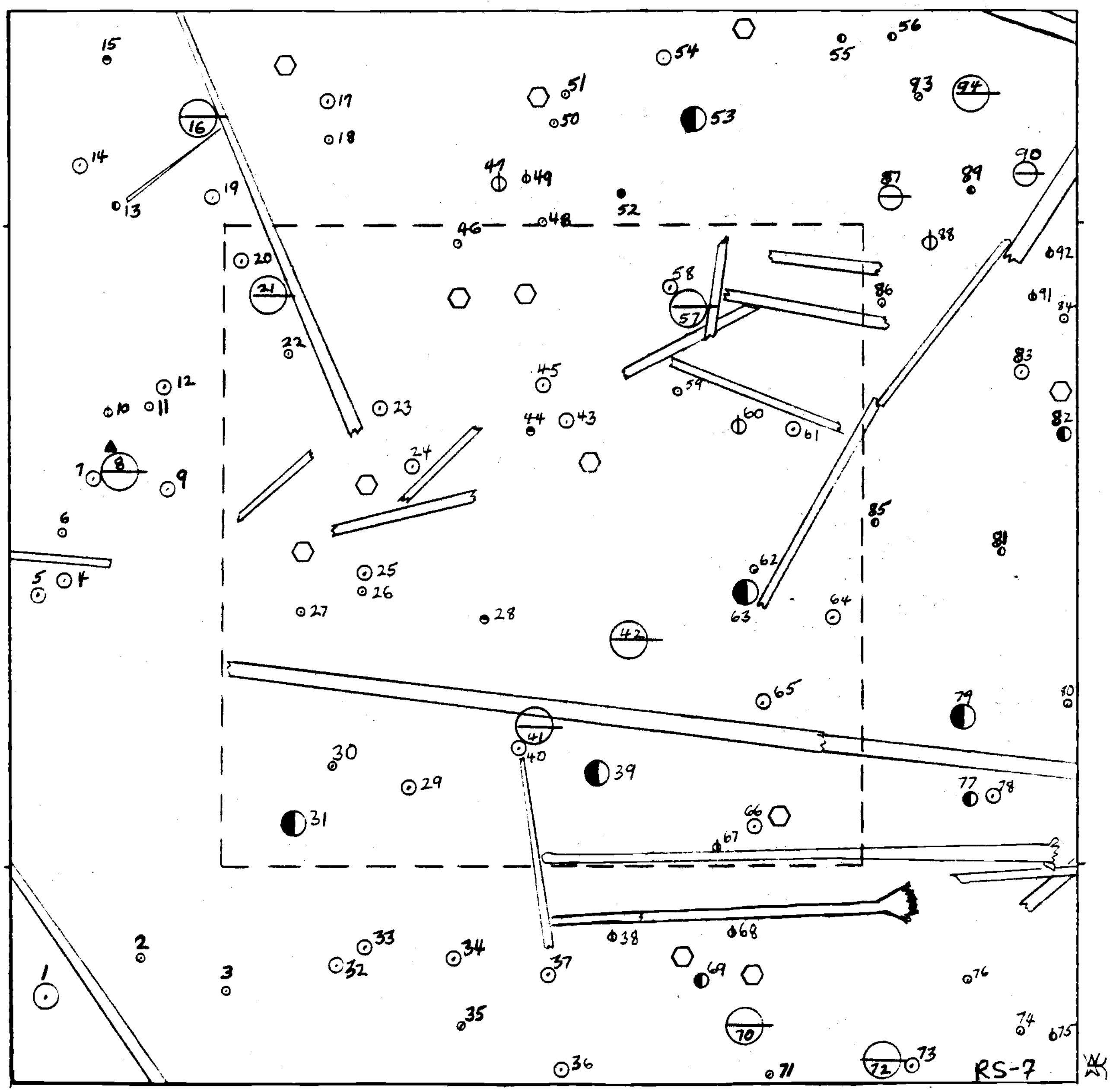
REFERENCE STAND 4



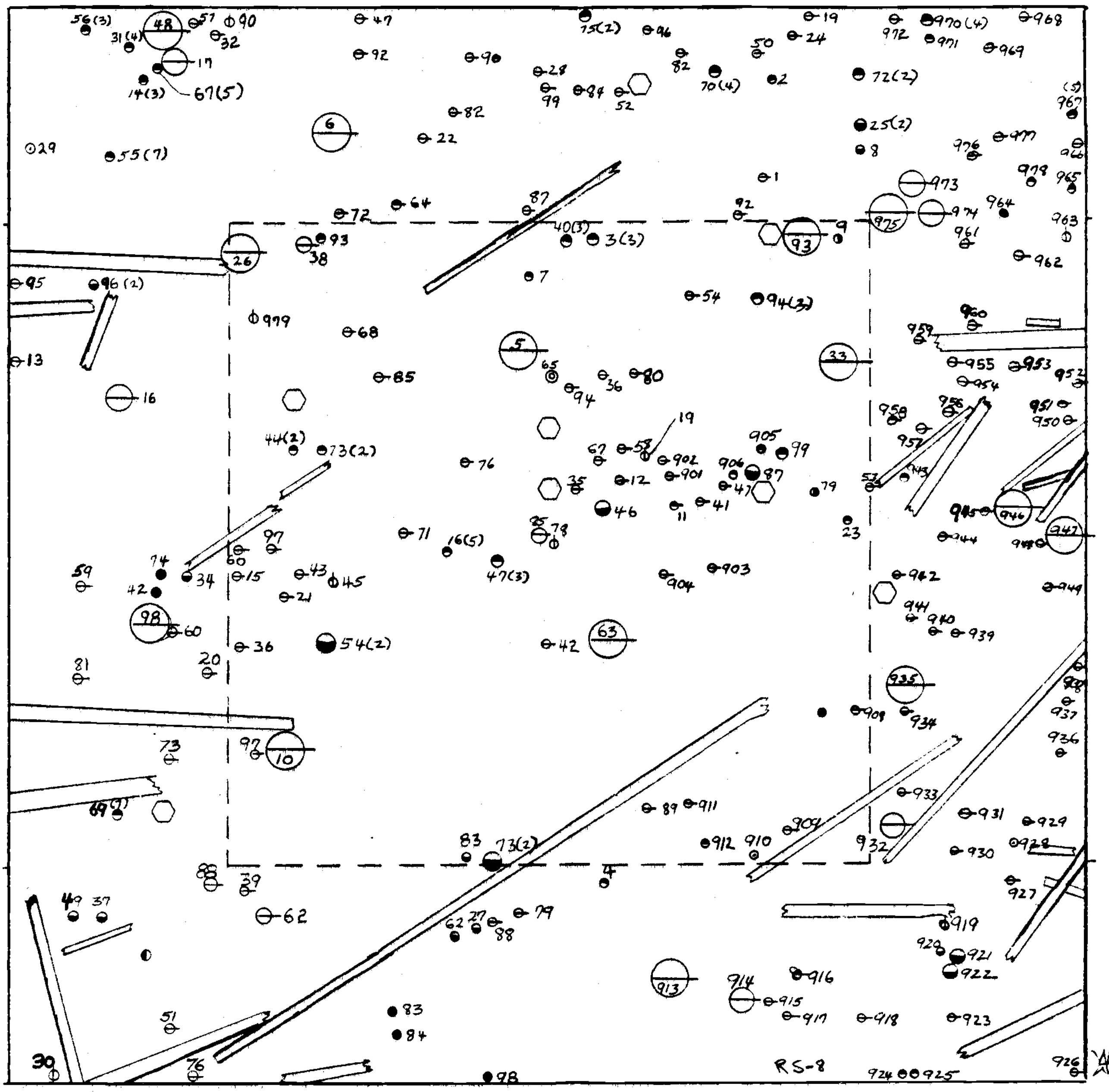
REFERENCE STAND 5



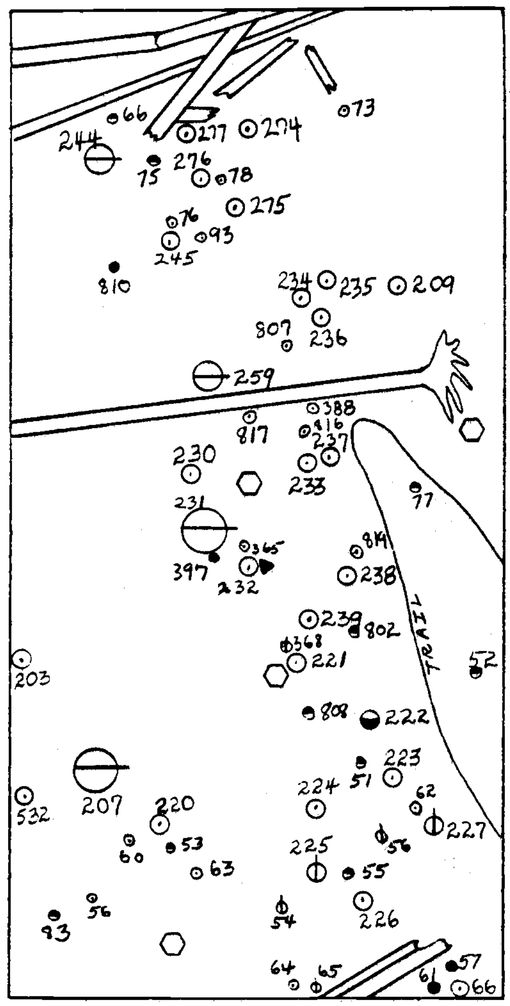
REFERENCE STAND 6



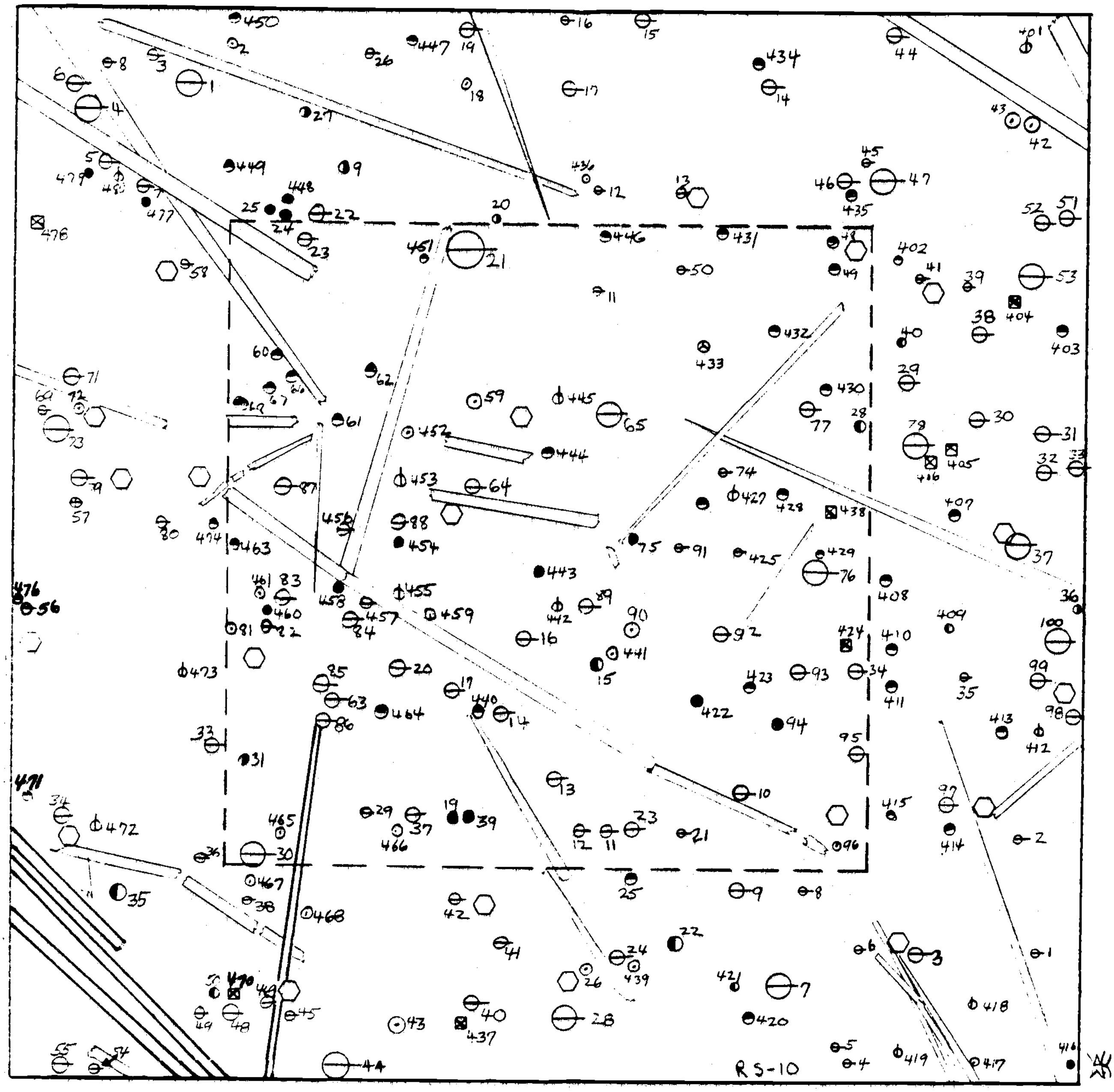
REFERENCE STAND 7



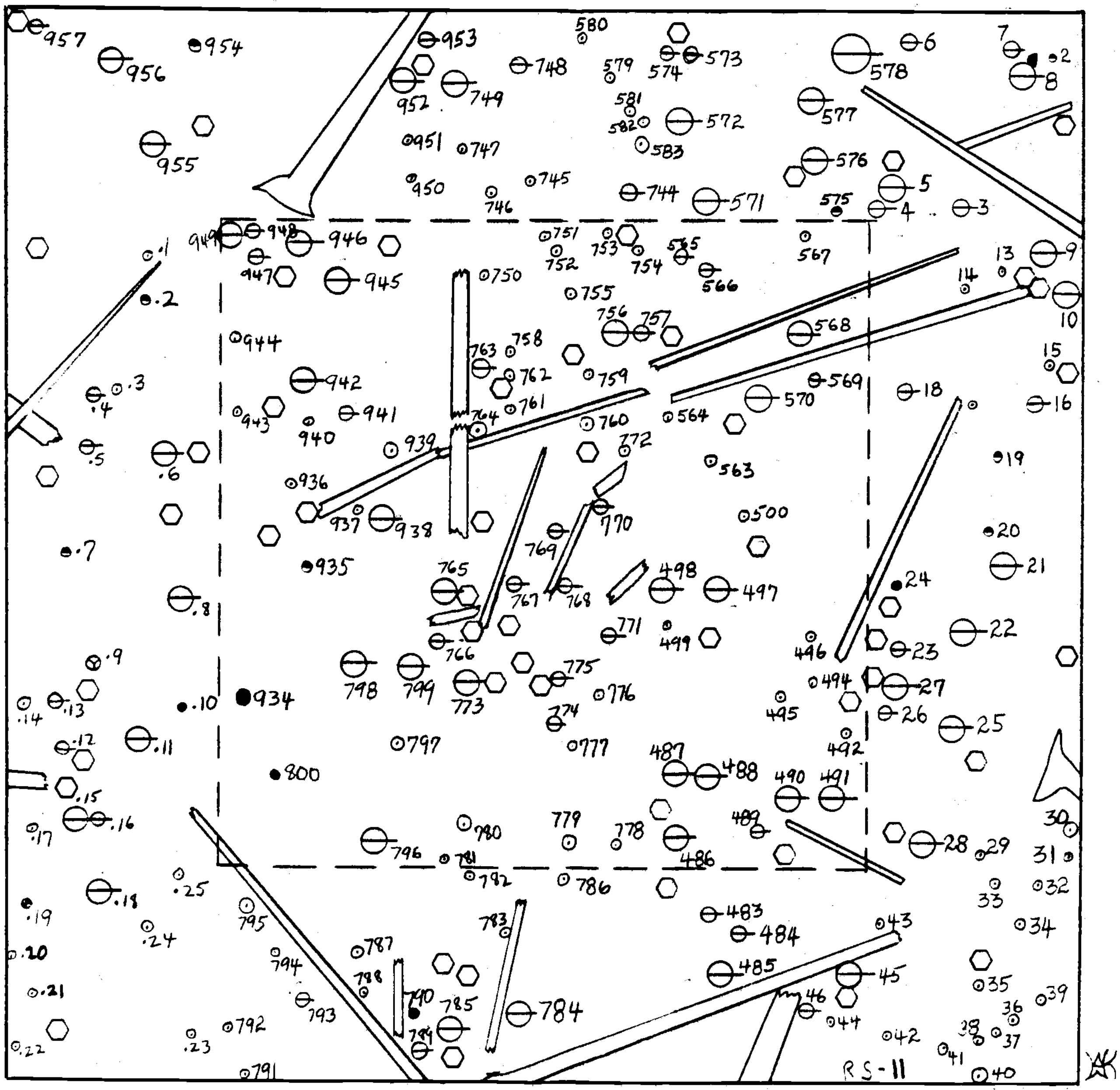
REFERENCE STAND 8



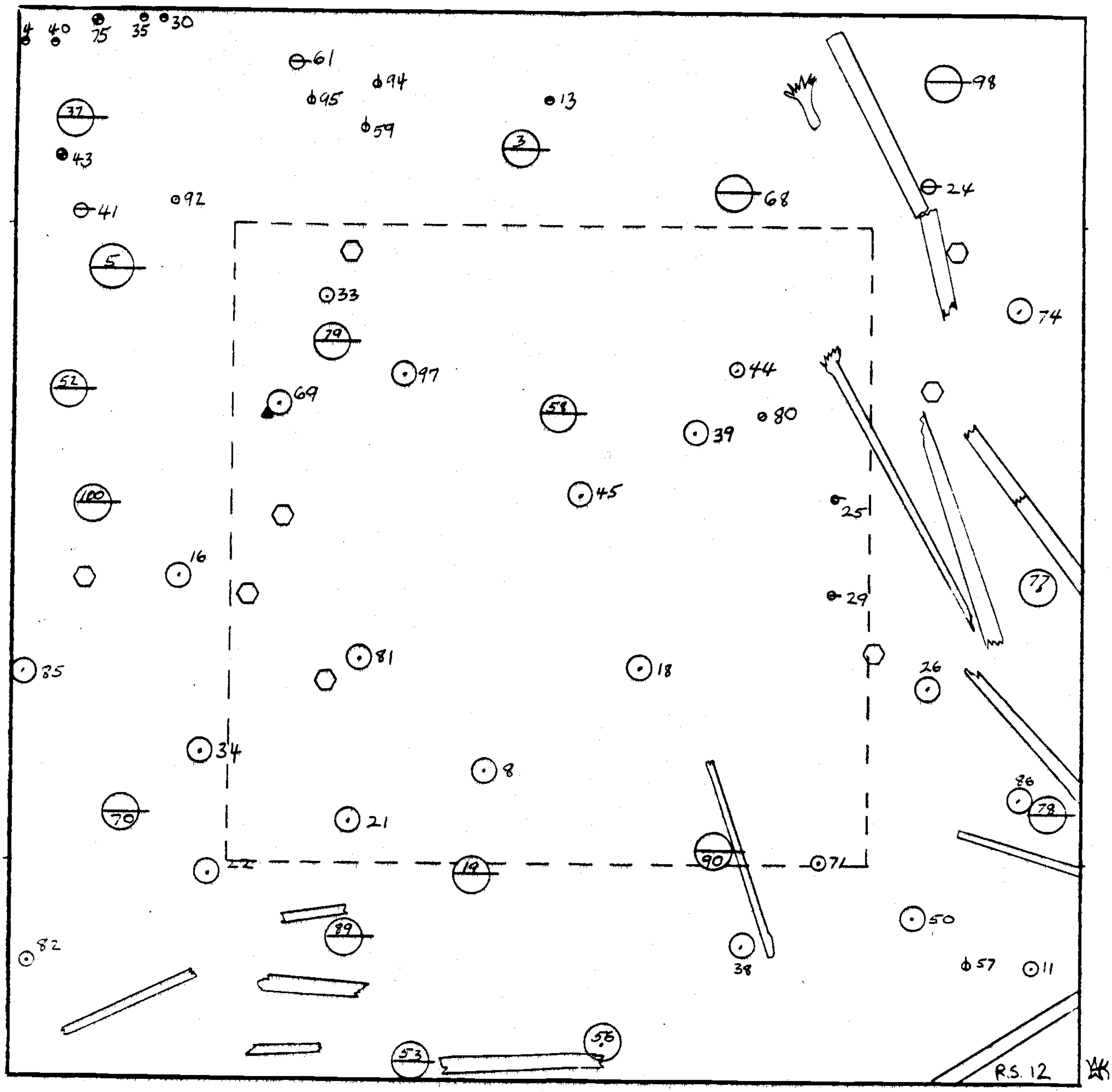
REFERENCE STAND 9



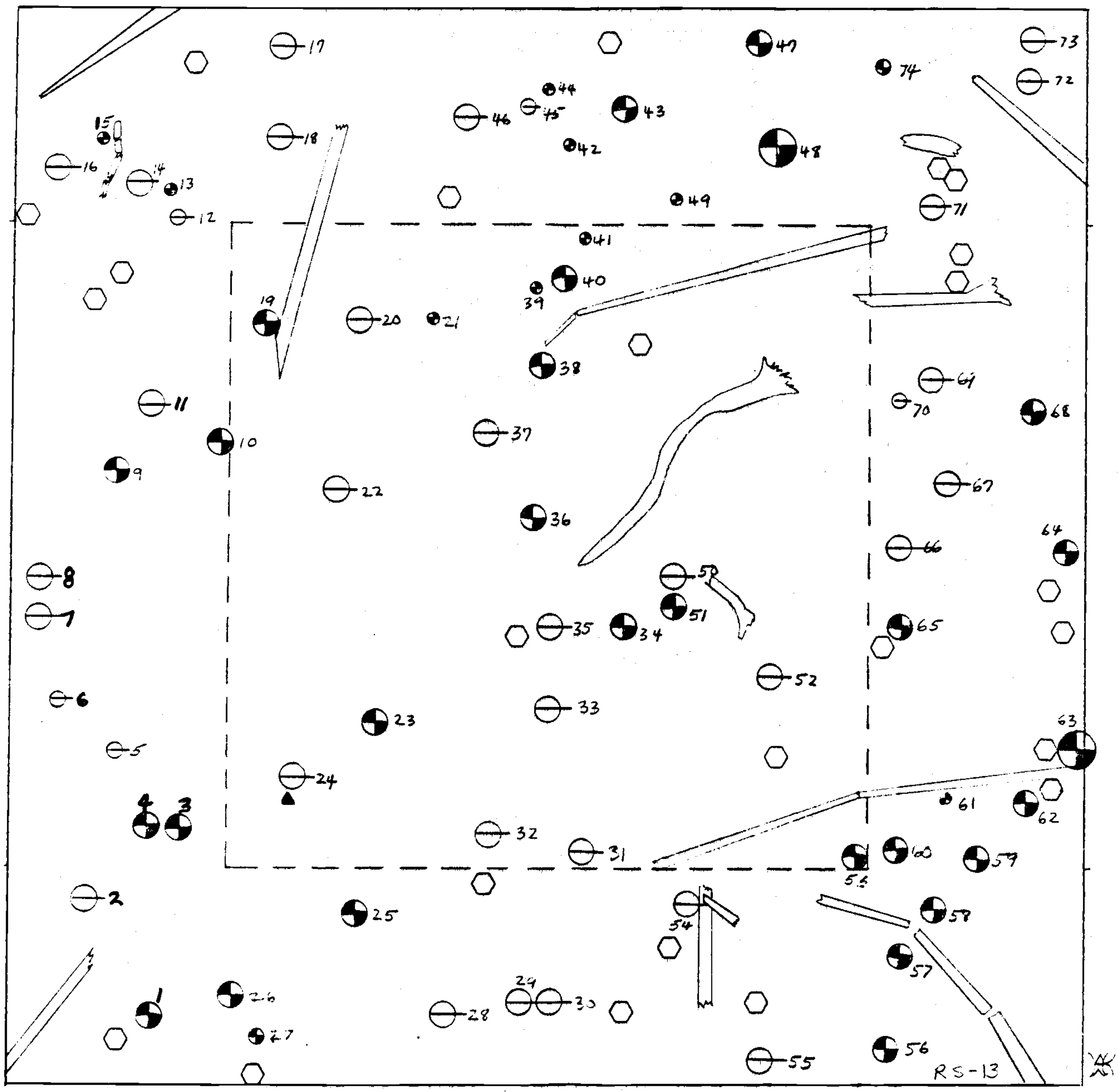
REFERENCE STAND 10



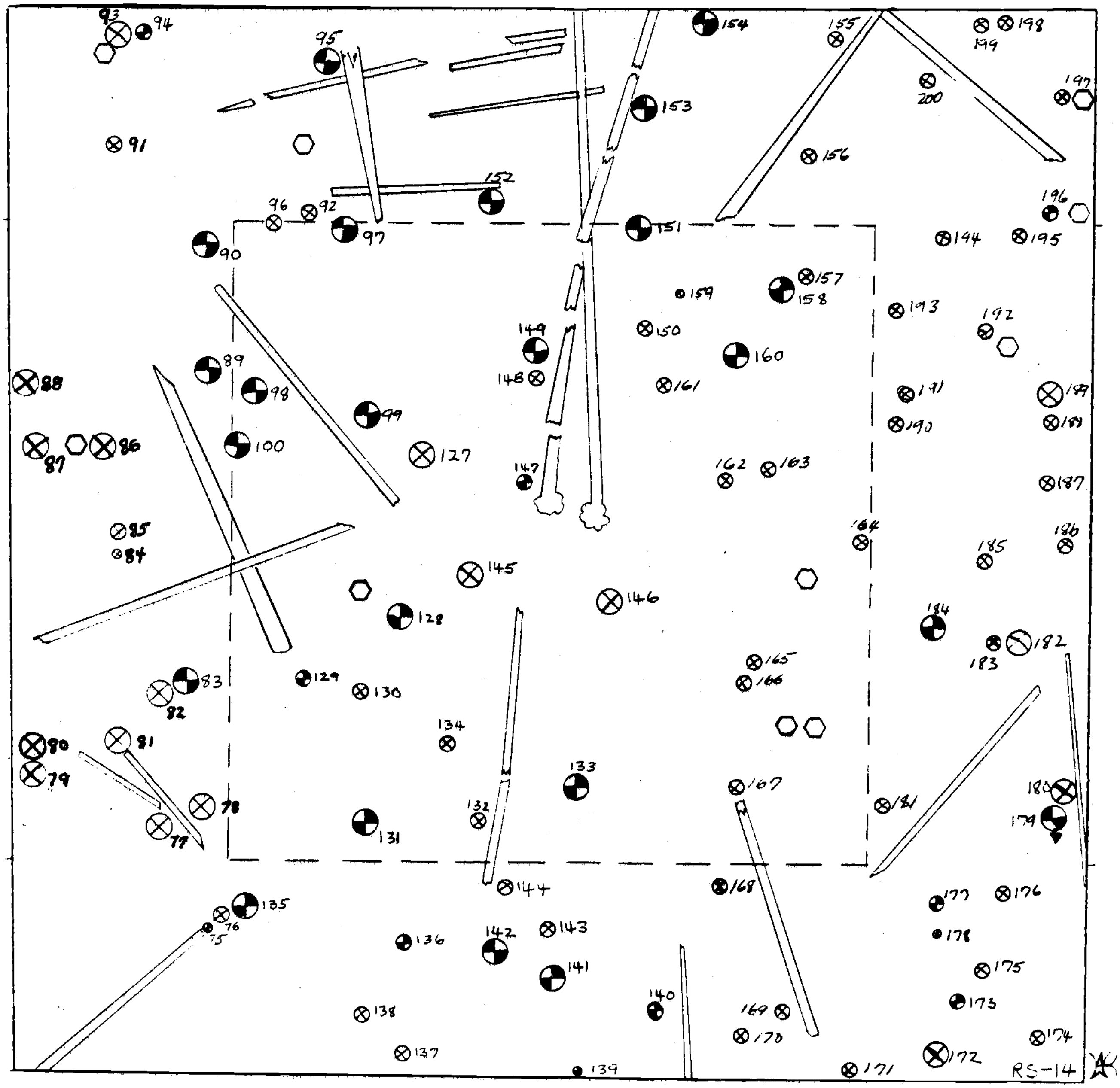
REFERENCE STAND 11



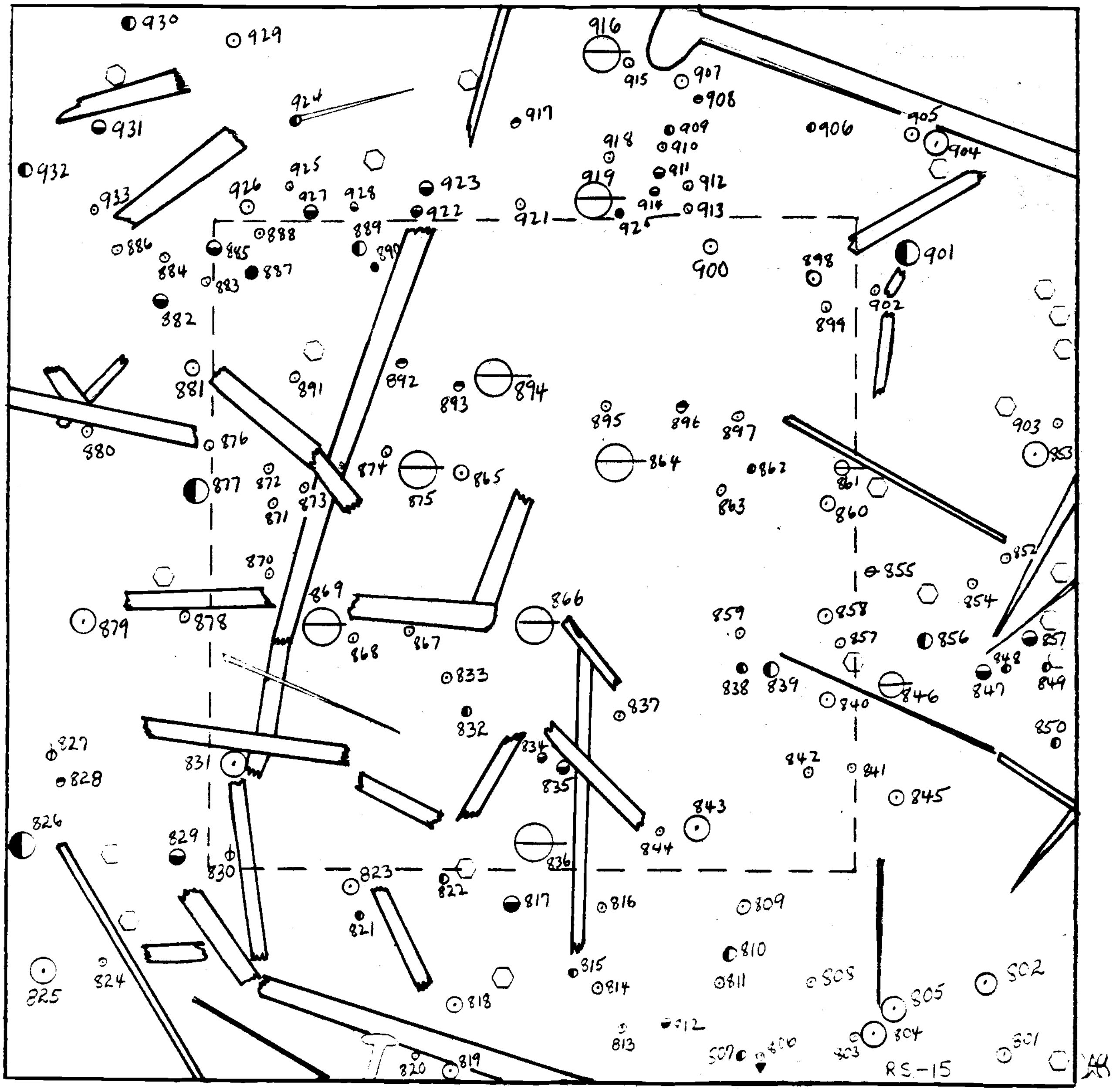
REFERENCE STAND 12



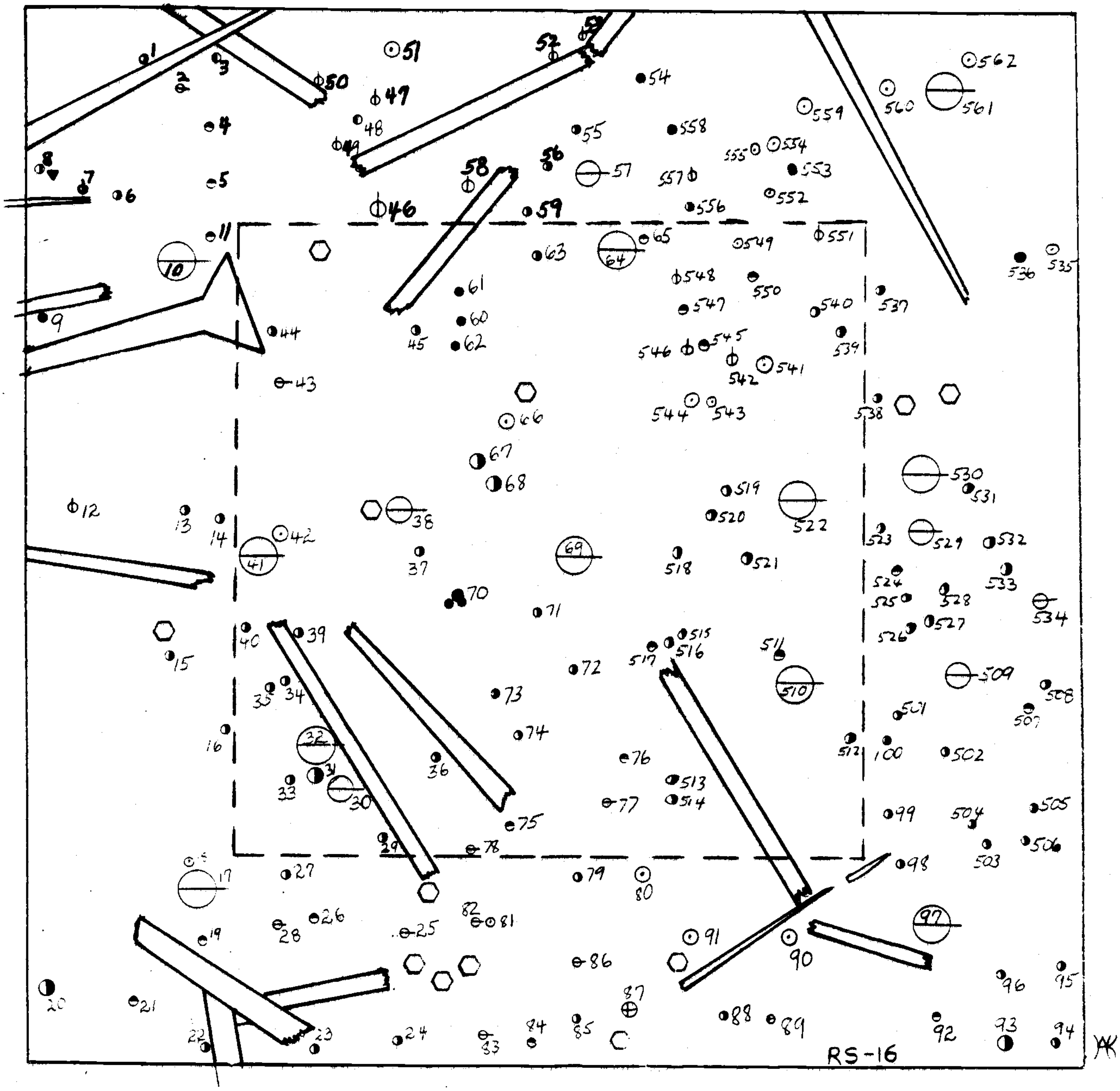
REFERENCE STAND 13



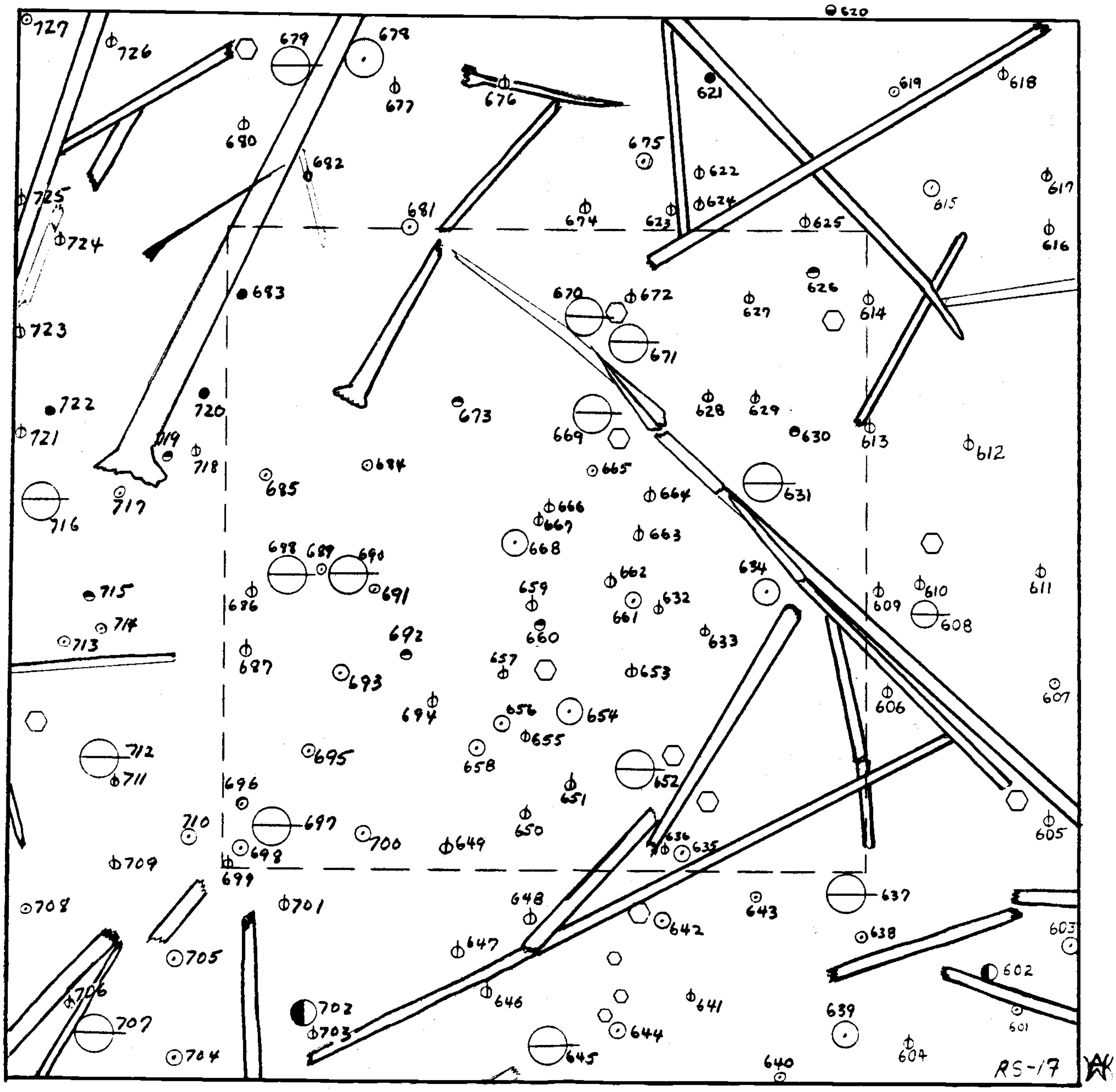
REFERENCE STAND 14



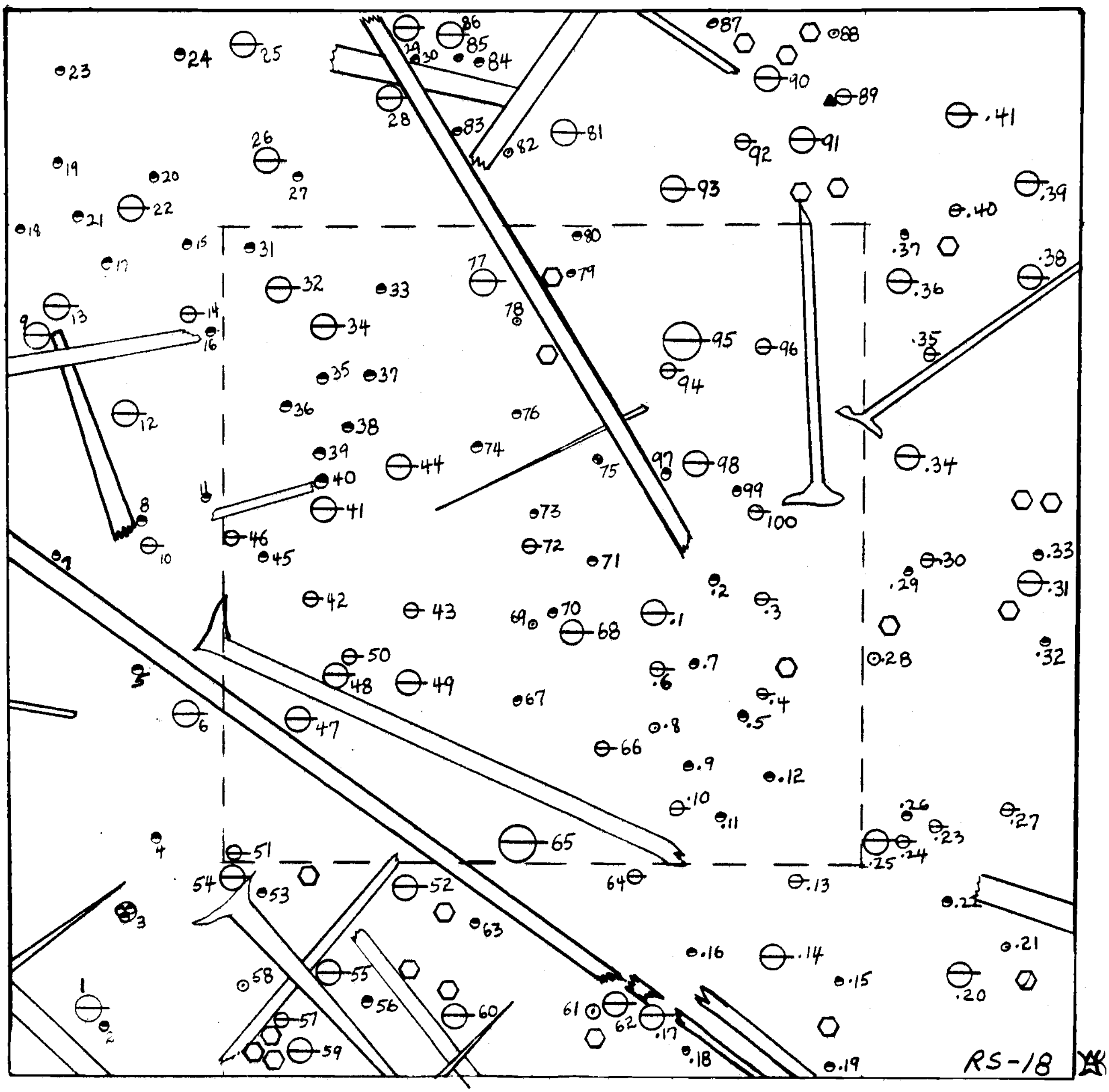
REFERENCE STAND 15



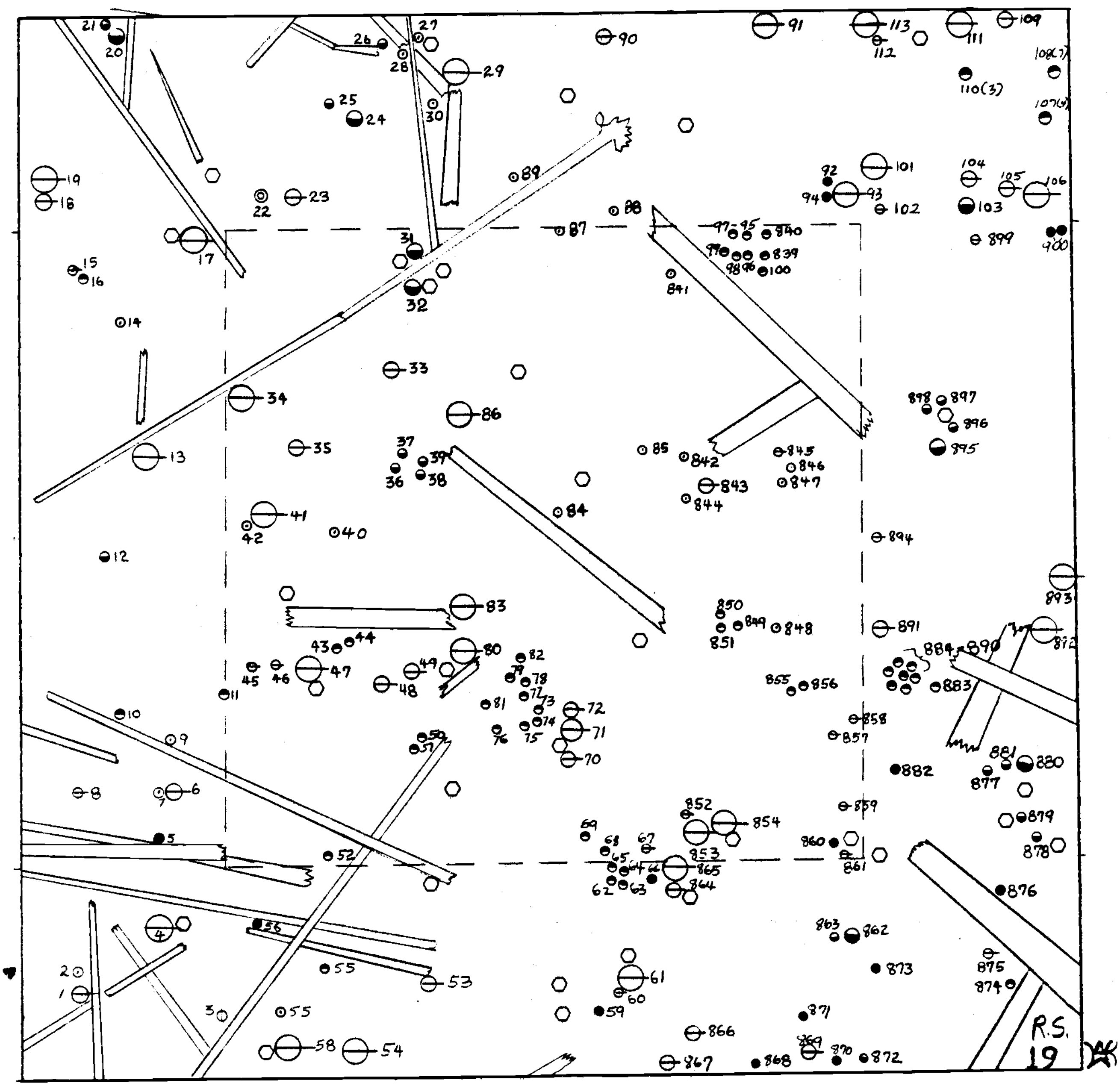
REFERENCE STAND 16



REFERENCE STAND 17



REFERENCE STAND 18



REFERENCE STAND 19