FIRST YEAR REPORT TO NATIONAL PARK SERVICE
ON STUDIES OF FOREST ECOSYSTEMS
AT MOUNT RAINIER NATIONAL PARK

April 1, 1976

by

William Moir and Jerry F. Franklin

TABLE OF CONTENTS

PREFACE

There's just not another word. The forests at Rainier are magnificent. Their presence consciously or subconsciously shapes the visitor's perceptions and moods of the Park scenery and landscapes. Who could imagine driving along the Ohanepecosh Valley without 200-foot trees curtained on either side of the highway and the sky only a thinnest slit above? Or that first view of the mountain framed and focused by forests along the White River road? Ferns glowing with yellow-green luminescence while rain and fog shroud or obscure the forest heights? The pitched trill of a varied thrush or red flash of the pileated woodpecker through columnar, hoary stems of old-growth silver fir? Magnificent! That hackneyed, overused, and trite adjective attaches comfortably and appropriately to these forests. The forests are the most extensive scenic resource at Rainier in terms of aerial coverage. They occur from the Park boundaries well onto the volcanic cone to about 5,000 feet elevation, and mantle everywhere in valleys and slopes this landscape of superlatives with a rich cloak of tall greenery. They are forests equal to the challenge of glaciers and snowfields, milky torrents, and brilliant flowered meadows. As we hike beneath these canopies we are simultaneously humbled and exalted. The presence of dripping foliage, rich aromas of fermenting litters, massive, lichen-covered trunks flood our senses and defy our numbers. We measure but even more we feel. We attach dimensions to forest types, but revel in the matchless diversity of these intricately complex ecosystems. We record data from various stands but our records fail to encompass the silent timelessness of ancient forests. We measure the girth of a patriarch, but how hopelessly inadequate is the mere number! We describe the composition of vegetation of the forest floor but not the beauty of shape, form, and pattern to be found here. But from the pungence of molding cedar and profligacy of thousands of hemlock seedlings along a fallen log, our numbers gradually emerge as a first-order approximation in witness of these miracles. We begin to appreciate the scales of pattern and diversity of Rainier's forests. We begin to perceive individual elements and botanical arrangements that comprise important themes and variations to this forest symphony. Those valley forests along the Carbon River are, we discover, subtly different from valley forests of the Nisqually not just because we can sense and feel the differences but because we can also measure them. And with these measured approximations we become even more impressed with harmony between forests and landscapes. And perhaps we can better understand why and how these forests dignify the landscapes of Rainier. How they respond to the changing land, how they heal and stabilize the raw wounds of geological convulsions, mature internally with time despite outward appearance of immutability and timelessness. And, perhaps most important, we can begin to learn procedures by which man can live with and love these forests without detracting from their magnificence.

INTRODUCTION

The study of ecosystem classification and analysis of landscape dynamics at Mount Rainier National Park (MRNP) was initiated on April 1, 1975. The initial contract was based on a prospectus (Franklin 1974) which outlined a comprehensive series of studies designed to determine the ecosystem types, map them, characterize their environmental and biological features, and determine direction and rates of change (succession).

Neither National Park or Forest Service resources were available to undertake such a grandiose effort at this time. It was decided in the spring of 1975 to initiate some of the activities outlined at a modest level, particularly the classification, biological characterization, mapping, and successional analysis of the forest ecosystems. These studies were to contribute to the total Resources Basic Inventory (RBI) for MRNP and to provide experience and data to administrators and scientists on the desirability of expanding the work in the future. The forests were chosen for the initial effort since they are the most poorly known of Mt. Rainier's ecosystems.

We have now completed the first year's efforts in the study of the forest ecosystems. The purpose of this report is to bring NPS and MRNP staff up-to-date on what we have found out and outline the direction we will take in the second year.

RESULTS IN YEAR 1

SAMPLING OF OLD-GROWTH FOREST

Field Methods

For our first season of forest sampling we decided to distribute our efforts over the entire Park rather than concentrating in any particular sector or drainage. In this manner we hoped to achieve an overview of all of the forest types even if we risked undersampling certain of the types. We also decided to limit our data gathering to relatively mature or old-growth stands and not to younger, seral stands that would eventually develop into these more mature types.

Established methods of forest sampling (e.g., Dyrness et al. 1974, Daubenmire 1968) did not appear appropriate at Mt. Rainier National Park because of the low density of massive trees in old-growth stands and very high variability of microrelief within stands that resulted in considerable vegetation patchiness or mosaics of potentially different forest community types. We needed to determine plot sizes and methods of measuring vegetation and soil characteristics. We also required some procedure that would permit the field crew to cover the entire Park in a single field season. We experimented in several contrasting forests with plots of 375, 500, and 1,000 m^2 and of rectangular or circular shapes for obtaining measures of tree density and various procedures for subsampling these plots for understory vegetation and tree seedlings. Systematic placement of quadrat frames for measuring herb and shrub cover (e.g., Daubenmire 1968) yielded poor values, we felt, under conditions of high patchiness where terrain was hummocky or uneven, but could be used to validate visual estimates of average cover of herb species in a plot of more uniform microrelief and greater vegetation homogeneity. After experimentation we settled upon circular plots of 500 or 1,000 m^2 area (depending upon mature tree density) for estimation of stem densities of trees and a smaller, concentric circular plot of 50 m^2 for counting established seedlings approximately 1 dm (ankle) height. Understory herbs and shrubs within the larger plot were estimated visually (Franklin et al. 1970) to the nearest percent of cover for each species that exhibited cover less than 10% and to the nearest 5 or 10% cover for those over about 10% cover in the plot. All trees in the plot were tallied by stem diameter at breast height to the nearest 2 inch (0.5 dm) diameter class.

A soil pit was dug in or near most plots in an area judged to contain typical understory vegetation for the stand. From each pit we made measurements of the depth and color of parent materials within the rooting zone (usually 50 cm to 1 m depth), degree of soil development, root density, texture of different horizons, and other morphological descriptions deemed appropriate. Occasionally several soil pits were examined at a given stand to judge variation in soil properties.

Other measurements at each sample location included: elevation, exposure, slope, degree of canopy closure, landform, position in landscape (lower, middle, upper slope, ridge, bench) and location on the USGS topographic map.

Plots were established in transects along trails and roads or along cross-country traverses. About 4-8 plots could be described in a workday We selected plot locations by noting significant changes in dominance relationships of plant species along transects. When these dominance relationships changed from that of a previous plot sample, we would look for a forest stand of sufficient acreage, homogeneity, and "typicalness" for another plot sample. Thus, our "bag" of plot samples for a working day usually consisted of different forest types, although sometime with replication within an extensive type. Any conspicuous or unusual features of forest stands were recorded as notes or remarks. These might include signs of browsing by elk, insect damage to trees, windthrow of large tree specimens, mosaics and ecotones with other forest types, diameters of very large trees in the stand, or estimated ages of fallen or living trees by ring counts.

Office Methods

Our data, excepting the soil profile descriptions, has been transferred to machine cards for computerized storage, retrieval, and processing.

The initial, tentative forest types were determined first by the rather painstaking process of subjectively sorting all 242 plots into subsets based upon general similarities of dominant species in each of the tree, shrub, and herb layers (Franklin et al. 1970, Dyrness et al. 1974). Many plots could not be classified by this manner, since they represented either intergrades between types or were sufficiently different in major dominance features to exclude them from any of these preliminary forest types. We used our field experience and past knowledge (e.g., Franklin 1966) of forests at MRNP to perform this first classification.

The next step will be to utilize computer techniques of vegetation classification to refine and better resolve the forest types. We are currently involved in this task, with Miles Hemstrom developing programs to process the forest data. Our programs will include:

1. Vegetation stand tables and summaries. (Now complete.)
2. Similarity matrices within and between forest types.
3. Vegetation ordination.
4. Principal component analysis of the species correlation matrix.

Our goal for the start of the 1976 field season is mainly to better resolve and clarify the tentative forest classification system. This means that we should have good definition of each forest community type together with the extent of variation of forest composition permissable within each type. We should know the environmental relationships between these types, ecotones and mosaics that are found at Mount Rainier National Park between these different types, and have practical knowledge of the kind of forest mapping units that can be used at various scales or levels of generalization and resolution.

The soils data are being treated differently by Don Hobson at Washington State University. Because of the complexity of forest soils at MRNP, correlations of soils with particular forest vegetation or site features seemed futile and meaningless. Instead, Hobson is working to classify the soils at higher levels of generality. The nature of soil parent material, degree of soil development, and landform are being used to evaluate each profile into generalized classes of soils. This work is currently in progress.

Old-Growth Communities

During the course of the first year we have collected data from 242 plots--227 stands in MRNP and an additional 15 stands located on surrounding National Forest and State park lands. The distribution of the MRNP plots by drainage are:

Ohanapecosh	62
White	43
Nisqually	42
Carbon	36
Mowich	30
Puyallup	14
Cowlitz	0
Butter Creek	0

The absence of plots in the Cowlitz is mainly a consequence of its burned-over status; it will be sampled in Year 2. The only other major area which hasn't yet been sampled is the West Fork of the White River. Numerous informal (reconnaisance-level) plots have been taken previously in Butter Creek.

The plot locations are shown on the attached map.

We have not yet done computer analyses of the data but did conduct a manual sorting and develop a tentative classification. It is not definitive but is a good start. Many community types proved to be very distinctive and were easily identified. Stands at high elevations proved most difficult to sort into groups and computer assistance is clearly needed.

At present we recognize 16 major types of mature forests in Mount Rainier National Park. They are listed in Table 1 by both common and scientific names and by the "shorthand" abbreviations derived from the scientific names. Technical summaries of each type is provided in Appendix II, a key for their field identification in Appendix I, and a narrative description of the important types in Appendix III.

Management Considerations

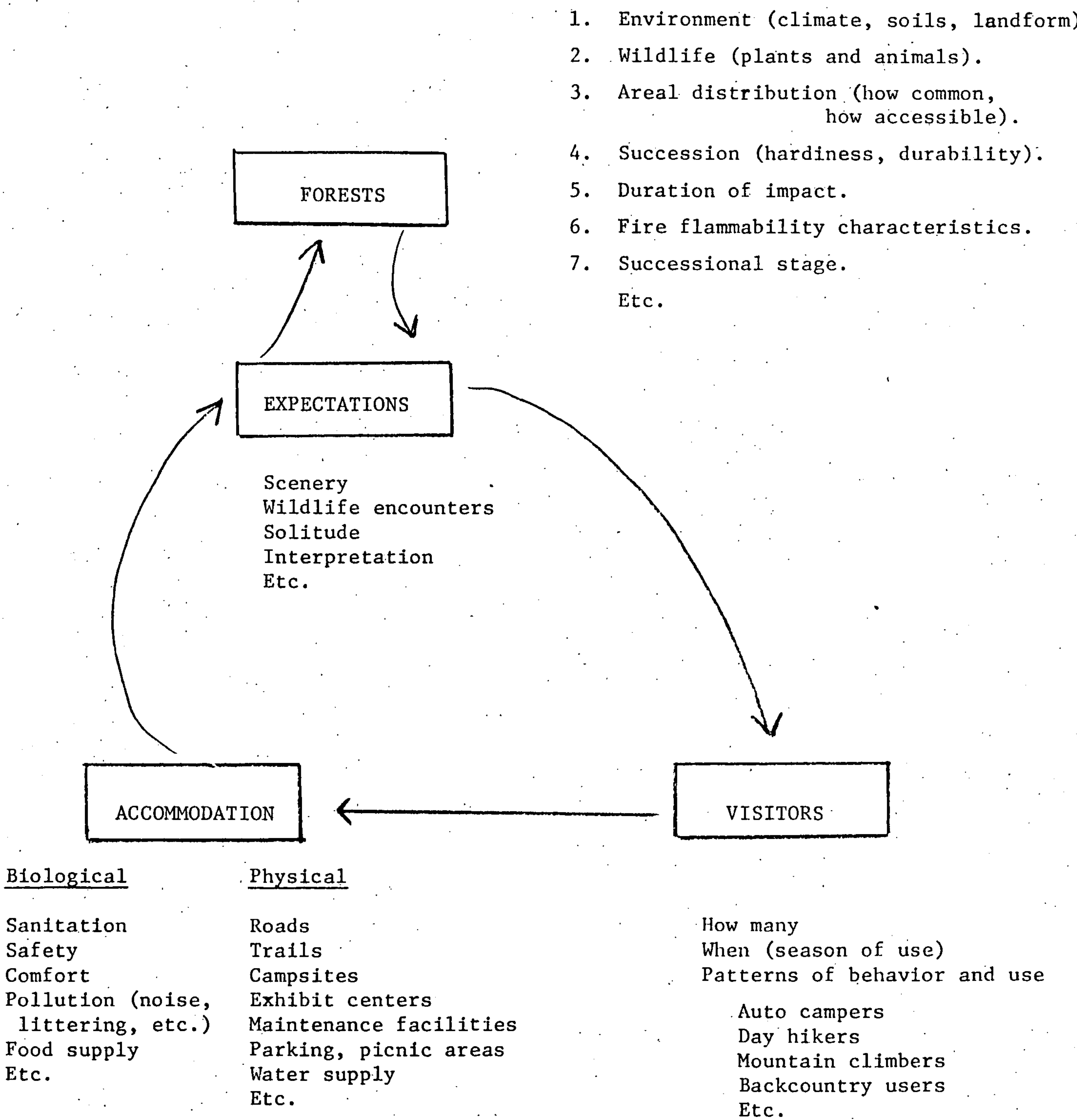
We hesitate to make specific management recommendations concerning the forest types at this early stage of study. Some of the considerations leading to management prescriptions that are compatible with the Park Services' dual objectives of visitor accommodation and preservation of the forest resources are shown in Figure A. The generalizations of Figure A indicate the necessity of recognizing different forest communities as a factor of the decision-making process. Each forest type encompasses a relatively narrow range of environmental conditions such as climate, landform, drainage patterns, and these conditions will help determine certain limitations of visitor usage and accommodation. Wildlife factors are also dependent upon forest type: seasonal concentrations of animals, rare plants or plant communities, critical breeding or foraging areas, etc. Forest types differ in their aerial extent--from the very common Silver Fir/Alaska Huckleberry type to the restricted and localized Western Hemlock/Swordfern forest. The remote, inaccessible forests, such as Western Hemlock/Salal may present little or no management complications in contrast to Silver Fir/False Huckleberry where so many backcountry users hike and camp.

Forests also present variable tolerances to visitor usage. We can recognize two important factors of forest succession in relation to different kinds of visitor (or maintenance) influences. Vegetation hardiness is the ability of a forest type to withstand or tolerate impacts without severe change. Herb dominated communities along river bottoms, for example, may have very little hardiness as campsite areas, since vegetation trampling would quickly spoil the scenic or wildlife values of this forest (Western Hemlock/Devil's Club/Oakfern type). On the other hand, salal or Oregon-grape understories on well-drained soils may have considerable hardiness to camping or hiking influences. Vegetation durability pertains to recovery of vegetation following usage, or the response of vegetation to a new management prescription. How long must a backcountry campsite be rested for acceptable revegetation? How quickly do the ferns along the Grove of the Patriarchs trail fill in a rerouted trail site?

Table 1. Forest Types of Mount Rainier National Park (Preliminary Classification).

LOW ELEVATION		
Western hemlock/salal	TSHE/GASH	Tsuga heterophylla/Gaultheria shallon
Western hemlock/vanillaleaf	TSHE/ACTR	Tsuga heterophylla/Achlys triphylla
Western hemlock/swordfern	TSHE/POMU	Tsuga heterophylla/Polystichum munitum
Western hemlock/devil's club/oakfern	TSHE/OPHO/GYDR	Tsuga heterophylla/Oplopanax horridum/Gymnocarpium dryopteris
INTERMEDIATE ELEVATION		
Western hemlock-silver fir/deerfern-swordfern	TSHE-ABAM/BLSP-POMU	Tsuga heterophylla-Abies amabilis/Blechnum spicant-Polystichum munitum
Silver fir-western hemlock/Oregongrape	ABAM-TSHE/BENE	Abies amabilis-Tsuga heterophylla/Berberis nervosa
Silver fir/Alaska huckleberry	ABAM/VAAL	Abies amabilis/Vaccinium alaskaense
Silver fir/Alaska huckleberry/trailing raspberry	ABAM/VAAL/RUPE	Abies amabilis/Vaccinium alaskaense/Rubus pedatus
Silver fir/coolwort foamflower	ABAM/TIUN	Abies amabilis/Tiarella unifoliata
Silver fir/devil's club/coolwort foamflower	ABAM/OPHO/TIUN	Abies amabilis/Oplopanax horridum/Tiarella unifoliata
Silver fir/devil's club/trefoil foamflower	ABAM/OPHO/TITR	Abies amabilis/Oplopanax horridum/Tiarella trifoliata
Silver fir/salal/beargrass	ABAM/GASH/XETE	Abies amabilis/Gaultheria shallon/Xerophyllum tenax
Silver fir-Alaska yellow-cedar/ovalleaf huckleberry	ABAM-CHNO/VAOV	Abies amabilis-Chamaecyparis nootkatensis/Vaccinium ovalifolium
HIGH ELEVATION		
Silver fir/huckleberry/beargrass	ABAM/VAME/XETE	Abies amabilis/Vaccinium membranaceum/Xerophyllum tenax
Silver fir/rustyleaf	ABAM/MEFE	Abies amabilis/Menziesii ferruginea
Silver fir/huckleberry/avalanche fawnlily	ABAM/VAME/ERMO	Abies amabilis/Vaccinium membranaceum/Erythronium montanum

Figure A.--Some elements of management decision-making in relation to forest communities at Mount Rainier National Park.



The duration of impact is also of consequence in evaluating the vulnerability of different forest types. Will the campsite be used season long for many years, opened for short intervals only, avoid heavy use during the sensitive growing season, have concentrations of visitors at berrypicking time, and so forth?

The above are primarily biological considerations of forest management. The visitors, their expectations and modes of accommodation are social factors that interplay with biological factors. Management conducts and regulates the intensity and mode of this interplay to compromise as best as various options can allow, the effects upon forest processes and visitor expectations.

The forests at Mount Rainier National Park fulfill the visitors' sense of aesthetics, serve as locales for wildlife encounters, for solitude, or for interpretative (educational) needs. Different forest types variously accommodate or satisfy these purposes. Equally important are the nature of these expectations according to the type of visitor. Auto campers, for example, may perceive forests primarily as cool, shaded, pleasant environments for social encounter with other auto campers, and their expectations are fulfilled mostly from valley forests of the major camping areas. Their impact upon forests are mostly limited by road system, parking areas, and auto campgrounds. Forests most affected are the Western Hemlock/Devil's Club/Oakfern and several Silver Fir types at intermediate elevations. By contrast, a group of Boy Scouts along the Wonderland Trail have expectations of scenery, wildlife encounters, and natural history interpretation from entirely different forest types and the impacts upon these types arise from their group behavior in backcountry camps and along high-country trails.

It is crucial to recognize that man does not partake of the forests and their environments as a naked animal. He is sheltered and cloaked in the technological bubbles of his auto, raincoat, tent, vibram-soled shoes, sanitary facility, food-stuffed picnic basket or aluminum-coated chocolate wrapper. The physical and biological buffers fall within a wide range of physical and biological accommodations. These accommodations help shape his attitudes, well-being, and expectations and are the primary instruments whereby the visitor has impact upon the forests. The physical accommodations should certainly be planned with regard to forest durability and hardiness, and effect upon such expectations as scenery or wildlife encounters. On the biological side, certain forests may present severe constraints concerning just where physical facilities such as campsites or sanitation sites can be found. One obvious example might be avoidance of deep, lingering snowpack microsites in the Silver Fir/False Huckleberry or mucky, mosquito-ridden fern communities in valley lowland forests as camp or shelter sites. The elements of planning depicted in Figure A show general relationships between biological and social factors within forest types. But we feel that our present state-of-knowledge about these forests precludes any management generalizations within any particular type. The accommodation of man within the forest ecosystems at Mount Rainier National Park are probably best approached from on-site inspection of forest vegetation, wildlife, and environmental patterns and site specific evaluations of possible solutions.

SOILS

The soils in MRNP are very complex and are almost entirely depositional in character, i.e., developed (if that term can be used) in alluvium, colluvium, mudflow deposits, glacial till, and/or ash and pumice falls. Soils are both youthful and dominated by their depositional features so that traditional concepts of soil genesis, classification, and description have limited value. The typical soil profile consists of one to ten (or more) layers of volcanic ash and pumice over colluvium, alluvium, mudflows, or till.

In any case, Don Hobson is utilizing the soils data in a Master's project at Washington State University. Since the primary purpose is a classification relevant to management needs he is basing his divisions on: (1) parent material, (2) landform, and finally, (3) genetic development. Soils with impeded drainage will receive special attention.

A preliminary breakdown Hobson has suggested is:

	Parent Material	Landform	Genetic Considerations
1.	Colluvium	Steep sideslope	None
		Toeslope	None
2.	Volcanic ash	Bench	Weak structural B
		Lowerslope	Bir
		Ridgetop	Weak structure
3.	Alluvium	Alluvial fan	A-1 horizon
		Floodplain	None
4.	Mudflow	Floodplain	None

Some exemplary soils would be: (1) mixed colluvium, steep sideslope, no development--unstable, highly erodible soil to be avoided for engineering works; (2) layered ash, valley bottom, weak structure in B horizon, well drained--good soil for human use and development with proper attention to avoid chanelling drainage; and (3) ash on midslope benches and toeslopes, strong iron pan development, impeded drainage--approach use with care, e.g., trails which would interrupt lateral flow or camping areas.

Our main concerns in soil identification and classification will be to identify parent material-landform combinations which must be approached carefully in so far as heavy human use or development is concerned.

FOREST AGES

Originally we had not planned to do much aging of forests during the first year. Studies in adjacent regions suggested some standard age classes that should be present in Mount Rainier, 650 years being the oldest of these known age classes. The Grove of the Patriarchs was known to contain specimens about 1,000 years old but this was considered to be a unique situation.

About mid-summer a situation was encountered which aroused our curiosity and got us moving on stand aging. About 3 miles above the Grove on the trail along the Ohanapecosh we encountered a down Douglas-fir that the trail crew had recently cut through. The cut was located about 100 feet above the root crown and 3- to 5-foot hemlocks and cedars were growing on it. The ring count at the point of the cut was 915 years which clearly indicates a tree 1,000 years or more in total age. Yet it appeared comparable in size and bark form to many of the live Douglas-firs scattered all through the upper Ohanapecosh.

This stimulated us to begin boring trees and counting stumps in earnest. Some of our aging is shown in Table 2. Few complete age counts were made due to the size of the trees but our observations indicate 650- and 750-year-old stands are well represented in the Park and that much of the upper Ohanapecosh drainage has probably been free of catastrophic fire for around 1,000 years. This is, incidentally, an area where numerous outstanding specimens of Douglas-fir, western hemlock, Pacific silver fir, and mountain hemlock are encountered.

The ancient state of many stands combined with the "normal" appearance of many of the stands which occur on mudflows that occurred during the last 400 years has lead us to question the frequency and importance of fire in the Mount Rainier landscape prior to 1840. Many stands are much older than we supposed based on their structure and at least some stands that would normally be interpreted as resulting from fire are first generation stands on mudflows. Most of the conspicuous burns at Mount Rainier are post-settlement and may be biasing our view of the original extent and frequency of wildfires. Wildfires (lightning set) probably were much more common in the subalpine regions than in the slopes and valleys and burned relatively smaller areas.

PROPOSED WORK FOR YEAR 2

The work proposed for the coming year is outlined in Table 3. In part we will be attempting to complete work initiated during the first year. Several new lines are proposed, however, as a consequence of Park suggestions and leads unearthed during the first year.

PARTICIPANTS

Before talking about the proposed work some mention of expected participants is in order. Dr. Jerry Franklin will continue as project leader and is expected to contribute about 3 months of his personal effort to these studies, including at least 5 weeks in the field. The major field crew will consist of three people--Dr. William Moir, Mr. Miles Hemstrom, and Ms. Sarah Lewis. Dr. Moir will function as the field leader and continue to be employed from September to March to ramrod the data analysis and reporting activities. Miles Hemstrom, a graduate student at Oregon State University will also continue to work on the analysis of the data during the winter of 1976-77 (as he is presently doing) and will select a fecet of the Rainier study for a Ph.D dissertation project. Mr. Donald Hobson (Washington State University) will probably be involved as a soil consultant and his M.S.

Table 2. Age determinations of some old-growth Douglas-firs.

Area	Tree Diameter	Core Length	Core Age	Estimated Total Age
	----- inches	----	----- years	-------
Ohanapecosh Apts.	65	24	659	750 +
West Side Trail *	70	--	--	1005 +
Grove Patriarchs Trail **	78	12	347	750
	60	12	454	825
Fryingpan Creek Trail	56	11	435	735
	38	10	580	730
Green Lake Trail *	57	--	--	550

* down tree
** not on island

Table 3.--Work planned for Year 2 of the Mount Rainier study.

Forest Classification

- Completion and field checking of the initial classification of the mature forests
- Field sampling of young (seral) forest communities
- Comparison of several analytic methods for analysis and display of the forest data
- Photographic coverage of the major forest types

Successional Analysis

- Expanded collection of data on forest stand ages
- Initiate comparative analysis of the relative importance of fire, avalanche, and geomorphic events in presettlement times
- In connection with above definition of extent and dates of wildfires at Mount Rainier

Permanent Plots

- Begin establishment of permanent plots and photo points for future measurements of rate-of-change

Forest Mapping

- Initiate mapping of the forest communities with the Ohanapecosh drainage

Effects of Management of Surrounding Lands

- Initiate analysis of probable effects of management on lands surrounding Mount Rainier forests

Soils

- Complete initial classification of the forest soils of Mount Rainier and provide management interpretations

Campgrounds

- Prepare preliminary vegetation-soil guidelines for location of backcountry camps and test them
- Collaborate, as appropriate, with Driver's studies at the Ohanapecosh and White River Campgrounds

Cooperation

- Classify the forest communities on the Wiesbrod small mammal study areas dissertation will provide us with an initial classification of the forest soils when it is completed in June. Drs. Dale Thornburg (Humboldt State University) and Jan Henderson will be utilized as consultants on the vegetation and successional research to benefit from their local expertise in the forests and meadow vegetation in and around Mount Rainier. Finally, a two-man Forest Service crew (Richard Carkin and Jack Booth) will be utilized to establish the first permanent sample plots.

FOREST CLASSIFICATION

A primary objective during the second year of the study will be to essentially complete the field sampling of the mature forests and, at the same time, field check the preliminary classification presented in this report as modified by computer runs between now and June. This should not be a difficult task since almost all portions of the Park have already been sampled excepting only the West Fork of the White River drainage. Furthermore, much of the additional sampling can be accomplished in connection with other objectives, such as the mapping.

Seral or young forest stands have been sampled infrequently to date and will receive considerably more attention during the second year. Much of this work will be accomplished in connection with the effort to define the age and extent of various wildfires.

Both the mature and seral data sets will be utilized in extensive analytic exercises during the winter of 1976-77. Specifically, we want to compare the effectiveness of several methodologies in understanding and displaying, for the manager, the nature of the forest communities at Mount Rainier. Techniques that will be used include manual (stand table), indirect gradient analysis, principal components analysis, and direct gradient analysis as applied by Kessel at Glacier. We are not only interested in understanding how the forests and plants are distributed but, ultimately, in the most useful ways of making the information available to the manager.

SUCCESSIONAL ANALYSIS

Several of our experiences during the first year have greatly intensified our interest in the relative ages of the forests and the relative importance of fire, avalanche, and geomorphic events as forest destroyers/initiators. One factor is the antiquity of much of the mature forest, at least as it appears in the glimpse our limited age data gave us; many of the stands appear to be much older than we supposed. Another factor is the "normal" appearance of many stands on youthful mudflow surfaces; stands interpretable superficially as being of even-aged origin from fires are obviously first generation stands on mudflow surfaces. The generally postsettlement age of most known wildfires are yet a third factor.

In any case, we intend to obtain much more extensive data on stand ages during the second year by increment boring, counting butt sections on windthrows (exposed by trail crews or ourselves), and stump counts in campgrounds. It is our intention to age essentially every stand we sample in the coming year.

We have, however, an even broader long-term interest than simply generating a lot of age counts. We intend to develop a fire history for the Park so that we can (a) determine fire frequency and extent in the Park during the pre-1800 and post-1800 periods and (b) determine the importance of fire, relative to other disturbances during presettlement times. In order to do this, field work during the second year will specifically include efforts to date and map the extent of major wildfires. This work should fit in well with additional forest sampling. Mapping of geomorphic disturbances and of avalanches will depend heavily upon USGS studies and aerial photographs, at least initially. Our goal is an analysis of the relative role of various disturbances in the presettlement parklands.

PERMANENT PLOTS

It is absolutely essential that permanent plots, transects and photo points be established if future managers are going to have concrete evidence of (not inferences or predictions about) rates and direction of successional change. Eventually such a system has to involve many plots, transects and/or photo points given the diversity of the Park. These would sample major forest and meadow communities, developed sites (campgrounds and trailside zones), and ecotones (e.g., forest-meadow). We will initiate this activity this year with establishment of 5 to 10 permanent sample plots in noble fir-dominated stands. This work will be done mainly by a Forest Service (PNW) crew. The methods, including plot marking, to be used are outlined in Appendix V.

FOREST MAPPING

Very little mapping was done during the first year but with completion of the initial forest and soil classification we are ready to begin. The drainage tentatively selected for the initial effort is the Ohanapecosh for a variety of reasons including its extent and importance there, abundance of large specimens and old-age forest, and convenience. It is anticipated that in June or early July the entire drainage will be flown by the Oregon Air National Guard photo-recon unit to provide 1:20,000 color infra-red photographs. Vertical, oblique and panoramic coverage will be provided simultaneously. For the summer field work will consist of ground mapping along trails, raods, and cross-country transects. During the winter, the ground truth provided by plots and this mapping will be combined with the aerial photography for mapping of the entire drainage. Field checking of the mapping will take place during the third year.

EFFECTS OF ADJACENT LAND MANAGEMENT

A major concenr of Park managment is the effect that management practices on adjacent lands are going to have on Park ecosystems. To a degree this can take the form of examining biological integrity of a natural island in an ocean of lands heavily committed to logging and forest management. We are not prepared at this point to apply existing theory on the possibility of preserving overall biotic and genetic diversity at Rainier. We will initiate a specific analysis of the potential effects of land management practices (mainly logging) around the Park on forests around the margin of the Prk. A major part of this effort will be identification of those of those areas within the Park where clearcutting on adjacent lands may (a) result in accelerated windthrow, (b) cause soil erosion on water quality problems within the Park, or (c) accelerate invasion of exotic species or alterations in the numbers of endemic species (e.g., coyotes, elk, marmots). In connection with (a) we will make predictions about the types of alterations in appearance, visit enjoyment, and composition of Park stands that would be associated with accelerated windthrow. We will begin our analysis along the west boundary of the Park, which is most exposed.

SOILS

Extensive soil sampling and mapping (separate from the community mapping) is not planned for the second year. We will be in the process of (a) digesting the classification which should be completed by Hobson in June and (b) developing management interpretations of the soils based upon their properties and the experience on adjacent National Forest properties. We will continue to collect some soils data on new plots using Hobson's classification and, possibly, obtain one or two more monoliths. We will also use the soils criteria in developing the guidelines for location of backcountry camps.

CAMPGROUNDS

Our primary objective during Year 2 will be to develop some vegetation-soil-landform guides for location of backcountry camps that can be used by Park staff and to try these out in a test area. This activity is one the Park staff has encouraged and we will be making our first try at it this year. Guides will be constructed based on the resilience of the vegetation and soil, i.e., our estimates of its ability to withstand heavy use without rapidly deteriorating, and then tempered with considerations of aesthetics, water supply, etc. in applying them on the ground. We believe vegetation and soils have a major contribution to make to camp selection criteria and are ready to take a crack at it.

What will be done on developed campgrounds will depend upon any contracts between Dr. Charles Driver and the Park Service. We will attempt to augment any work that he does and will definitely examine the cut tree stumps at White River and Ohanna to determine (a) total age and (b) deterioration in growth areas associated with the development and increasing use of the sites. Establishment of permanent plots inside and adjacent to the campgrounds (as check areas) are possibilities as are suggestions on materials and methods the Park Service can use in overused areas.

COOPERATION

At a minimum we will collaborate with Dr. Richard Wiesbrod in classification of the community types on his small mammal sampling areas and in analysis of relationships between our vegetation types and small mammal species distribution.

PRODUCTS

We expect at least one thesis (Hobson) and one major manuscript on the forests to have been completed during Year 2 of the study. We will continue to provide the Park staff with current information on our findings by way of personal communication, the annual report, and other interim reports. We should have as good data of forest ages, relative importance of fire and other disturbances, and effects of use of adjacent properties on the Park by the end of Year 2 as we have for mature forests at present although these projects will not be complete at that time. Tentative guidelines for backcountry camps will have been prepared, tried and revised before the summer of 1977, and a first-order classification and interpretation of soils available.

APPENDIX I. KEY TO THE FOREST TYPES

1. Silver fir regeneration absent, accidental, or minor, appreciably less than other tree species (but see also 18) ... 2
1. Silver fir regeneration from light to high density, but when light at least about equal in density to western hemlock regeneration ... 7

2. Shrubs (except sometimes vine maple) of only minor contribution to understory cover ... 3
2. Shrubs (especially salal, devil's club or Oregongrape) comprising major proportion of understory cover ... 4

3. Ferns dominant elements of the herb layer: TSHE/POMU
3. Angiosperms (vanillaleaf, evergreen violet, etc.) dominant in herb layer: TSHE/ACTR

4. Devil's club common in understory; forests of bottomlands or wet lower slopes: TSHE/OPHO/GYDR
4. Devil's club minor at best; forests of slopes ... 5

5. Salal a dominant shrub; swordfern and deerfern absent or minor: TSHE/GASH
5. Salal absent or minor; swordfern or deerfern at least 1 % cover ... 6

6. Combined cover of dominant ferns over 10%: TSHE-ABAM/BLSP-POMU
6. Combined cover of dominant ferns under 5%: TSHE/BENE

7. Ground flora mainly herbaceous (excluding beargrass) with total herb cover greatly exceeding total shrub cover (excluding vine maple) ... 8
7. Understory primarily shrubby, or shrubs and herbs about equal in cover composition ... 10

8. Ferns dominant: TSHE-ABAM/BLSP-POMU
8. Angiosperms dominant ... 9

9. Avalanche lily absent or minor; noble fir often in high proportion of the canopy: ABAM/TIUN
9. Avalanche lily common; noble fir absent: ABAM/VAME/ERMO

10. Huckleberries dominant or codominant elements of the shrub flora ... 17
10. Huckleberries of only minor contribution to shrub cover ... 11

11. Devil's club conspicuous; habitats wet and herb-rich ... 12
11. Devil's club absent or minor ... 14

12. Alaska-cedar with abundant advanced regeneration; ovalleaf huckleberry the leading huckleberry: ABAM-CHNO-TSHE/VAOV/TIUN
12. Alaska-cedar regeneration minor or occasional at best; ovalleaf huckleberry not more abundant than other vacciniums or, if so, then rustyleaf cover less than 10% ... 13

13. Coolwort foamflower considerably more important than trefoil foamflower: ABAM/OPHO/TIUN
13. Trefoil foamflower considerably more important than coolwort foamflower: ABAM/OPHO/TITR

14. Beargrass dominant or codominant ... 15
14. Beargrass absent, minor, or at best subdominant ... 16

15. Salal codominant: ABAM/GASH/XETE
15. Salal minor or with cover less than big huckleberry: ABAM/VAME/XETE

16. Cover of swordfern plus deerfern greater than about 20% or exceeding the cover of other herbs: TSHE-ABAM/BLSP-POMU
16. Cover of swordfern plus deerfern less than about 5% or less than the cover of other herbs; forests of rather sparse understories: ABAM-TSHE/BENE

17. Red huckleberry the leading huckleberry ... 18
17. Alaska, ovalleaf or big huckleberries the leading huckleberries ... 19

18. Salal absent or minor: ABAM-TSHE/BENE
18. Salal dominant or codominant: ABAM/GASH/XETE

19. Alaska huckleberry the leading huckleberry ... 20
19. Ovalleaf or big huckleberry leading huckleberries ... 21

20. Strawberry-leafed blackberry often dominant to subdominant in the herb assemblage; species of twistedstalk may also be very common: ABAM/VAAL/RUPE
20. Strawberry-leafed blackberry mostly rather minor; twistedstalk absent or infrequent: ABAM/VAAL

21. Ovalleaf huckleberry cover exceeding about 5% ... 22
21. Ovalleaf huckleberry cover less than about 5% ... 23

22. Alaska-cedar and western hemlock with common advanced regeneration: ABAM-CHNO-TSHE/VAOV/TIUN
22. Either Alaska-cedar or western hemlock with infrequent advanced regeneration: ABAM/MEFE

23. Rustyleaf or azalea codominant in shrub assemblage; beargrass minor: ABAM/MEFE
23. Rustyleaf or azalea either minor, or if not, then either beargrass or avalanche lily common ... 24

24. Beargrass common: ABAM/VAME/XETE
24. Beargrass absent or infrequent: ABAM/VAME/ERMO

APPENDIX II. SYNOPSIS AND SUMMARIES OF THE FOREST TYPES

1. TSHE/GASH — *Tsuga heterophylla/Gaultheria shallon*

Western hemlock/Salal

Overstory dominated by *Pseudotsuga menziesii* or sometimes *Tsuga heterophylla*; the tree regeneration is usually light and consists mainly of *Tsuga heterophylla* with *Pseudotsuga menziesii* less frequent. Other tree species are minor or accidental.

The understory is conspicuously shrubby. *Gaultheria shallon* ranged from 15 to 85 percent in our plots. Other important shrubs included *Acer circinatum* (0 to 60 percent cover), *Berberis nervosa*, and *Vaccinium parvifolium*. Shrubs usually within our plots (high constancy) but of minor cover included *Amelanchier alnifolia*, *Symphoricarpos mollis*, *Vaccinium membranaceum*, *Rubus ursinus*, and *Taxus brevifolia*.

Herbs are less important than shrubs. Except for occasional high cover of *Achlys triphylla* (up to 30 percent), the total herb cover was mostly under 20 percent. Principal species included *Trientalis latifolia*, *Linnaea borealis*, *Viola sempervirens*, *Chimaphila umbellatum*, *Goodyera oblongifolia*, or *Pteridium aquilinum* but none of these are particularly restricted to this community type.

This forest type is most extensive on moderate to steep slopes of the Ohanapecosh Formation at low elevations (1800 to 2900 ft.). However, similar vegetation also was found in the Mowich and Carbon River drainages. Soils are generally colluvial or ashy and lack development or have weak structural or iron-illuvial B horizon. At some plots the solum was shallow over bedrock.

We regard this community to reflect the hottest, driest forest environment at Mount Rainier National Park.

2. TSHE/ACTR — *Tsuga heterophylla/Achlys triphylla*

Western hemlock/Vanillaleaf

Overstory dominated by mixtures of *Pseudotsuga menziesii*, *Tsuga heterophylla*, and *Thuja plicata*, but tree regeneration mostly by *Tsuga heterophylla* with *Abies amabilis* at best a distant second.

Acer circinatum may be conspicuous in tall shrub understory (up to 60 percent cover), but other shrubs are infrequent or of minor cover (Berberis nervosa achieved 5 percent in one plot).

Herbs are the most conspicuous element of the ground vegetation. Principal species are *Achlys triphylla* (4-80 percent cover), *Viola sempervirens* (1-30 percent cover), *Cornus canadensis*, *Tiarella unifoliata*, and *Linnaea borealis*. Herb cover can decline relative to mosses of the forest floor in shaded phases of this community type. Reduction of light intensity under nearly closed forest canopies can lead to ground mosses approaching 90 percent or more of the forest floor cover and vascular herbs reduced to 10 percent or less cover.

Our plots were on terraces, benches, and lower slopes of the Ohanapecosh River at low elevations. Soils of either alluvial or colluvial parent materials either lacked development or show only weak development of either A1 or B horizons.

These forest environments are interpreted tentatively as warm, mesic environments.

3. TSHE/POMU — Tsuga heterophylla/Polystichum munitum

Western hemlock/Swordfern

Mixtures of Pseudotsuga menziesii, Tsuga heterophylla, and Thuja plicata in overstory, but Tsuga heterophylla clearly the leading regeneration (Thuja plicata and Abies amabilis minor or absent).

Berberis nervosa ranges from trace to 20 percent cover. Taller understory shrubs might include Acer circinatum or Taxus brevifolia.

Ferns dominate the herb layer: primarily Polystichum munitum (5-40 percent cover), occasionally Gymnocarpium dryopteris (to 15 percent cover).

Examples of this community occurred at low elevations (1800-2300 feet) along the Carbon and White Rivers on lower slopes of ash, colluvium or (plot 132) alluvial terraces.

The environment is probably relatively warm and mesic, similar to Tsuga heterophylla/Achlys triphylla. The community type is common outside the Park (e.g., plot 208 at Federation Forest State Park) but just barely occurs within Mount Rainier National Park boundaries. It is doubtless an extensive type of the commercial forests of the Washington Cascades.

4. TSHE/OPHO/GYDR — Tsuga heterophylla/Oplopanax horridum/Gymnocarpium dryopteris

Western hemlock/Devil's Club/Oakfern

Thuja plicata, Tsuga heterophylla, and Pseudotsuga menziesii are common trees of the dominant canopy. Other mature trees sometimes include Picea sitchensis (Carbon River entrance), Abies grandis, Populus trichocarpa, Acer macrophyllum, and Alnus rubra. Tree regeneration is found especially along the Nisqually River. The Grove of the Patriarchs belongs to this community type--this forest is essentially stagnant (having very little tree regeneration).

Conspicuous shrubs include Oplopanax horridum, Acer circinatum, and Rubus spectabilis. Many other shrub species occur within this type, however, including Vaccinium parvifolium, Taxus brevifolia, Sambucus, and shrubby forms of Alnus rubra.

Herbaceous cover is almost always quite remarkable, and can vary among many dominant species including Gymnocarpium dryopteris, Polystichum munitum, Oxalis oregana, Cirsium alpina, Tiarella trifoliata, Tiarella unifoliata, and Achlys triphylla. Other common herbs include Viola glabella, Tolmiea menziesii, Equisetum fluviatile, Athyrium filix-femina skunk cabbage, Corydalis scouleri, and many others. This is one of the most floristically diverse forest habitats at Mount Rainier National Park, and certainly one of the richest in terms of number of plant species found in the understory.

Sites are usually alluvial or mudflow surfaces along major drainages and valleys with fine-textured soils either lacking development or with A1 horizons. We suggest these forests, at low elevation (1700-2200 feet) to be of the warmest and wettest environments in the Park.

5. TSHE-ABAM/BLSP-POMU Tsuga heterophylla-Abies amabilis/ Blechnum spicant-Polystichum munitum

Western hemlock-Silver fir/Deerfern-Swordfern

Canopy dominated by mature Tsuga heterophylla; Pseudotsuga menziesii infrequent. Regeneration conspicuously by Tsuga heterophylla; Abies amabilis ranging from dense to sparse reproduction.

Shrub layer consists of Berberis nervosa (up to 20 percent), vaccinium parvifolium (1-5 percent), and Taxus brevifolia (to 2 percent) with sporatic occurrence of other species.

Ferns exhibit a showy ground display. Polystichum munitum, Blechnum spicant, and Gymnocarpium dryopteris are the main species. Other locally common herbs are Viola sempervirens, Tiarella trifoliata, and Achlys triphylla.

Our plots are on northerly lower slopes of the Carbon and Mowich drainages from 2200-2900 feet. Soils are colluvial or ashy and have a weak iron-illuvial horizon. The environment is tentatively suggested as relatively cool and mesic.

This is a rather limited forest type at Mount Rainier National Park, but is noteworthy by the dominance of ferns on the forest floor. Shaded phases of this type may occur on slopes of intermediate elevations (e.g., plot 186) with pronounced diminution of herb cover and greater relative cover of mycotrophic flora (Coralorrhiza, Allotropa). Mosses seldom achieve any importance over the litter mantle of these shade-phase stands.

6. ABAM-TSHE/BENE — Abies amabilis-Tsuga heterophylla/ Berberis nervosa

Silver fir-western hemlock/Oregongrape

Canopy dominated by Pseudotsuga menziesii, Thuja plicata, and occasional Abies procera. Regeneration dominated by either or both of Tsuga heterophylla and Abies amabilis.

The most constant understory shrub is Berberis nervosa with cover varying from about 1 percent to 35 percent. Acer circinatum or Taxus brevifolia may be locally dominant. Other shrubs include Vaccinium parvifolium (up to 10 percent cover), Vaccinium membranaceum, Pachistima myrsinites, Rosa gymnocarpa, and Vaccinium alaskaense. The total shrub cover is generally rather sparse, however, averaging about 20 percent, almost half of which can be attributed to Berberis nervosa.

Herb cover also usually sparse, averaging about 10 percent. Constant species include Clintonia uniflora, Chimaphila umbellata, and Goodyera oblongifolia. Others of occasional dominance among the herb assemblage includ Achlys triphylla, Linnaea borealis, , and Viola sempervirens.

This forest occurs on mostly steep, colluvial or ashy slopes of the Ohanapecosh, White River, and Puyallup drainages (and locally in other drainages) between 3100-4400 feet. At lower elevations Abies amabilis regeneration density declines markedly (plots 46, 140, 193). Soils may lack development or have weak structural B horizons.

The forest environment appears to be relatively cool, seasonally dry, and with rather low understory light intensity (from canopy closure by dominant trees).

7. ABAM/VAAL — Abies amabilis/Vaccinium alaskaense

Silver fir/Alaska huckleberry

Mature trees generally mixtures of Tsuga heterophylla and Abies amabilis with occasional Pseudotsuga menziesii and, less often, Thuja plicata or Chamaecyparis nootkatensis. Regeneration is dominated by Abies amabilis, often with high density, and includes Tsuga heterophylla as a co- or subdominant.

Understory characteristically shrubby with mixtures of Vaccinium. The dominant is usually Vaccinium alaskaense, but Vaccinium membranaceum, Vaccinium ovalifolium, or Vaccinium parvifolium may sometimes be co-dominant. Acer circinatum may be absent or present to 60 percent cover; Taxus brevifolia is similarly of sporatic occurrence.

Herb cover averages about 10 percent (ranging from 2-20 percent). The most constant species are Linnaea borealis, Cornus canadensis, Rubus lasiococcus, Chimaphila umbelata, Goodyera oblongifolia, and Pyrola secunda.

Soils are deep and well-drained (except plot 68). Parent materials include colluvial mixes of volcanic rocks and ash, layered ash tephras, and alluvial deposits. Profiles may lack soil development or have moderate to conspicuous iron-illuvial horizons.

This is the most common forest at intermediate elevations (2100-4100 feet) of the Ohanapecosh, White and Nisqually drainages on various slopes, exposures, and landforms. It is replaced by the Abies amabilis/Vaccinium alaskaense/Rubus pedatus forest in the Carbon and Mowich drainages. The environment is probably modal (moderate regime of both temperature and moisture) for this elevational range. The Abies amabilis/Vaccinium alaskaense forest types are also extensive in the Abies amabilis zone of other Cascade Mountains (Franklin 1966).

8. ABAM/VAAL/RUPE — Abies amabilis/Vaccinium alaskaense/Rubus pedatus

Silver fir/Alaska huckleberry/trailing raspberry

This forest is very similar to the preceding one except as follows:

(1) Vaccinium ovalifolium and Menziesii ferruginea are more frequent and dominant, and (2) the herb layer is better developed. Conspicuous increasers are Rubus pedatus and Similacina stellata whereas Linnea borealis is less important.

Common to the Carbon and Mowich River drainages on slopes and valleys between 2800-4100 feet, this forest, like the related Abies amabilis/Vaccinium alaskaense type is also of modal environments. (What this implies is that other forests at these elevations are either of drier-hotter or cooler-wetter sites.)

9. ABAM/TIUN — Abies amabilis/Tiarella unifoliata

Silver fir/Trefoil foamflower

Canopy dominated by Tsuga heterophylla, Abies procera, Pseudotsuga menziesii, and Abies amabilis with understory tree regeneration mostly of Abies amabilis. Some stands are nearly pure Abies procera in mature size classes.

The vegetation of the understory is herbaceous, often with total herb cover well over 50 percent. The major species are Achlys triphylla, Tiarella unifoliata, Clintonia uniflora, Viola sempervirens, and Stretopus roseus.

These forests are often between 3600-4800 feet elevation on warm (south- or west-facing) slopes. The deep, well-drained soils, either of colluvial mixed mineralogy or of layered tephra deposits, show good development of A2/B2ir horizons. This appears to be optimal habitat for noble fir at Mount Rainier National Park. Stands occupy environments that we provisionally identify as thermally moderate (or warm for this elevation) and mesic.

This forest is of particular interest to Park visitors because of excellent growth and form of noble firs. The bluish canopies can be seen from afar as, for example, the conspicuous rectangular pattern of pole-sized noble fir below Sunrise Ridge as viewed along the highway north of Cayuse Pass. Many noble fir stands seem to have originated as result of prehistoric crown fires sweeping along warm slopes.

10. ABAM/OPHO/TIUM — Abies amabilis/Oplopanax horridum/Tiarella unifoliata

Silver fir/Devil's club/Coolwart foamflower

Canopies dominated by Abies amabilis and Tsuga heterophylla, and occasional Pseudotsuga menziesii or Thuja plicata (rarely Picea engelmannii). Regeneration mostly of Abies amabilis.

Conspicuous Oplopanax horridum dominates the understory, while Rubus spectabilis and Rubus lacustre are also common shrubs. A very rich herb assemblage includes Achlys triphylla, Tiarella unifoliata, Clintonia uniflora, Stretopus roseus, Gymnocarpium dryopteris, and Athyrium filix-femina, among the more common plants but numerous other species too. Total herb cover exceeds 50 percent and more typically approaches 100 percent.

These are the forests of lower slopes, benches, and streamside terraces of the Ohanapecosh, White, and Nisqually drainages at intermediate elevations (2200-4200 feet). They prevail commonly on alluvial, mudflow, and glacial drift surfaces. Seeps, rivulets, small creeks, and shallow subsurface drainage are common on the valley slopes. Several stands appear of remarkable antiquity especially in the upper Ohanapecosh drainages. Here large specimens of Pseudotsuga menziesii may exceed 1000 years. Elsewhere near climax stands of Abies amabilis, with mature specimens over 48 inches d.b.h. are found. Major trails (such as the East Side Trail, Wonderland Trail up Fryingpan Creek) pass through excellent stands of this forest, as do scenic road segments (such as the West Side Road to Round Pass). Thus the visual presence of this forest type contributes to visitor appreciation of Rainier scenery primarily by way of canopied drives and trails and occasionally by framing focal or feature landscapes with views along river corridors or of the Rainier summit.

These valley bottom forests are also important, especially at certain locations along migration routes, for elk. The plethora of shrub and herb species constitute important food resources for these animals, and makes this valuable wintering habitat.

11. ABAM/OPHO/TITR — Abies amabilis/Oplopanax horridum/Tiarella trifoliata

Silver fir/Devil's club/Trefoil foamflower

This forest is analogous to the Abies amabilis/Oplopanax horridum/ Tiarella unifoliata type, but is peculiar to the Carbon and Mowich Rivers where it fringes the major rivers and tributaries along alluvial and mudflow terraces. The forests occur between 2200-3200 feet. Both Abies amabilis and Tsuga heterophylla are important trees of the canopy and understory structure.

The principal distinctions from Abies amabilis/Oplopanax horridum/ Tiarella unifoliata are:

(1) Increased importance of Vacciniums in the shrub assemblage, and
(2) Shifts in composition of herb dominance to include as the most important plants: Tiarella trifoliata, Blechnum spicant, and Rubus pedatus.

Other vegetative features of this forest type are similar to the Abies amabilis/Oplopanax horridum/Tiarella unifoliata, including rich herb diversity and dominance of the shrubs by Oplopanax horridum and Rubus spectabilis. The forests occur on similar landform and soils. We tentatively assign both types to cool, wet environments of the intermediate elevations at Mount Rainier National Park.

12. ABAM/GASH/XETE — Abies amabilis/Gaultheria shallon/ Xerophyllum tenax

Silver fir/Salal/Beargrass

Tsuga heterophylla, Pseudotsuga menziesii, and Thuja plicata in mixed composition with regeneration principally of Tsuga heterophylla but light or moderate density of Abies amabilis. Occasional seral species also include Pinus monticola, Chamaecyparis nootkatensis, and Abies procera.

The important understory shrubs are Gaultheria shallon (6-85 percent cover), Berberis nervosa (1-10 percent), Vaccinium parvifolium (1-25 percent), and Vaccinium alaskaense. Acer circinatum is seldom present.

Xerophyllum tenax ranges from 1-50 percent cover. Other herbs of high constancy are Chimaphila umbellatum and Linnaea borealis. The number of understory vascular plant species is typically low.

These are forests of mostly southerly slopes or ridges in the Nisqually, Puyallup, and Mowich drainages at intermediate elevations (3300-4300 feet). Soils are undeveloped or have weak structural B horizons developed from ash or ash-volcanic rock mixed colluvium. They are deep and well-drained. Topography and aspect at this elevational range suggest these forests to be of warm, dry environments grading at higher elevations into environments of the following forest type.

13. ABAM/VAME/XETE — Abies amabilis/Vaccinium membranaceum/Xerophyllum tenax

Silver fir/Big huckleberry/Beargrass

Usually open or semi-open stands dominated in many (but not all) stands by Tsuga heterophylla with mixtures of Pseudotsuga menziesii and Abies amabilis. Sometimes Abies lasiocarpa occurs in significant density. Tsuga heterophylla or Chamaecyparis nootkatensis are occasionally found but replace Tsuga heterophylla as canopy dominants in some stands. Young or advanced regeneration is dominated by Abies amabilis (often with moderate to high density) and may include fair proportion of Tsuga heterophylla or Chamaecyparis nootkatensis.

Ground cover is mostly of Vaccinium membranaceum (averaging 23 percent cover) and Xerophyllum tenax (averaging 30 percent cover). Lesser amounts of Vaccinium alaskaense, Vaccinium ovalifolium, Menziesia ferruginea, and Rhododendron albiflorum are usually found. Gaultheria shallon is generally absent but sometimes has cover from 3-7 percent. Common herbs include Rubus lasiococcus, Linnaea borealis, and Clintonia uniflora.

Fire appears of rather frequent periodicity in this forest since few mature stands were found at Mount Rainier National Park. The forests are of high elevation (3800-5100 feet) upper slopes and ridges often of warm (south or west-facing) exposures. Soils of ash or colluvial parent materials vary from poor to good horizon development. They are well-drained and lack iron induration. The environment is judged to be cool and seasonally dry relative to other forest environments in the Park.

14. ABAM-CHNO-TSHE/VAOV/TIUN — Abies amabilis-Chamaecyparis nootkatensis-Tsuga heterophylla/Vaccinium ovalifolium/Tiarella unifoliata

Silver fir-Alaska-cedar-Western hemlock/Ovalleaf huckleberry/Coolwart foamflower

Semi-open forests dominated by mixed Abies amabilis-Chamaecyparis nootkatensis-Tsuga heterophylla. These species also exhibit advanced regeneration, and Abies amabilis is the leading species of young regeneration.

These are forests of wet benches in the White, Mowich, and Nisqually drainages and doubtless elsewhere at Mount Rainier National Park. Vaccinium ovalifolium and Menziesia ferruginea are important shrubs. Oplopanax horridum may be absent or present with cover ranging between 0-15 percent. The herb layer is rich and diverse. The most common species are Tiarella unifoliata, Gymnocarpium dryopteris, Clintonia uniflora, Streptopus roseus, Viola glabella, Streptopus amplexifolius, Equisetum fluviatile, Rubus pedatus, Habenaria saccata, and Achlys triphylla.

15. ABAM/MEFE — *Abies amabilis/Menziesia ferruginea*

Silver fir/Rustyleaf

These are forests of rolling uplands, benches, terraces, and slopes of higher elevations in all the drainage systems. The most important species of both overstory and regeneration is *Abies amabilis*, but *Chamaecyparis nootkatensis*, *Tsuga heterophylla*, and *Tsuga mertensiana* are usually represented by larger specimens and some regeneration.

The understory is shrubby, but the complement of shrubs varies widely--shifting from site to site among dominance by *Vaccinium ovalifolium*, *Menziesia ferruginea*, *Rhododendron albiflorum*, *Vaccinium alaskaense*, and *Vaccinium membranaceum* and various combinations of these. Herbs range from 4-50 percent cover. *Rubus pedatus* and *Rubus lasicoccus* are constant species generally exhibiting around 5 percent cover each. Sometimes *Erythronium montanum*, *Streptopus roseus*, *Tiarella unifoliata*, or *Clintonia uniflora* are strong dominants.

Soils are developed in ash layers and are characterized by well-developed iron pans which limit vertical drainage. Heavy snowpack in these forests and their laterally flowing meltwaters are other important environmental features.

This is one of the most important forests of the backcountry. Wilderness camps at Golden Lakes, Mystic Lake, and elsewhere are within this type. Mowich Lake is situated amidst this forest as are other high country lakes. The Wonderland Trail winds in and out of this type in passage across the rolling uplands of the hinterlands. Development of trails, improvements, campsites, sanitary facilities, etc. should make allowance for the restricted soil drainage and lateral movement of runoff. The vegetation itself, however, appears durable to impacts related to backcountry use and probably recovers rapidly.

We characterize these forest environments as cold and wet. Growing season is short and varies according to the depth and persistence of snowpack. Visitor impact is also likely to be most concentrated during the brief "summer" of snow-free conditions.

16. ABAM/VAME/ERMO — *Abies amabilis/Vaccinium membranaceum/Erythronium montanum*

Silver fir/Big huckleberry/Avalanche lily

This forest is closely related to the above. It occurs on rolling uplands or steep upper slopes of drainages in all Park sectors at elevations over 4400 feet. Stands are very open but canopy closure is also possible, especially in younger forests. Open, old-growth climax types are particularly impressive in the younger Laughingwater Creek drainage and vicinity of Three Lakes. *Abies amabilis* is dominant both in overstory and regeneration. Occasional *Chamaecyparis nootkatensis* *Tsuga mertensiana*, or *Abies lasiocarpa* may share the canopy or regeneration structure.

The shrubby understory is dominated by *Vaccinium membranaceum*. Other shrubs are usually absent, infrequent, or minor (cover <3 percent). *Erythronium montanum* is an abundant herb with cover up to 40 percent. Also common are *Luzula* spp., *Tiarella unifoliata*, *Arnica latifolia*, or *Valeriana sitchensis*. Occasional species of adjoining subalpine meadows, such as *Vaccinium deliciosum* or *Phyllodoce empetriformis* may occur in the understory.

These forests are of cold, wet environments burdened by heavy snow accumulation and short seasons. Snowmelt is a common summer feature and surface soils are usually wet and spongy. Soils, however, seem moderately drained, and iron pan formation is not so prevalent or highly developed as in the *Abies amabilis*/*Menziesia ferruginea* forest complex. They are characterized by accumulation of iron sesquioxides and well-structured B horizons developed in ash parent materials.

APPENDIX III. Narrative Description of the Important Forest Types

In this Appendix we will describe the more extensive or important of these from the point of view of the Park visitor and management. We made no attempts to describe all 16 of the forest types (Table 1); only those of greater visitor usage in the Park. Technical summaries are found in Appendix II and a key in Appendix I.

1. Forests along major rivers at low elevations.

The visitor approaches Longmire through stately forests along the Nisqually River. There is immediate awareness of giant Douglas-firs, lush vegetative understories, shaded and filtered light, moss-festooned logs, and swamps of skunkcabbage and devil's club. The contrast between these mature stands and forest second-growth outside the Park or along the Kautz Mudflow only serves to emphasize the grandeur and character of the mature forests. The visitor along this canopied drive suddenly leaves behind the alarms and hassles of the outside world. The forests embrace and assure him, and provide fitting prologue and expectation for further encounters with the Park's scenery.

This forest belongs to our Western Hemlock/Devil's Club/Oakfern type, so named because of conspicuous plants in each of the tree, shrub, and herb layers of the climax vegetation. As visitors continue toward Longmire, the forest scenery frequently changes. This perceptual diversity gives the viewer additional stimulus. Now giant ferns appear, now an astonishing display of lush herbs (vanillaleaf, bunchberry, foamflower), now a steamy pool of devil's club and vine maple.

A fallen monarch conducts the eye along a mossy, elevated tramway over rooftops of devil's club and salmonberry, past highrise towers of western redcedar, to the tumbling ribbon of milky water where ominous klunking sounds emanate from incredible polished boulders grating their way to the sea. The forest shields and protects. The river rages or seethes, but the vegetation along its banks is a timeless witness to perseverance of life, the self-maintaining ability of complex forest ecosystems that have colonized the riverbeds and mudflows of the past and healed those once raw wounds.

A closely related forest is found along the Carbon River from the entrance station to Ipsut Campground. But the scenic impression is quite different! At first old Sitka spruces join the parade of giants but not for long. Douglas-fir and western redcedar have impressive stature (one Douglas-fir measured 109 inches dbh but was inconspicuous among peers!). Some of these trees are so massive, indeed, that the roots branching from the trunk bases create huge mounds that are climbed only with difficulty before one can measure the stem girth. The forest floor is ridden with decomposing trunks of fallen giants, intricately criss-crossed into networks of superhighways and interchanges. Even the devil's clubs have tall stature. Crooked stems like immobilized troupes of belly dancers wriggle and twist to 8 or 10 feet above their watery floors. Space is at a premium on these dimly illuminated forest floors. Every roothold is a competitive struggle. The search for light, nutrients, and soil oxygen and nitrogen is intense. Salal, so widespread and common on hot slopes of the Ohanapecosh Formation (our Western Hemlock/Salal forest type) is at Carbon crowded onto the upper surfaces of fallen logs or the higher, drier summits of the root mounds.

The forests along the Carbon River Valley are good examples of our Western Hemlock/Devil's Club/Oakfern forest type, but with a flavor of their own. Here Foamflower is the three-leaflet type (Tiarella trifoliata) and other herbs have more luxuriance than in the forests paralleling the Nisqually. Gentle streamlets carrying snowmelt waters from adjoining slopes to the Carbon River cross the terraces on cobbly beds rich with Scouler's corydalis and twistedstalk (Streptopus spp.). Oakferns in profusion extend in patches along the uneven, hummocky forest floor. As one approaches Ipsut Campground (and from there on up the main Carbon River Valley and its tributaries), the proportion of Pacific silver firs in the tree structure increases. This increase is accompanied by other vegetatimal changes in the composition of mature forests. Thus the Western Hemlock/Devil's Club/Oakfern forest gradually transists into a Silver Fir/Devil's Club/Foamflower forest type.

Low elevation Western Hemlock/Devil's Club/Oakfern forests also occur in the Ohanapecosh drainage. Here are important wintering areas for elk who may have consumed much of the devil's club, a preferred browse species. Perhaps these valley forests of the Ohanapecosh have for a long time accommodated the wintering elk herds, and this history of utilization may help explain some of the different proportions of browse and forage plants. Of course, the Grove of the Patriarchs is famous, too, as a visitor attraction and perhaps is the most marvelled of all stands of the Western Hemlock/Devil's Club/Oakfern forest types. Seen as wonders of antiquity by the visitor, the ecologist or manager asks why the western redcedars are not being replaced by western hemlocks normally of the climax forest. The Grove, on very recent alluvial soils is a good example of forest stagnation, and there are no clear, easy explanations why. There are other profundities of nature's extravagance to be found in the Grove too. Tall red alders are vigorous nitroeen pumps here. The richest and most diverse of all plant assemblages within this valley forest type occur in the Grove. We found about 70 understory vascular plants in about a fifth of an acre and about 33 percent of these plants occurred in profusion!

In summary, the Western Hemlock/Devil's Club/Oakfern forest has high scenic quality, high visibility from well-travelled roads and trails, and creates favorable impressions and expectations to Park visitors. A wide diversity of forest structure and plant composition is found within this vallye type--from Sitka spruce swamp forests on one hand to stagnant old growth western redcedar on the other. These are strong reasons for regarding Western Hemlock/Devil's Club/Oakfern forests as one of the more important of the Park's forest types.

2. Forests of slopes and valleys at intermediate elevations.

The Silver Fir/Alaska Huckleberry forest is the most common forest in the Park. It is found along the East Side Trail, the Olallie Creek Trail, the Owyhigh Lakes Trail, Ipsut Creek Trail, and segments of the Wonderland Trail through intermediate elevation forests. Like valley forests at lower elevations, there is considerable variation in the structure and composition of the Silver Fir/Alaska Huckleberry forest. The trail hiker, however, is soon aware of the major important and characteristic facets of this forest: the omnipresence of huckleberry shrubs, sometimes with vine maple, sometimes not. A forest floor of mosses and shiny-leafed herbs: twinflower, pyrolas, bunchberry, beadlily (Clintonia uniflora), and pipsissiwa. Out of this greenery from his ant's view perspective, the hiker sees lichen-coated branches and arboreal greenery far above. These two layers of green are fastened together by a system of giant bolts, the vascular conduits of silver fir and western hemlock, and here and there a super-bolt of Douglas-fir or western redcedar. Occasionally the trail crew has to cut away a section of some new-fallen bole, and the more curious hiker might indulge in some ring counting. Should the tree be a Douglas-fir in the upper Ohanapecosh, then 700 rings or more might be counted, depending on where the cut was made along the stem.

The forest is full of sudden surprises: a spotted owl flushed up from the trail, three elk startled during their feast on huckleberry browse, the turbulent plume of mist surging up from the deep gorge of a waterfall. At lunch break along a soft mossy log, a family of boreal chickadees make inquisitive, twittery visits. Or a thousand other images, sounds, moods, and impressions are contained in these forests and along the trail systems through them.

Silver Fir/Alaska Huckleberry forest is seldom uniform or uninterrupted. Talus slides and avalanches may intrude, or fires create dense pole or sapling thickets within more open old-growth stands. Wet, seepy slopes or benchy terraces may contain Devil's club and large old Alaska yellow cedars (our Silver Fir/Devil's Club/Foamflower and Silver Fir-Alaska yellow Cedar/Ovalleaf Huckleberry types). Warm slopes may have rich herbs assemblages under noble fir (described below).

The soils are commonly of ash deposits. The whitish or yellowish sands of St. Helen's tephras (W or Y) are usual features of trail cuts. More fascinating, however, is the repetition of this process of soil emplacement and forest growth as recorded in the statigraphy of soil profiles (or seen along the deeper trails or road cuts). Buried forest litters may exist at two or three depths below the vibram soles of trail parties. The different ashes can be recognized by colors and sizes of their grains, and within any layer might be found evidence of paleosoils--soil formation and mineral weathering of another millenia, another forest. Was that forest the same as the primeval stand today? What happened during the years following burial; what was the successional pattern? Was the event holocaustic or mere settling of aerial dust from a dimmed, yellowish sky? Are some of these ancient Douglas-firs witnesses of the volcanic belches that gave rise to the newest soil materials? These layered ash soils are widespread in the Silver Fir/ Alaska Huckleberry forest; our monoliths from Fryingpan Creek display the layers in complete, well-differentiated sequences to about the 6-foot depth.

The Silver Fir/Alaska Huckleberry forest has greatest significance, we feel, because of its extent and because a substantial proportion of the forested trails of Mount Rainier National Park traverse this type. The encounters between visitor and wildlife are intimate, and many impressions from plant and animal life, as well as forest environments, streams, falls, and cascades are acquired here.

The Silver Fir/Foamflower forest is sometimes very conspicuous to the knowledgeable Park visitor. Several outstanding features set this forest type apart. From a distance the bluish canopies of dominant noble fir crowns can be sharply distinguished from green or yellowish green canopies of other forest types. Noble fir is a major seral tree of the Silver Fir/Foamflower forest type. Since it is a relatively intolerant true fir (that is, it requires high light intensity on the forest floor for effective germination and seedling survival and growth), this tree often attests to past forest fires. A rectangular patch of even-aged noble fir occurs in the White River drainage on south-facing slopes of Sunrise Ridge. Other stands are found along the Mowich Lake Road, Nahunta Falls, and locally on warm slopes along Laughingwater Creek and other drainages. Stands near climax condition are predominantly composed of silver fir, but occasional large noble firs with their platy purple barks sometimes stand out among the silvery, lichen-draped stems of silver fir. Trails through a Silver Fir/Foamflower forest offer very contrasting forest scenery to that of Silver Fir/Alaska Huckleberry type. The shrubs abruptly give way to profusion of herbs. Vanillaleaf, foamflower, twistedstalk, false Salmon's seal, beadlily, arnicas, and oakferns may each or in combination mask the forest floor under dense sheets of foliage. This geometry of leaf display is amazingly well-ordered and precise. Each leaf and leaflet has its own space, but unused space does not exist. Every photon of light descending below the far overhead canopy has a billion eager, outstretched begging surfaces ready to prevent its falling wasted on some detrital surface. Our footsteps temporarily disorder this foliar array, as a wake of bent or crushed herbage is the price for our serendipitous wandering. But our steps miss far more stems than they hit and these readily adjust to the temporary disturbance of our passage. After tremulous reproach, our path soon refills with geometric green. And that geometry has infinite variation depending upon the herb composition of different patches.

This herb-rich forest also occurs on soils that may have many layers of ash. Or the ash may mix with rocks and cobbles of volcanic origins on steep slopes subject to slow downhill soil movement and mixing by windthrow and other forces not well understood. But the soils are well-drained, deep, and probably well-watered from melting snows. The podzolic soil-forming processes are expressed as leached surface horizons (A2) where weathering minerals are removed and horizons of accumulation where this mobile weathering residues (mostly iron sesquioxides) are deposited (B2 and B2ir horizons). Occasionally the ash layers are thinner or washed downslope, leaving a cobbly-bouldery residue that is usually taken over by vine maple. Or small rivulets pass through the stand along which stringers of devil's club, scouler's corydalis, or other herbs or shrubs of wetter microsites might be found.

This Silver Fir/Foamflower forest contributes its measure to forest scenery and diversity at mid-elevations. While not as extensive as the Silver Fir/Alaska Huckleberry type it is nevertheless a major element of the forest mosaic on the flanks of Rainier. As optimal habitat for the commercially valuable noble fir, the stands at Rainier might serve as continuing seed sources, benchmarks, or controls for research, and studies of its autecology. Any stand employed for such purposes becomes increasingly significant as forests of similar age get logged on more and more noble fir habitat (Silver Fir/Foamflower) on commercial forests outside the Park.

3. High elevation forests.

The rolling uplands and upper slopes of major glacial drainage basins have great snow burdens and short, wet growing seasons. Snowpack may persist through August at sites of deeper accumulation, and soils are most always saturated. Forests are interrupted by avalanche tracks, subalpine meadows, cascades, and glacial lakes. Lobes of massive glaciers intrude their ponderous, boulder-laden masses in radial, spiderlike geometry down the volcano cone. This is the backcountry, the subalpine, the place of awesome mountain scenery, cloud and fog condensation, and forests distorted and hardened by the hostilities of high elevation climates.

The most extensive forest here is not easily definable. We prefer, at this stage of our study at least, to think of a forest complex. Silver fir is always the leading tree and at most locations exhibits very high regeneration densities of seedlings and saplings. Alaska yellow-cedar is, perhaps, second in importance, followed by mountain hemlock, western hemlock, and subalpine fir. Let us point out now that these are not forests of the subalpine park-land--so conspicuous along Sunrise Ridge, Spray Park, and other locations that ecologists might characterize as forest-tundra ecotone. These subalpine parkland forests are commonly structured in islands or copses dominated in part by subalpine fir. We are concerned, instead, with closed forests usually well below the parkland zone, but grading into the parkland and sometimes interrupted by meadow communities on different soils or exposures. We have named this forest the Silver Fir/False Huckleberry complex.

Important shrubs are Alaska and ovalleaf huckleberry, black huckleberry (Vaccinium membranaceum), false huckleberry (Menziesia ferruginea), and white-flowered rhododendron. These shrubs may form dense thickets. In the Golden Lakes region, for example, where fires have swept the upland forest the shrubs comprise impenetrable tangles between the snags of the former forests. Older forests of shrub-dominanted understories can be seen at Mowich Lake, upper Huckleberry Creek Trail, and Cayuse Pass.

Spring arrives late in this forest complex. As winter snow melts the fawn-lilys follow with their new spring snow, the carpets of white beneath the shrubs that have not yet fully leafed out. Then other ground herbs are also soon in flower: twistedstalk, trailing raspberries (Rubus pedatus and R. lasiococcus), and yellow violet (Viola sempervirens). But the herbs are usually few in number of species, for not many endure so long under the snowpack. In some areas, indeed, where several years of snowpack might persist the herb (and shrub) populations might be wiped out. At some sites herbs may be common. elsewhere very infrequent. The variability and pronounced shifts in vegetation composition of this forest puzzle us.

Soils of the Silver Fir/False Huckleberry forest have an iron pan horizon that restricts vertical drainage. The pan varies from thick and extremely hard to rather interrupted and with moderately hard iron cementation. We're not sure just how it develops, but the lateral movement of soil water between ash layers of different textures may be responsible. Dissolved iron minerals in this water gradually build up and clog the pores of the soil space. Vertical drainage is then further impeded and the lateral water movement brought closer to the soil surface. Roots cannot penetrate the thicker, more indurate pans. Thus meltwater or rainfall percolation and runoff are restricted to the uppermost mineral soil and organic layers. Trails along these pan soils are commonly mucky. Campsites are difficult to locate because of soil saturation and close attention to drainage patterns is required. Vegetation roots are concentrated in the uppermost soil horizon and in overlying organic humus where most favorable soil temperatures, aeration, and mineral nutrition exists.

This forest is of particular significance to backcountry users at Mount Rainier National Park. Major segments of the Wonderland Trail pass through Silver Fir/False Huckleberry. Backcountry camps at Mystic Lake, Golden Lakes, Shadow Lake and elsewhere are found within the type. The scenic Mowich, Reflection, and Forest Lakes are among those whose shorelines are fringed by its silver firs or mountain hemlocks. The wet, dripping foliage of the shrubs and tree canopies have soaked many pairs of hiking socks, caused many a blister, and drummed incessant rhythms on the nylon or canvas shelters of numerous overnight campers. In kind of perverse mockery, the forests and saturated soils of these high elevations extend cool and limited hospitality to those seeking refuge from austere climates of the meadow and icelands of higher slopes. The forests embrace and comfort indeed! But also form picturesque fore- and middle-ground scenery to frame the lakes, meadows, and snowfields of the high country.

APPENDIX IV. Observations for Park Interpreters

Some of the following information is based upon work at MRNP and some is from studies in other old-growth Douglas-fir-western hemlock forests, particularly at the H. J. Andrews Experimental Forest. They are, in any case, items we thought would be of interest.

Many of the "subalpine" species can be expected to occur on habitats, especially disturbed ones, at low elevations. Alaska-cedar is an outstanding example and occurs in stands down to 2,000 feet. It is specimens of Alaska-cedar and not redcedar that the elk have browsed so heavily on the island where the Grove of the Patriarchs is located. It is also common around Longmire Meadows. A fine specimen of subalpine fir grows at the island end of the swinging bridge (Grove trail) and it is found on the recent debris flow occupied by the old Longmire Campground. Noble fir is scattered all the way down the Ohanapecosh and Kautz drainages. Mountain hemlock is in the Longmire Campground area. The area immediately west (50 to 100 feet) of the White River entrance station is an outstanding one for tree study as 12 of the Park's conifers are found there. The key point to remember is that the high-elevation species do drift down the valleys and can be encountered there. The only one we have not seen do this is whitebark pine.

Nitrogen is always a key nutrient and typically in short supply. We are finding more and more sources of input, however, routes by which elemental nitrogen in the air (N_2) is converted into biologically usable forms. There are, of course, the leguminous (e.g., lupine) and non-leguminous (e.g., all of the alders, snowbrush ceanothus) plants that have root nodules inhabitated by N-fixing microbes. Some suprising new sources discovered recently include: (1) Many of the lichens--those with blue-green algae associates which include several of the large "lettuce-like" foliose lichens that grow on trees (Lobaria, Pseudosyphillaria). In one forest they have been estimated to fix 10 pounds of nitrogen per acre per year; (2) Standing dead trees, down logs, and coarse woody debris over 2 inches in diameter are sites for substantial microbial N-fixation. Dead wood of this kind is rapidly colonized by such organisms and the nitrogen fixation may be quite important in speeding decomposition and preparing the substrate for other organisms. Insects may be vectors that assist in innoculating the wood with such organisms; and (3) Nitrogen-fixation has been discovered in moss patches in the arctic tundra and may also occur in temperate mountains. The fixation itself is probably done by blue green algae associated with the moss.

Logs play important roles in these forest ecosystems besides providing sites for N-fixation. Debris dams they create in small streams may play valuable roles in creating habitat diversity (gravel bars behind, plunge pools below) and in dissipating energy (through falls) that would otherwise be spent down cutting and eroding the stream channel. They also serve as nurseries or seedbeds for establishment of young trees. "Elevated" seedbeds of this type can be particularly helpful in snowy regions such as MRNP where debris and snow can crush seedlings on ground surfaces and may offer the advantages of more favorable moisture, temperature, and, perhaps, nutrient conditions.

Canopies of large old trees are essentially complete ecosystems in themselves with cycles of energy, water, and nutrients taking place within them. Some organisms such as the red-tree mouse, northern spotted owl, and flying squirrel live all or most of their life cycles in these tree canopies.

The forests of MRNP are located mainly in the Pacific Silver Fir and Mountain Hemlock zones. There is really very little true temperate forest representative of that found in the lowlands. Elevations are too high and climates too cool. Forests representative of the cooler, wetter portions of the Western Hemlock zone occur in the lowest reaches of the Carbon, Nisqually, Ohanna, and White River drainages with the transition from Western Hemlock to Pacific Silver Fir zone coming at elevations of about 3,000 feet.

APPENDIX V. Plot Designs

During 1975, we experimented with various circular plot designs as a replacement for the 15 x 25 m Daubenmire plot which has been the standard analytic plot up to this time. Ultimately we selected a series of modular circular plot sizes:

Name	Length radius	Area
Full	17.9 m	1000 m^2 or 1/10 ha
Half	12.6 m	500 m^2 or 1/20 ha
Quarter	8.9 m	250 m^2 or 1/40 ha

In addition a subplot for sampling seedlings (trees < 4.5 ft tall) was selected which was used in 1975: 5.65 m radius, total area 100 m^2 or 1/100 ha. This winter it was decided to use four seedling subplots of smaller size:

Seedling	2.0 m	12.5 m^2 or 1/800 ha

The smaller subplot will allow a more accurate seedling count and since four will be taken the total seedling sampling area will normally be 50 m^2. (Note: actual radius of seedling plot is 1.996 m.)

In addition to size of plot we considered type of data to be collected, i.e., estimates as opposed to quantitative measures. The three classes devised were:

1. Reconnaisance
   a. Estimation of tree species abundance by four (seedling, sapling, pole and mature) size classes.
   b. Estimation of ground cover % for each species.
   c. Basal area tally with wedge prism.
2. Standard
   a. Stand table for tree species (tally of stems in plot by species and 10 cm dbh size class).
   b. Estimation of ground cover % for each species.
   c. Determination of ages and heights of at least two dominant trees. 1/
   d. Seedling tally on four 12.5m^2 circular subplots.
3. Analytic
   a. Stand table for tree species (tally of stems in plot by species and 10 cm dbh size class).
   b. Cover and frequency of herbs using 1 x 5 dm microplots.

c. Cover and frequency of shrubs using line intercept. 2/

d. Determination of ages and heights of at least two dominant trees. 1/

e. Seedling tally on four 12.5 m^2 circular subplots.

1/ Added in 1976, not done in 1975
2/ During 1975, cover and frequency of shrubs was taken on microplots, same as the herbs

We have now adopted these three size classes and the three quality classes as our standard set of plots for vegetation analysis and, with modification, for forest stand growth and yield analyses. There are, of course, a number of standard data that will be collected on all plots such as slope, aspect, landform, total overstory canopy cover (using densiometer when available), estimates of total mass, herb, and shrub cover, etc.

Vegetation Analysis. For most community analysis research in the mature conifer forests of the Northwest, we will utilize the "Half Standard" plot (500 m^2) with stand table and herb and shrub cover estimates. This size has generally provided sufficient tree tallies to provide adequate data on stand structure, i.e., for community analysis (but not yield) studies. The estimation of ground cover percent for shrubs and herbs, when done by trained observers, appears to be far better than those obtainable using microplots during a comparable amount of time. Excessively large number of microplots are also required for estimates on very patchy species. Since the "standard" procedure will normally give us the accuracy necessary for community analysis work we will, therefore, normally use it and be able to sample larger number of plots due to time saving.

The larger ("Full" or 1000 m^2) plot will be used in very large, old-growth with widely scattered individuals. The "Quarter" plot will be used in dense stands of small trees.

Occasionally, to "calibrate" the eye of new crew members or due to a necessity or desire for quantitate data on understory cover and frequency, the analytic procedure will be used. The arrangements and number of microplots and line intercept will be as follows:

Full (1000 m^2) plot - microplots and line intercept along tapes laid out along the four cardinal directions--north, west, south, and east. Twelve microplots along the north and south radii beginning 6 m from the center (0) point, thirteen microplots along the east and west radii beginning 5 m from the center (0) point; total 50 microplots. Line intercept beginning 2 m from the center (0) point and extending to 17 m mark on each of the four radii; total 60 m of line transect.

Half (500 m^2) plot - microplots and line intercept along tapes laid out along the four cardinal directions (N, E, S, W) with the zero point of each tape in the center. On all four radii 10 microplots beginning 3 meters from the center of the plot; total 40 microplots. Line intercept from 3 to 11 meters along each radius; total 40 meters of line transect.

The arrangement of the seedling subplots, microplots and line intercept on both full and half size plots is shown in Figures 1 and 2.

Stand Structure and Productivity Plots. In stands where we wish to obtain better data on stand size class distribution, standing timber volumes or biomass, and growth we will normally use the "Full Analytic" plot. The increased size is necessary to obtain more accurate data on these items than we are usually interested in during normal vegetation studies. Since considerable time is being invested in these plots, whether temporary or permanent, the use of the analytic procedure for the understory is warranted.

Temporary stand productivity plots differ from the Full Analytic procedures mentioned above in only one detail. Instead of heights and ages on two dominant trees we will (a) collect height data for a sufficient sample trees to allow construction of height-diameter curves for the stand or for all the trees and/or (b) use the dendrometer to measure diameters at a range of heights on a sample of trees to provide data on tree form. Ages on a representative sample of size classes and species will also be collected, not just on two trees.

Permanent stand productivity plots will include the same standard measurement of stand and understory mentioned under Full Analytic and in the previous paragraph. However, the objective is to permanently mark the plot so that remeasurements of both the trees and understory is possible five, ten or twenty years in the future. Procedures will include the following:

1. Mark the plot center with a tall (4 to 6'), permanent metal stake;

2. Mark the centerpoint of the seedling plots and the plot boundary (anchor point) on each of the four primary radii (N, E, S, W) with permanent metal stakes (e.g., 2' to 3' tall concrete reinforcing rod);

3. Tag all live trees (over breast height in height) with numbered metal tags using aluminum nails; do not repeat a number in the same plot and, if possible, in a series of plots with the same stand; if a tree is too small to take a nailed tag at breast height, place the tag near ground line;

FIGURE 1

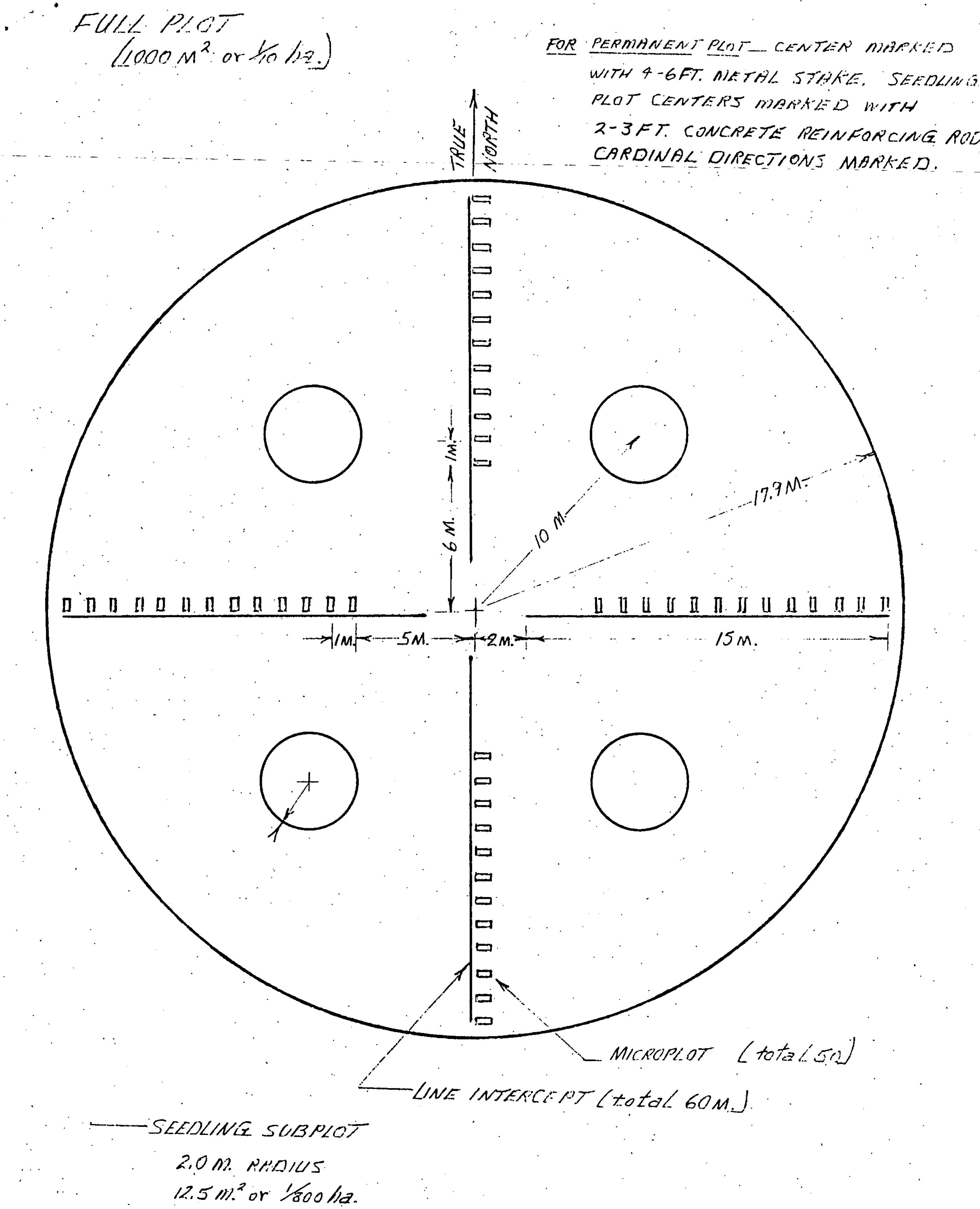
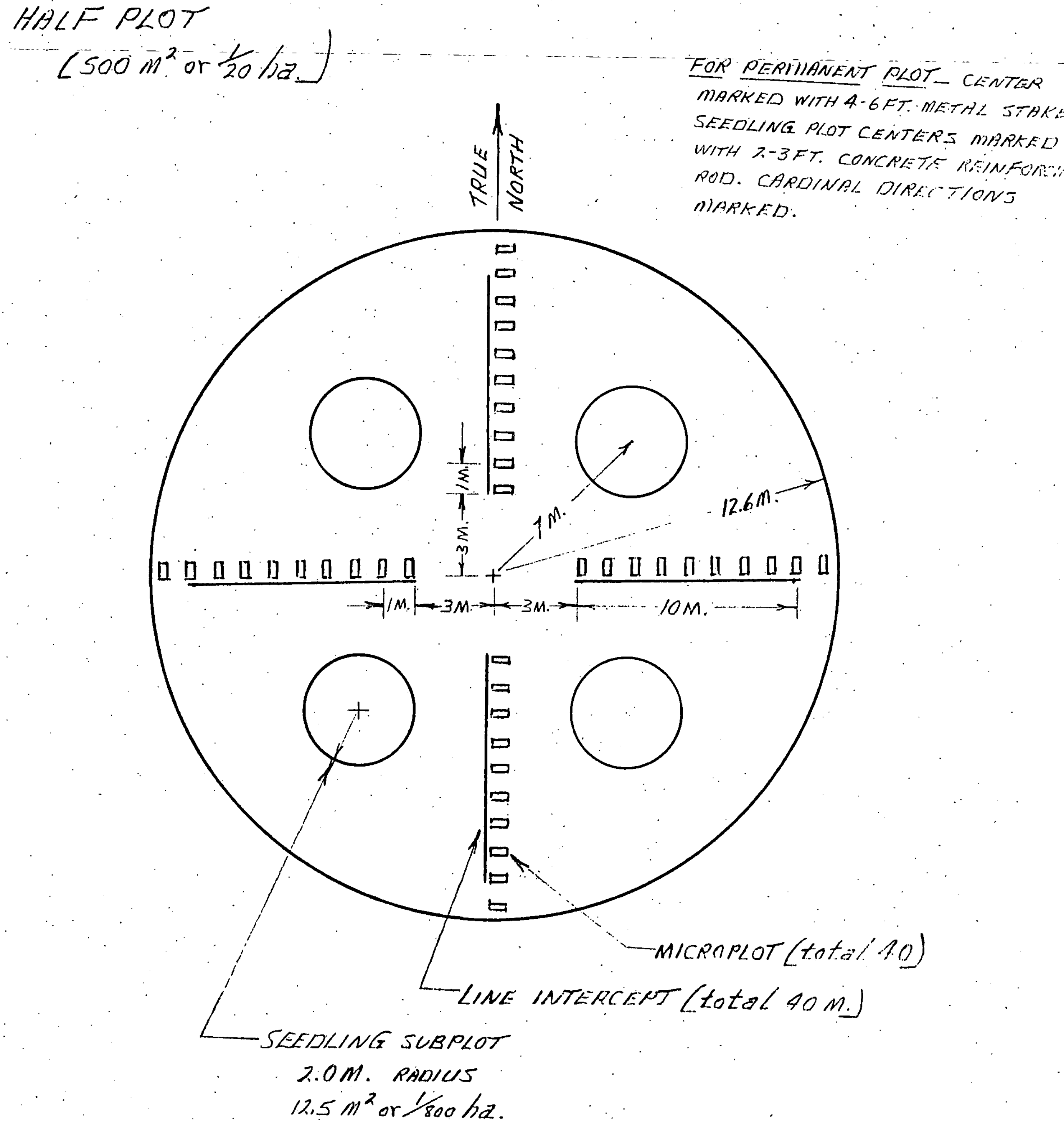

FULL PLOT
(1000 M² or 1/10 ha.)
FOR PERMANENT PLOT — CENTER MARKED WITH 4-6 FT. METAL STAKE. SEEDLING PLOT CENTERS MARKED WITH 2-3 FT. CONCRETE REINFORCING ROD. CARDINAL DIRECTIONS MARKED.
TRUE NORTH
1M.
6 M.
10 M.
17.9 M.
1M.
5M.
2M.
15 M.
MICROPLOT (total 50)
LINE INTERCEPT (total 60 M.)
SEEDLING SUBPLOT
2.0 M. RADIUS
12.5 M² or 1/800 ha.

FIGURE 2


HALF PLOT
(500 m² or 1/20 ha.)
FOR PERMANENT PLOT— CENTER MARKED WITH 4-6 FT. METAL STAKE SEEDLING PLOT CENTERS MARKED WITH 2-3 FT. CONCRETE REINFORCING ROD. CARDINAL DIRECTIONS MARKED.
TRUE NORTH
1M.
3M.
1M.
3M.
3M.
10M.
12.6M.
MICROPLOT (total 40)
LINE INTERCEPT (total 40 m.)
SEEDLING SUBPLOT
2.0M. RADIUS
12.5 m² or 1/800 ha.

4. All tags to face the center of the plot and, to the degree possible, follow a reasonable numbered sequence in so far as travel around the plot is concerned;

5. Tag and record standing dead >4" (10 cm) dbh and 15' in height. Estimate (or measure) diameter, height, and condition (buckskin) large branches still present, broken off at X feet, etc.);

6. Record notes on broken tops (height at which broken) and other significant features of standing live;

7. Measure dbh on live trees at the same point nail is attached (except on the small trees tagged at butt); and

8. Pay very close attention to trees near the 4.5' breaking point for inclusion in the stand tally. Height should be measured from ground line to tallest projection of leader. Straighten droopy leaders of hemlock when checking.