ECOLOGICAL CLASSIFICATION AND MANAGEMENT CHARACTERISTICS OF MONTANE FOREST LAND IN SOUTHWESTERN WASHINGTON[1]

Dale G. Brockway
Department of Natural Resources
Lansing, Michigan 48909

and

Christopher Topik
USDA Forest Service
Gresham, Oregon 97030

ABSTRACT

Vegetation, soil, and site data were collected throughout the forested portion of the Pacific silver fir and mountain hemlock zones of the Gifford Pinchot National Forest as part of the Forest Service program to develop an ecologically based plant association classification system for the Pacific Northwest Region. The major objective of sampling was to include a wide variety of long-term stable communities and aggregate those of similar ecological characteristics into associations which would respond in similar fashion to various management manipulations. Analysis of data collected from over 300 study plots indicated the presence of 14 associations representative of the pronounced temperature and moisture gradients characteristic of the Cascade Range. Among the management considerations which could be related to environmental conditions in each association were soil compactability, nutrient availability, susceptability to fire damage, drought, growing season frost, snow pack, competition, gopher problems, optimum reproduction methods, tree species suitability for reforestation and timber productivity.

INTRODUCTION

The Cascade Range is an area where varied climatic, geologic and edaphic conditions have resulted in the development of a complex flora (Franklin and Dyrness 1973). The forests of the mountains of southwestern Washington occupy a portion of this region where practices of past exploitation and present regulation have played a major role in shaping vegetation patterns. In recent decades, the traditional forest management practices of clearcutting and broadcast burning, which were developed for lower elevation, more productive sites dominated by western hemlock (TSHE;

---

[1]Contribution from the USDA Forest Service, Vancouver, WA 98660.

Tsuga heterophylla (Raf.) Sarg.), Douglas-fir (PSME; Pseudotsuga menziesii (Mirb.) Franco), and western redcedar (THPL; Thuja plicata Donn) have been transferred onto upper elevation, less productive sites dominated by Pacific silver fir (ABAM; Abies amabilis (Dougl.) Forbes) and mountain hemlock (TSME; Tsuga mertensiana (Bong.) Carr.). The result has been many incidents of less than satisfactory regeneration success (Halverson and Emmingham 1982), particularly in stands growing at elevations above 4,000 feet (1,200 m). Largely in response to these regeneration difficulties, a program of ecological classification was initiated for the Gifford Pinchot National Forest to partition the land base into relatively homogeneous units by plant association. This program was undertaken as part of the larger USDA Forest Service Program of Ecological Studies for the National Forests of the Pacific Northwest Region.

The study of plant communities provides useful information about the environment in which they occur (Mueller-Dombois and Ellenberg 1974). Communities are a product of long-term interaction between factors in the physical environment and the organisms present (Zobel et al. 1976). Environmental factors such as temperature, moisture, light and nutrients act as selective influences on plant populations, favoring species best adapted to a particular type of site. An understanding of the basic environmental factors that influence a site allows better prediction of the results of natural processes and management actions. Sites occupied by similar plant associations may be expected to respond similarly to silvicultural treatment.

While discontinuities may be found (Whittaker 1962), generally the composition of vegetation varies continuously over the landscape (Ramensky 1924; Gleason 1926; McIntosh 1967). As a management convenience, vegetation can be aggregated into discrete associations based on dominant overstory, understory and indicator species which characterize environmental conditions on similar sites. This concept is similar to that of habitat type (Daubenmire 1968; Franklin 1966; Pfister et al. 1977) except that the land area upon which the association occurs is not included. It is important to bear in mind that associations represent conceptual abstractions and that ecotones of transitional vegetation may be frequently encountered when assessing composition in the field.

METHODS

The vegetation, soil and site data used in formulating this classification were collected across the forested portion of the Pacific silver fir and the mountain hemlock zones (Franklin and Dyrness 1973; Franklin 1966), which comprise a major portion of the commercial montane forestland present within the Gifford Pinchot National Forest. The primary objective of sampling was to include a wide variety of long-term stable plant communities growing throughout the middle and upper elevations of the forest. Circular 0.05 acre (0.02 hectare) plots were established in selected undisturbed stands occurring on a variety of aspects, elevations and slopes.

Many plots were located along transects oriented to measure the range of environmental factors along perceived gradients. Sampled stands met the following criteria: (1) at least 75 years old, (2) relatively undisturbed and (3) relatively uniform in vegetation composition and cover within the plot area. The classification is based upon data collected from 318 reconnaissance plots, 101 of which were intensively sampled to obtain estimates of productivity.

Data collection consisted of (1) ocular estimates of tree, shrub and herb cover by species, (2) height, diameter (dbh) and radial growth measurements of dominant and codominant trees, (3) basal area determination of stand and of each species by diameter class, (4) forest floor and soil profile description and (5) assessment of site location, elevation, aspect, slope, landform and microtopography. Increment cores were evaluated in the laboratory and all other information was coded on data cards in the field.

Standard computation techniques and procedures developed for ecological studies in the Pacific Northwest Region (Voiland and Connelly 1978) were used to evaluate floristic data. Procedures included association tables, similarity index, cluster analysis and discriminate analysis (Gauch 1982). From these data preliminary plant associations were identified and a dichotomous key was constructed which would facilitate identification of the associations in the field.

Productivity data were evaluated using procedures from the Statistical Package for the Social Sciences (Nie et al. 1975) and Biomedical Data Programs (Dixon 1981). Locally developed indices of relative production among associations were also computed. These included volume index, SDI volume increment and current volume increment. Volume index (VI) was calculated as a product of site index (SI) and growth basal area (GBA, Hall 1983): VI = SI x GBA x 0.005 and is an expression of potential volume growth for normally stocked, even aged stands at age 100. SDI volume increment was computed by a series of equations which relate the actual production (Pa) of a sampled stand to the production (Pn) of a normally stocked stand: Pa = Pn (SDIa/SDIn) and developed to discriminate between commercial and non-commercial stands (Knapp 1981). Current volume increment is the mean annual volume increment over the past ten years and an estimate of net production, not including mortality, in natural, mixed species stands (Hemstrom 1983). It is one-tenth of the difference between current tree volumes and volumes of the same trees ten years earlier. Volume of overstory trees was estimated by equations of the form, $V = a(D^2H)^k$, where V is volume, D is diameter at breast height, H is tree height and a and k are empirically derived constants specific to each species. Understory volume was estimated from the relationship, CGu = BAu (CGo/BAo), where CGu and CGo are the last ten years radial increment and BAu and BAo are the mean basal area of understory and overstory, respectively. The stand volume was determined by summation of the component estimates.

Height-age curves were empirically derived from data collected in the field. These curves were developed using a nonlinear polynomial curve fitting technique (Dixon 1981) for the natural growth function, $f(x) = a(1-e^{-bx})$, where x is the tree age, f(x) is tree height, a is the maximum value for tree height, b is the rate at which tree height approaches the maximum and e is the natural log constant (Parton and Innis 1972).

RESULTS, AND DISCUSSION

A major product of this program was the development of a management guide for use by local forest managers (Brockway et al. 1983a). This guide was designed to help classify stands or sites into associations so that previous research and management experience pertinent to a particular plant community could be implemented. Its contents include (1) a summary of associations and their characteristic environments, (2) a discussion of association management considerations, (3) a key to the associations which can be used for field identification and (4) detailed descriptions of physiography, soils, vegetation, regeneration and productivity of each association which should be used to verify identification and develop management options. For convenient field use, the major aspects of this guide have also been condensed into a pocket sized format (Brockway et al. 1983b).

Classification

Long-term stable vegetation has been classified on two basic levels: series and association. The "long-term stable state" is the stand condition which is normally achieved following 300 years without unnatural disturbance. The Pacific silver fir series exists wherever the long-term stable vegetation will have at least 10 percent cover of Pacific.silver fir. Continuing on to more severe environments, the mountain hemlock series exists wherever the long-term stable vegetation will have at least 10 percent cover of mountain hemlock. Stand development is usually sufficient to allow series identification between 50 and 100 years after stand formation. On recently disturbed sites, series may be inferred from adjacent stands. The series were divided into 14 associations based on dominant species in the understory which are indicative of the ambient environmental conditions (Table 1). These species may be shrubs or herbs which exhibit prominent indicator value. An example association, named for an important tree/shrub/herb assemblage, would be Pacific silver fir/big huckleberry/beargrass (ABAM/VAME/XETE).

Environmental Relationships

A generalized east-west transect through the Columbia Gorge (Figure 1) shows the spatial arrangement of the major vegetation series present in this area. Environmental gradients in moisture east (dry) to west (moist) and temperature from low elevation (warm) to high elevation (cold) are readily apparent from the occurrence of various series. Within the broader context of environmental gradients which influence the presence of each series is a subset of more subtle gradients which largely determine the occurence of various plant associations. Again, moisture and temperature are prominent influences at this level, but other atmospheric or edaphic factors may be locally important. Variation not only in total precipitation, but also variation in the proportion incident as snow versus rain and variation in soil and air temperatures resulting from elevation, aspect and soil drainage characteristics produces different environmental conditions and a corresponding diversity of plant associations. The plant associations occurring in the montane forests of southwestern Washington are illustrated in Figure 2. Their relationships to one another and to the remaining series are represented along moisture and temperature gradients.

TABLE 1. MONTANE PLANT ASSOCIATIONS

Association	Scientific Name	Abbreviation
Pacific silver fir/salal association	Abies amabilis/Gaultheria shallon	ABAM/GASH
Pacific silver fir/dwarf Oregon grape association	Abies amabilis/Berberis nervosa	ABAM/BENE
Pacific silver fir/vanillaleaf-queencup beadlily association	Abies amabilis/Achlys triphylla-Clintonia uniflora	ABAM/ACTR-CLUN
Pacific silver fir/Alaska huckleberry association	Abies amabilis/Vaccinium alaskense	ABAM/VAAL
Pacific silver fir/Alaska huckleberry-salal association	Abies amabilis/Vaccinium alaskense-Gaultheria shallon	ABAMNAAL-GASH
Pacific silver fir/coolwort foamflower association	Abies amabilis/Tiarella unifoliata	ABAM/TIUN
Pacific silver fir/devil's club association	Abies amabilis/Oplopanax horridum	ABAM/OPHO
Pacific silver fir/Cascades azalea association	Abies amabilis/Rhododendron albiflorum	ABAM/RHAL
Pacific silver fir/fool's huckleberry association	Abies amabilis/Menziesia ferruginea	ABAM/MEFE
Pacific silver fir/big huckleberry/queencup beadlily association	Abies amabilis/Vaccinium membranaceum/Clintonia uniflora	ABAM/VAME/CLUN
Pacific silver fir/big huckleberry/beargrass association	Abies amabilis/Vaccinium membranaceum/Xerophyllum tenax	ABAM/VAME/XETE
Mountain hemlock/big huckleberry association	Tsuga mertensiana/Vaccinium membranaceum ,	TSME/VAME
Mountain hemlock/fool's huckleberry association	Tsuga mertensiana/Menziesia ferruginea	TSME/MEFE
Mountain hemlock/Cascades azalea association	Tsuga mertensiana/Rhododendron albiflorum	TSME/RHAL

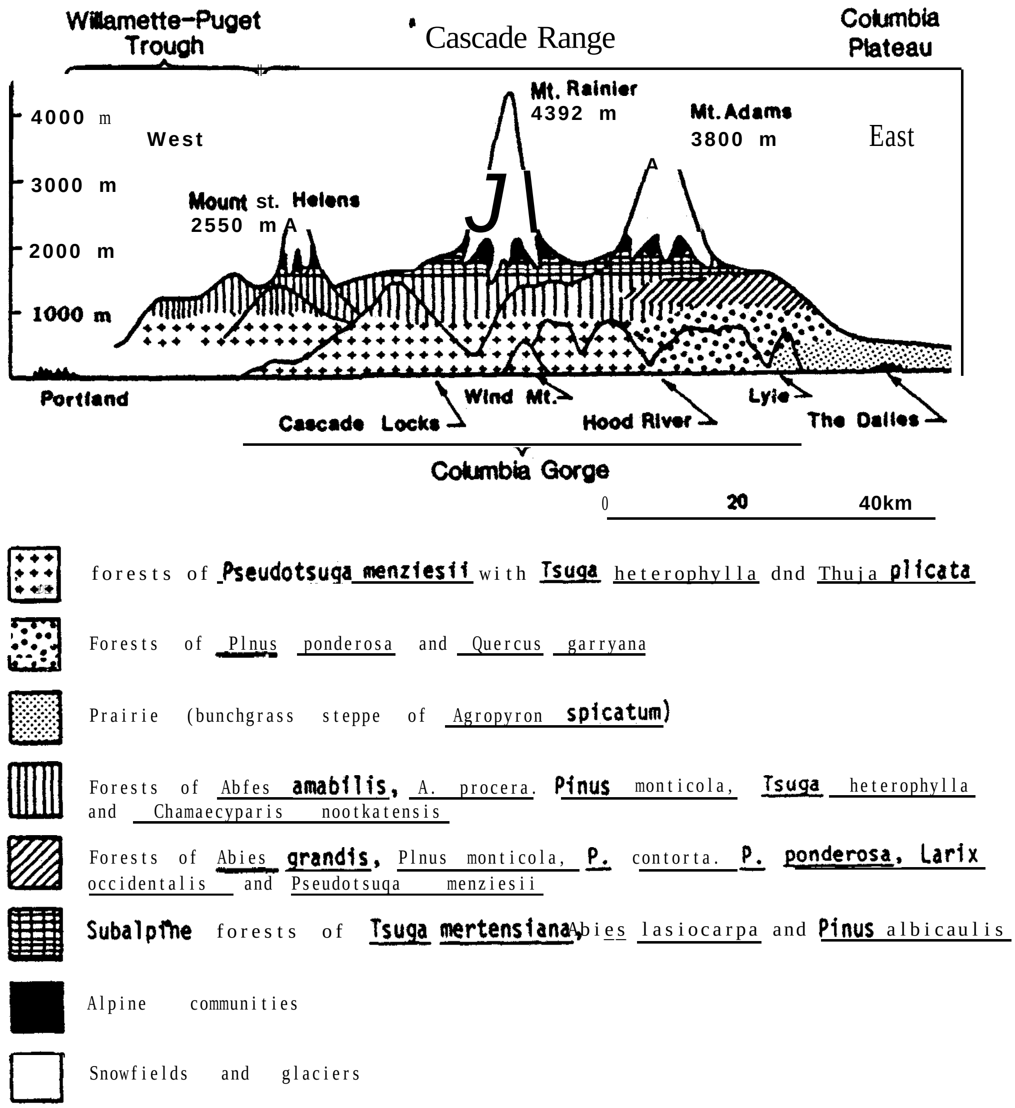


FIGURE 1. VEGETATION PROFILE THROUGH THE COLUMBIA GORGE AND CASCADE RANGE (Troll 1955)

Indicator species have been a useful tool in determining the relative environmental relationships among the various plant associations. Knowledge of the habitat preferences of one plant species or a co-occurring group of species in a particular plant association, can aid in characterizing the environmental conditions of a site occupied by the association. Understory plants have been identified as belonging to the warm site shrub group (Rosa gymnocarpa Nutt., Symphoricarpus mollis Nutt., Vaccinium parvifolium Smith, Acer circinatum Pursh, Berberis nervosa Pursh, Gaultheria shallon Pursh and Chimaphila umbellata (L.) Bart.), the cool site shrub group (Vaccinium alaskaense Howell, Menziesia ferruginea Smith and Vaccinium membranaceum Dougl.), the cool to cold, moist site shrub group (Oplox horridum h) Miq. and Rhododendron albiflorum Hook.), the warm site herb group (Disporum hookeri (Torr.) Nicholson, Galium oreganum Britt., Hieracium aibiflorum

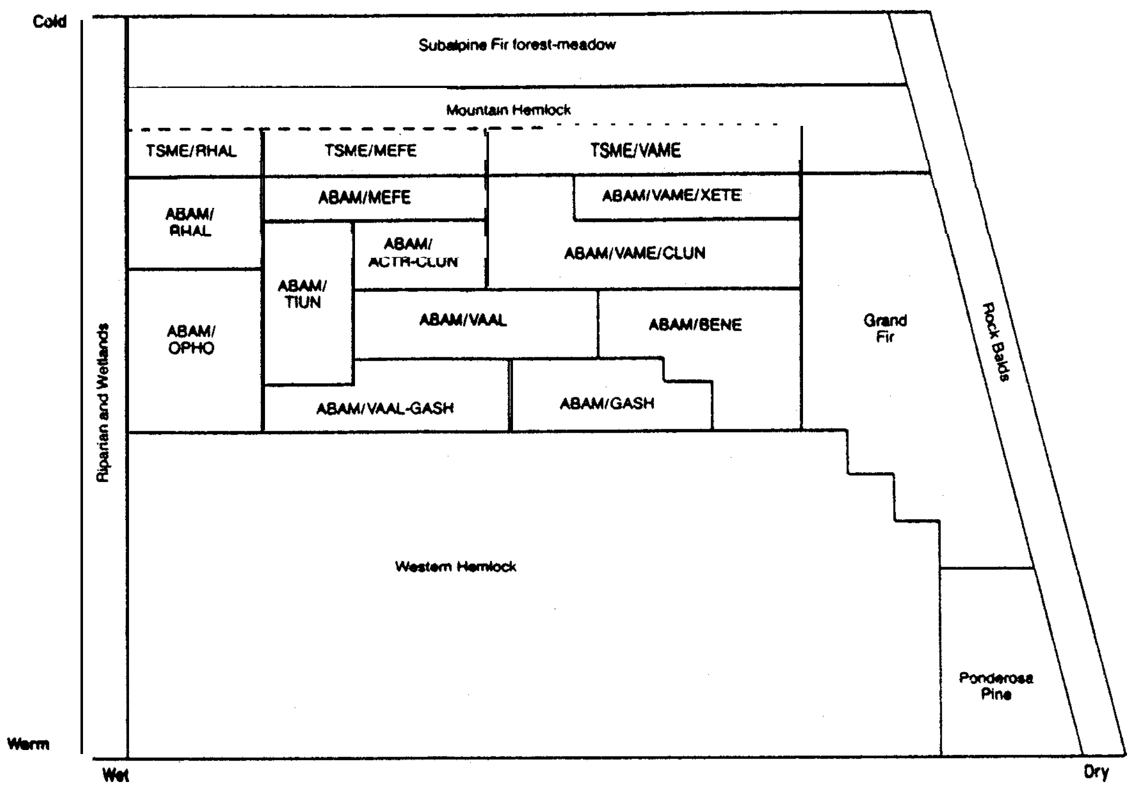


FIGURE 2. RELATIVE ENVIRONMENTAL RELATIONSHIPS AMONG MONTANE SERIES AND ASSOCIATIONS

Hook., Linnaea borealis L., Polystichum munitum (Kaulf.) Presl. and Trillium ovatum Pursh), the mesic site herb group (Achlys triphylla (Smith) Dc., Vancouveria hexandra (Hook.) Morr. & Dec., Viola glabella Nutt., Galium triflorum, Michx., Anemone deltoidea Hook., Smilacina stellata (L.) Desf., Streptopus roseus Michx., Valeriana sitchensis Bong. and Tiarella unifoliata (Hook.) Kurtz.), the moist site herb group (Gymnocarpium dryopteris (L.) Newm., Montia sibirica (L.) How., Oxalis oregana Nutt., Actea rubra (Ait.) Willd., Athyrium filix-femina (L.) Roth. and Blechnum spicant (L.) With.) and the cold, dry site group (Xerophyllum tenax (Pursh) Nutt.).

The descriptive characteristics of the environments occupied by the various montane plant associations are summarized in Table 2. The mountain hemlock/Cascades azalea (TSME/RHAL), mountain hemlock/fool's huckleberry (TSM E/M EFE), mountain hemlock/big huckleberry (TSM E/VAM E) and Pacific silver fir/big huckleberry/beargrass (ABAM/VAME/XETE) associations are typically encountered at high elevations on sites with northerly aspects. This results in cold temperatures, heavy snowpacks and occasionally high water tables. Sites occupied by ABAM/VAME/XETE have southerly aspects and are slightly warmer and drier than those of the TSME associations. The Pacific silver fir/Cascades azalea (ABAM/RHAL), Pacific silver fir/devil's club (ABAM/OPHO), Pacific silver fir/big huckleberry/queencup beadlily (ABAM/VAME/CLUN) and Pacific silver fir/f ool's huckleberry (ABAM/M EFE) associations are characterized by cool environments on sites with northerly aspects, positioned on benches or upper slopes. Sites occupied by ABAM/VAM E/C LU N have southerly aspects and are somewhat drier fhan those where ABAM/RHAL, ABAM/OPHO and ABAM/MEFE occur. The Pacific silver fir/coolwort foamflower (ABAM/TIUN), Pacific silver fir/Alaska huckleberry (ABAM/VAAL) and Pacific silver fir/vanillaleaf-queencup beadlily (ABAM/ACTR-CLUN) associations occupy mesic sites which are influenced by moderate environmental conditions. The Pacific silver fir/Alaska huckleberry-salal (ABAM/VAAL-GASH), Pacific silver fir/dwarf Oregon grape (ABAM/BENE) and Pacific silver fir/salal (ABAM/GASH) associations are found near lower elevations on warm sites bordering the western hemlock series.

Management Characteristics

Management characteristics unique to each association are summarized in Table 3. Hazards are subjective estimates of relative severity. Frost is the single most important factor affecting plantation establishment on montane forest sites. High elevations, northerly aspects, slopes less than 15 percent and topographic depressions tend to increase the frequency and severity of growing season frost. Residual thermal cover, offered by standing trees, enhances site protection. The presence of certain plant indicators and associations can provide valuable clues to the potential frost hazard (Halverson and Emmingham 1982). Beargrass is an extremely frost tolerant species and severe frost problems can be anticipated where it

TABLE 2. ENVIRONMENTAL CHARACTERISTICS OF PLANT ASSOCIATIONS

Group	Association	Number of Samples	Vegetation: Tree Cover (%)	Vegetation: Shrub Cover (%)	Vegetation: Herb Cover (%)	Physiography: Elevation Mean and Range (Feet)	Physiography: Aspect	Physiography: Slope Mean	Physiography: Slope Range (%)	Physiography: Landform and Slope Position	Soil: Total Depth Mean (Inches)	Soil: Total Depth S.D. (Inches)	Soil: Effective Rooting Depth* Mean (Inches)	Soil: Effective Rooting Depth* S.D. (Inches)	Soil: Litter Depth Mean (Inches)	Soil: Litter Depth S.D. (Inches)
Cold																
	TSME/RHAL	9	61	66	19	4644 (4000-5300)	NW,N,NE	29	(8-68)	Upper slopes and flats	53	13	37	14	1.9	0.8
	TSME/MEFE	10	58	65	36	3955 (3300-4400)	NW,N,NE,E	12	(2-43)	Upper slopes, ridges and flats	61	22	46	13	2.3	2.3
	TSME/VAME	13	63	'2	29	4362 (3300-5700)	W,NW,N,NE	22	(11-49)	Upper to lower slopes	43	22	33	12	1.3	0.9
	ABAM/VAME/XETE	13	61	37	29	3831 (2900-4800)	W,SW,S, SE,E	18	(0-55)	Middle slopes, ridges and flats	50	14	33	10	1.7	1.6
Cool																
	ABAM/OPHO	25	60	67	68	3728 (2600-4600)	Variable	36	(2-67)	Lower slopes and benches	60	18	43	16	2.4	2.3
	ABAM/RHAL	18	67	64	38	4272 (3600-5300)	NW,N,NE	28	(4-63)	Upper slopes and benches	49	19	30	11	1.7	1.1
	ABAM/MEFE	37	66	58	IO	3673 (2900-4500)	NW,N,NE	25	(0-66)	Middle to upper slopes	64	22	39	13	1.8	1.0
	ABAM/VAME/CLUN	26	69	31	PO	3781 (3100-4900)	W,SW,S, SE,E	21	(0-75)	Middle slopes and benches	46	14	33	10	1.3	0.6
Mesic																
	ABAM/TIUN	36	11	39	44	3342 (1500-5000)	Variable	36	(0-80)	Upper slopes and flats	62	16	39	31	1.7	1.2
	ABAM/ACTR-CLUN	42	73	56	50	3426 (2700-4500)	W,SW,S,SE	34	(2-76)	Middle slopes and flats	53	18	33	16	1.5	0.7
	ABAM/VAAL	42	69	44	13	3355 (2500-4200)	W,SW,S, SE,E	24	(2-75)	Middle slopes	58	18	37	15	2.1	2.0
Warm																
	ABAM/GASH	13	74	50	27	2631 (1100-3600)	SW,S,SE,E	33	(0-66)	Middle to lower slopes	60	18	37	14	1.2	1.1
	ABAM/BENE	17	77	40	26	3459 (2600-4600)	W,SE,S,SE	36	(13-70)	Middle to lower slopes	48	16	26	19	1.6	0.8
	ABAM/VAAL-GASH	17	69	66	17	2806 (1900-4700)	Variable	22	(2-45)	Middle to lower slopes	61	24	44	23	1.8	1.0

*Calculated by plot as the summation of (100 - % Coarse Fragments) x (Horizon Thickness) x 0.01

dominates ridgetops, benches and gentle slopes. The ABAM/VAME/XETE, TSME/VAME, TSME/MEFE and TSME/RHAL associations occur on high frost hazard sites and the ABAM/RHAL, ABAM/MEFE, ABAM/VAME/CLUN, ABAM/TIUN and ABAM/OPHO associations occur on those of moderately high hazard.

Clearcutting may be widely applied as a reproduction method in less frost prone montane associations; however, its indiscriminate application in associations characteristic of higher elevations may enhance or create frost pockets. Also, sites which are clearcut and not promptly planted, may be lost to competition from beargrass, sedge or Ceanothus and a resulting increase in pocket gopher activity. With the exception of windthrow prone ridgetops which must be clearcut, use of the shelterwood method in many cases can provide adequate protection from frost in high elevation associations (Hoyer 1980; Hughes et al. 1979; Jaszkowski et al, 1975; Williamson 1973). Selection of frost tolerant tree species for planting and utilizing advanced regeneration at higher elevations will also increase the likelihood of successful reforestation (Halverson and Emmingham 1982). Western white pine (PIMO; Pinus monticoia Dougl.), Engelmann spruce (PIEN; Picea engelmannii Parry), western larch (LAOC; Larix occidentalis Nutt.) and lodgepole pine (PICO; Pinus contorta Dougl.) survive planting at high elevations much better than Douglas fir or noble fir (ABPR; Abies procera (Dougl.) Lind.). Pacific silver fir, mountain hemlock and Alaska yellow-cedar (CHNO; Chamaecyparis nootkatensis (L.) B.S.P.) may be useful as advanced regeneration which can attain good rates of growth after a three to five year readjustment period following canopy removal.

TABLE 3. MANAGEMENT CHARACTERISTICS OF PLANT ASSOCIATIONS

		Regeneration						
		Relative Hazards			Suitable Species			
Group	Association	Frost Hazard	Snow Pack	Drought Hazard	Less than 15% Slope	Over 15% Slope	Soil Compaction Hazard	Opportunity for Intensive Management
Cold								
	TSME/RHAL	High	High	Low	PIEN TSME* LAOC PIMO PICO CHNO* ABAM*	PIEN LAOC TSME* PIMO ABAM*	Moderately high	Poor
	TSME/MEFE	High	High	Moderately low	PIEN TSME* ABAM* LAOC PICO PIMO	PIMO LAOC TSME* ABAM*	Moderate	Poor
	TSME/VAME	High	High	Moderately high	PIMO PICO LAOC TSME* ABAM* PIEN	PIMO LAOC TSME* ABAM*	Moderately low	Poor
	ABAM/VAME/XETE	High	Moderately high	Moderately high	PIMO PICO TSME* ABAM* LAOC PEIN	ABPR PIMO ABAM* TSME* LAOC	Moderately low	Moderate
Cool								
	ABAM/MEFE	Moderately high	Moderately high	Moderately low	PIMO ABPR ABAM* LAOC TSME*	ABPR ABAM* PIMO	Moderate	Moderate
	ABAM/VAME/CLUN	Moderately high	Moderate	Moderate	PIMO ABPR PIEN ABAM*	ABPR PSME PIMO	Moderately low	Moderate
	ABAM/RHAL	Moderately high	High	Low	PIMO PIEN TSME* ABAM* CHNO*	PIEN PIMO ABPR ABAM*	Moderately high	Poor
	ABAM/OPHO	Moderately high	Moderately high	Low	ABPR PIEN THPL* ABAM* CHNO*	PIEN ABPR PSME	High	Poor
Mesic								
	ABAM/TIUN	Moderately high	Moderately high	Moderately low	PIMO PIEN ABPR ABAM*	ABPR PIMO PSME	Moderately high	Good
	ABAM/VAAL	Moderate	Moderate	Moderate	ABPR PIMO ABAM*	ABPR PSME	Moderate	Good
	ABAM/ACTR-CLUN	Moderate	Moderately low	Moderate	ABPR PIMO ABAM*	ABPR PSME	Moderate	Good
Warm								
	ABAM/VAAL-GASH	Moderately low	Moderately low	Moderate	ABPR ABAM*	PSME ABPR THPL*	Moderately low	Good
	ABAM/BENE	Moderately low	Moderately low	Moderately high	ABPR ABAM*	ABPR PSME	Moderately low	Moderate
	ABAM/GASH	Moderately low	Moderately low	Moderate	ABPR ABAM*	PSME ABPR THPL*	Moderately low	Good

*Useful as advanced regeneration

In upper elevation associations (TSME/RHAL, TSME/MEFE, TSME/VAME, ABAM/RHAL, ABAM/MEFE, ABAM/VAME/CLUN and ABAM/VAME/XETE) a greater proportion of total site nitrogen is concentrated in the forest floor and above ground vegetation (Topik 1982). This predisposes high elevation sites to substantial nitrogen loss, should organic matter destruction be extensive as during a fire of severe intensity (Swank and Waide 1980). Site nitrogen losses as high as 80 percent resulting from harvest followed by slash burning (DeBell and Ralston 1970) may cause nitrogen deficiencies which depress productivity on already modestly productive sites (Swank and Waide 1980). While broadcast burning of slash may be a desirable site preparation and wildfire hazard reduction measure at lower elevations, intense burning of high elevation sites, where the antecedent fire hazard is low, merely results in destruction of valuable advanced regeneration and organic matter.

Compaction is the foremost soil related management problem. Plant associations (TSME/RHAL, ABAM/RHAL, ABAM/OPHO and ABAM/TIUN) which occur on sites where soils are moist during a substantial portion of the year are more subject to compaction. Proper timing of stand entry and use of cable logging methods can diminish adverse effects of harvest.

Productivity

Productivity varies considerably among the montane plant associations as is seen in Figure 3 where production indices are arrayed along temperature and moisture gradients. Values for volume index generally exceed those for SDI volume increment, both measures representing potential production near culmination of mean annual increment. Current volume increment values, by contrast, are lower than those for SDI volume increment and volume index because they represent production in virgin stands which are past culmination age.

The associations may be grouped into three productivity classes. High production was observed in the ABAM/TIUN, ABAM/OPHO and ABAM/ACTR/CLUN associations where sites are characterized by adequate moisture, deep soils and a rich herb cover. Low production was measured in the TSME/RHAL, TSME/MEFE, TSME/VAME and ABAM/RHAL associations where cold soil and air temperatures, heavy snowpacks and shorter growing seasons limit growth and in the ABAM/BENE association where shallow, rocky soils on southerly aspects may contribute to growing season drought stress. Moderate production levels were observed in the ABAM/MEFE, ABAM/VAME/XETE, ABAM/VAME/CLUN, ABAM/VAAL, ABAM/VAAL-GASH and ABAM/GASH associations which represent a broad range of intermediate environments.

The height growth patterns of the major tree species varied substantially among the association productivity groups (Figure 4). These empirically derived height-age curves do not fit many of the height-age curves currently in use. The shape of the height-age curve also changed within a species across different plant associations. It was concluded that the shape of a height growth curve for a species will change as environmental factors become more severe. Although many data were collected in stands over 250 years old, most future stands will be managed at rotations of 150 years

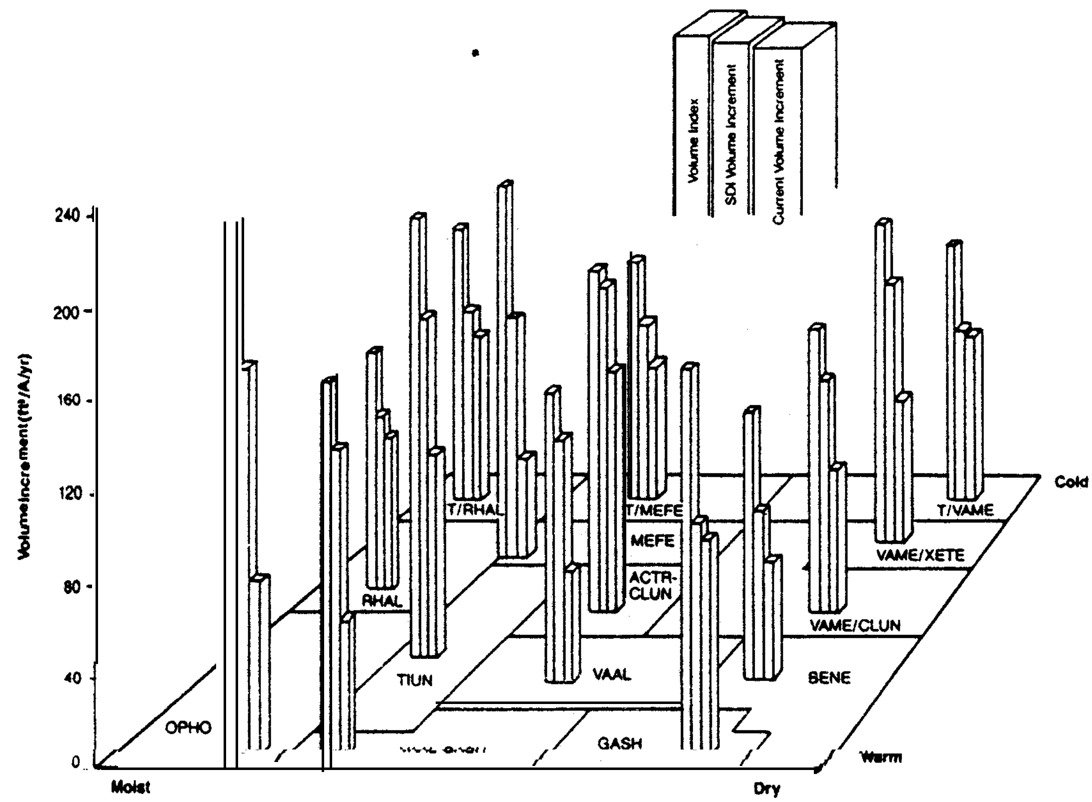


FIGURE 3. COMPARISON OF TIMBER PRODUCTION INDICES FOR PLANT ASSOCIATIONS ORDERED ALONG TEMPERATURE AND MOISTURE AXES

or less. It is worth noting that the long-term relative growth performance of these species does not in many cases correspond to their short-term growth potential.

CONCLUSIONS

An ecologically based classification was developed for the montane forest land in southwestern Washington. The 14 plant associations identified represent a broad range of environments, each with its own unique management considerations. Tree species growth characteristics and productivity were found to vary substantially among sites characterized by each association. Subsequent field application by district timber management staff has confirmed the classification as a useful tool in delineating environmental constraints and identifying treatment options appropriate to achieving management objectives. The classification will also be an aid in stratifying future inventory sampling and future mapping activity required for land management planning decisions.

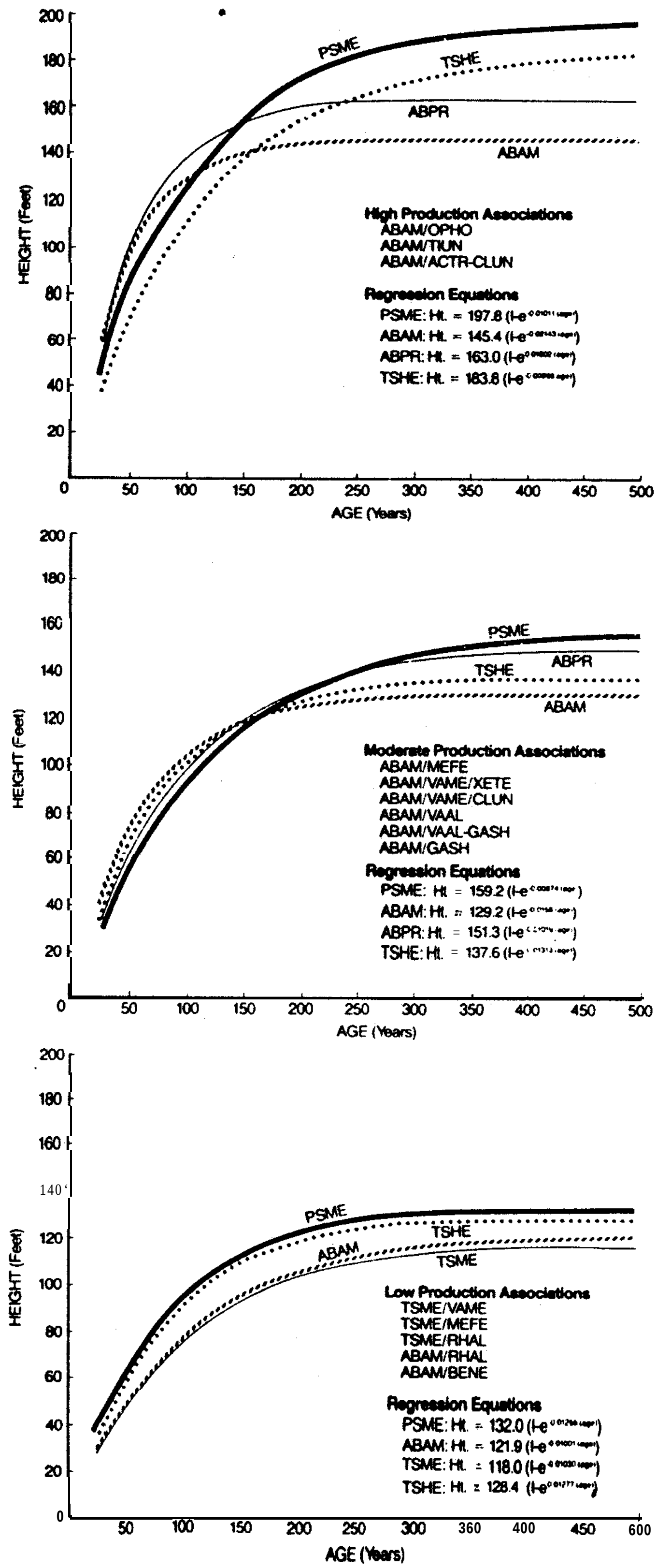


FIGURE 4. COMPARISON OF HEIGHT GROWTH AMONG IMPORTANT TIMBER SPECIES

ACKNOWLEDGEMENTS

This study was supported by funding from the Cifford Pinchot National Forest and the Pacific Northwest Region of the USDA Forest Service. The authors wish to express their gratitude to this agency, to William Emmingham who initiated this study, and to the following individuals whose efforts were invaluable to project completion and manuscript publication: Miles Hemstrom, Frederick Hall, Eugene Smith, Nancy Halverson, Sheila Logan and Deborah Cohen.

LITERATURE CITED

Brockway, D. G., C. Topik, M. A. Hemstrom and W. H. Emmingham. 1983a. Plant association and management guide for the Pacific silver fir zone of the Gifford Pinchot National Forest. USDA Forest Service Area Guide R6-ECOL-130a- 1983. Pacific Northwest Region. Portland, Oregon. 122 p.

Brockway, D. G., C. Topik, M. A. Hemstrom and W. H. Emmingham. 1983b. Plant association and management guide for the Pacific silver fir zone of the Gifford Pinchot National Forest. USDA Forest Service Area Guide R6-ECOL-130b-1983. Pacific Northwest Region. Portland, Oregon. 76 p.

Daubenmire, R. and J. B. Daubenmire. 1968. Forest vegetation of eastern Washington and northern Idaho. Washington Agricultural Experiment Station Technical Bulletin No. 60. Pullman. 104 p.

DeBell, D. S. and C. W. Ralston. 1970. Release of nitrogen by burning light forest fuels. Soil Science Soc. Am. Proc. 34(6):936-938.

Dixon, W. 3. 1981. Biomedical data processing statistical software. University of California Press, Berkeley. 726 p.

Franklin, J. F. 1966. Vegetation and soils in the subalpine forests of the southern Washington Cascade Range. Ph.D. Dissertation. Washington State University, Pullman. 132 p.

Franklin, J. F. and C. T. Dyrness. 1973. Natural vegetation of Washington and Oregon. USDA Forest Service General Technical Report PNW-8. Pacific Northwest Forest and Range Experiment Station. Portland, Oregon. 417 p.

Gauch, H. G. 1982. Multivariate analysis in community ecology. Cambridge University Press, New York. 298 p.

Gleason, H. A. 1926. The individualistic concept of plant association. Bulletin of the Torrey Botanical Club 53:7-26.

Hall, F. C. 1983. Growth basal area: a field method for appraising forest site potential for stockability. Can. J. For. Res. 13:70-77.

Halverson, N. M. and W. H. Emmingham. 1982. Reforestation in the Cascade Pacific silver fir zone: a survey of sites and management experiences on the Gifford Pinchot, Mt. Hood and Willamette National Forests. USDA Forest Service. Pacific Northwest Region Area Guide R6-ECOL-091- 1982. 40 p.

Hemstrom, M. A. 1983. A method of calculating stand volume and net periodic annual increment for high elevation mixed conifer stands. USDA Forest Service. Pacific Northwest Region. Willamette National Forest. Eugene, Oregon. (In review).

Hoyer, C. E. 1980. Shelterwood regeneration opportunities in Washington State, defined by forest habitats. Forest Land Management Contribution No. 203. Department of Natural Resources. Olympia, Washington. 36 p.

Hughes, J., C. Puuri, D. Boyer, K. Eldredge, K. Lindsay, R. Jaszkowski, D. Kingsley, M. Conan, D. Kyle and C. Spoon. 1979. Shelterwood cutting in Region 6. USDA Forest Service Task Force Report. Pacific Northwest Region. Portland, Oregon. 54 p.

Jaszkowski, R. T., H. Legard and K. McGonagill. 1975. A silvicultural guide to using the shelterwood system on the Willamette National Forest. USDA Forest Service. Pacific Northwest Region. Willamette National Forest. Eugene, Oregon. 31 p.

Knapp, W. A. 1981. Using Reineke's stand density index to estimate growth capability. In-house paper on file with USDA Forest Service. Pacific Northwest Region. Portland, Oregon. 6 p.

McIntosh, R. P. 1967. The continuum concept of vegetation. Botanical Review 33:130- 187.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York. 547 p.

Nie, N. H., C. H. Hall, J. G. Jenkins, K. Steinbrenner and D. H. Bent. 1975. Statistical package for the social sciences. McGraw-Hill, Inc., New York. 675 p.

Parton, W. J. and G. S. Innis. 1972. Some graphs and their functional forms. Technical Report No. 153. Grassland Biome, U.S.I.B.P. National Resource Ecology Lab. Colorado State University, Fort Collins. 41 p.

Pfister, R. D., B. L. Kovalchik, S. F. Arno and R. C. Presby, 1977. Forest habitat types of Montana. USDA Forest Service General Technical Report INT-34. Intermountain Forest and Range Experiment Station. Ogden, Utah. 174 p.

Ramensky, L. C. 1924. Basic regularities of vegetation cover and their study. Vestnick opytnogo dela Vorenezh. pp. 37-73.

Swank, W. L. and J. B. Waide. 1980. Interpretation of nutrient cycling research in a management context: evaluating potential effects of alternative management strategies on site productivity. pp. 137-157. In R. H. Waring (ed.) Forests: fresh perspectives from ecosystem analysis. Proceedings of the 40th Biological Colloquium. Oregon State University, Corvallis.

Topik, C. 1982. Forest floor accumulation and decomposition in the western Cascades of Oregon. Ph.D. Dissertation. University of Oregon, Eugene. 172 p.

Troll, C. 1955. Der Mount Rainier und das mittlere Cascaden-gebirge. Erdkunde 9:264-274.

Volland, L. A. and M. Connelly. 1978. Computer analysis of ecological data: methods and programs. USDA Forest Service. Pacific Northwest Region. Publication No. R6-ECOL-79-003. Portland, Oregon. 382 p.

Whittaker, R. H. 1962. Classification of natural communities. Botanical Review 28:1-239.

Williamson, R. L. 1973. Results of shelterwood harvesting of Douglas-fir in the Cascades of western Oregon. USDA Forest Service Research Paper PNW-160. Pacific Northwest Forest and Range Experiment Station. Portland, Oregon.

Zobel, D. B., A. McKee, G. M. Hawk and C. T. Dyrness. 1976. Relationships of environment to composition, structure and diversity of forest communities of the central western Cascades of Oregon. Ecological Monographs 46(2): 135-156.

FOREST LAND CLASSIFICATION: EXPERIENCES, PROBLEMS, PERSPECTIVES

Proceedings of a symposium held at the University of Wisconsin at Madison on March 18-20, 1984

Edited by James G. Bockheim

Department of Soil Science
University of Wisconsin
Madison, WI 53706

1984

SPONSORS

NCR-102 The North Central Forest Soils Committee

D. H. Alban -
USDA Forest Service
G. M. Aubertin -
Southern Illinois Univ.
J. G. Bockheim -
Univ. of WIsconsin
J. H. Brown -
OARDC, Ohio State Univ.
G. Cox -
Univ. of Missouri
A. R. Gilmore -
Univ. of Illinois
D. F. Grigal -
Univ. of Minnesota
J. G. Hart, Jr. -
Michigan State Univ.

G. S. Henderson -
Univ. of Missouri
G. Mroz -
Michigan Tech. Univ.
P. E. Pope -
Purdue Univ.
G. Evans -
Coop. State Research Service
K. Pregitzer -
Michigan State Univ.
R. Schultz -
Iowa-State Univ.
L. M. Walsh -
Univ. of Wisconsin
(administrative advisor)

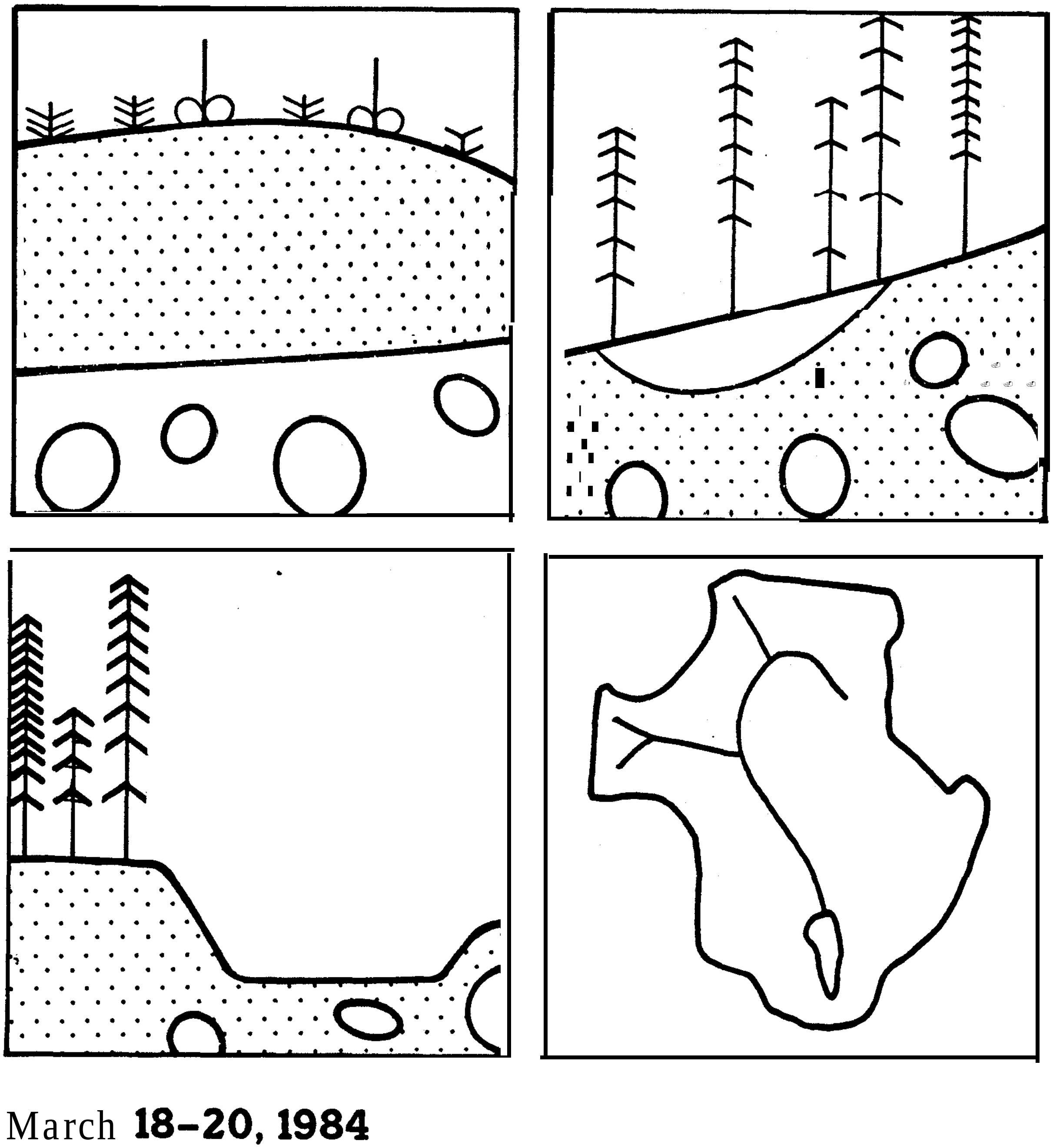
USDA Forest Service

USDA Soil Conservation Service

Society of American Foresters

Proceedings of the Symposium

Forest Land Classification: Experience, Problems, Perspectives



March **18-20, 1984**

Wisconsin Center
702 **Langdon** St.
Madison, WI 53706

Sponsored by: NCR-102 North Central Forest Soils Committee, Society of American Foresters, USDA Forest Service, and USDA Soil Conservation Service.