

ECOLOGICAL CLASSIFICATION AND CUMULATIVE SOIL EFFECTS

Mark E. Jensen

ABSTRACT

The Northern Region of the Forest Service, U.S. Department of Agriculture, has developed an efficient and consistent method for assessing cumulative effects of management practices on the soil and vegetation resources it manages. Ecological classification and analysis constitute the basis of this method. Since many of the management activities in the Region alter the present vegetation of a site (and consequently its values for a variety of resource uses) an understanding of plant succession relationships is critical to proper cumulative effects analysis. The ecological approach to cumulative effects analysis presented in this paper has proven effective in the Northern Region and is applicable to other wildland areas.

INTRODUCTION

The Forest Service has recently developed general guidelines (USDA FS 1988) for utilization of ecological classification and mapping in National Forest planning. This approach to land-use planning utilizes basic concepts of ecological classification (RISC 1983) in defining lands with similar potentials for management. National direction for a systematic approach to ecological analysis of cumulative effects has not been developed.

The primary objective of this paper is to discuss how ecological classification may be used in assessing the cumulative effects of management practices upon a variety of resources (for example, soil productivity, wildlife habitat, cattle forage, and watershed hydrologic function). A secondary objective is to describe some of the analysis software the Northern Region of the Forest Service uses in ecosystem cumulative effects analysis.

ECOLOGICAL CLASSIFICATION

Most ecological classifications utilize indicator plant species to describe environments with similar potentials for management. Habitat type classification based upon potential vegetation (associations) (Daubenmire 1952, 1968; Hironaka and others 1983; Jensen and others 1988; Pfister and others 1977) is an example of ecological classification that is widely used by various land management agency personnel, since relatively few diagnostic species are required to determine a site's ecological potential. In developing habitat type classification, minimally disturbed late-seral (potential natural community) or climax plant

communities are sampled to determine which combinations of plant species indicate distinctive environments for management (Pfister and others 1977). Vegetation, soils, and other site information are collected at sampled plots to fully describe the environment indicated by a given habitat type.

Occasionally the range of environment that a habitat type occupies is sufficiently broad that it is necessary to further delineate it into a smaller classification unit to meet management needs. Such delineations are referred to as ecological sites by the Range Inventory Standardization Committee (RISC 1983), ecological types (site types) by the Forest Service (USDA FS 1988), or range sites by the Soil Conservation Service (Shiflet 1973). Ecological sites, ecological types, and range sites are similar in that each represents "a kind of land with a specific potential natural community (a habitat type) and specific physical site characteristics, differing from other kinds of land in its ability to produce vegetation and to respond to management" (RISC 1983).

Hierarchical levels of ecological classification may be developed to describe land potential for specific management needs. For example, in broad regional analysis, description of land potential to the formation level of vegetation classification (for example, grassland and forestland) may be adequate for planning purposes. In detailed project work site types, ecological types, ecological sites, or range sites are commonly used to describe the land's potentials for management. The hierarchical ecological classification levels used by Forest Service personnel of the Northern Region (Hann and others 1988) allow for flexibility in describing land potential dependent upon analysis scale and precision of interpretation needs (table 1).

PLANT SUCCESSIONAL CLASSIFICATIONS

Once ecological classification units are described for an analysis area successional plant communities are sampled to denote the various types of communities and successional pathways that may exist within a given ecological unit. Paired-plot sampling is commonly employed (Arno and others 1986), where treated stands of vegetation and adjacent untreated "controls" are sampled to facilitate accurate assessments of the ecological unit (on the control stand) and the successional plant community response of the treated stand. Vegetation, soil, site, and disturbance information (Hann and others 1988) are collected at each plot in this approach.

Community analysis (Keane and others 1988) of plot data is performed to combine plots into similar "existing vegetation" classification groupings. Ordination software (for example, DECORANA and TWINSpan; Hill 1979a,b)

Paper presented at the Symposium on Management and Productivity of Western-Montane Forest Soils, Boise, ID, April 10-12, 1990.

Mark E. Jensen is Regional Soil Scientist, Northern Region, Forest Service, U.S. Department of Agriculture, Missoula, MT 59807.

Table 1—Description of hierarchical ecological classification levels utilized by the Forest Service Northern Region (Hann and others 1988)

Classification level	Example name	Appropriate analysis scale (map scale)	Potential cattle forage (lb/acre/yr/dry wt)
Ecoregion	Northern Rockies	1:500,000	N/A
Geo-climate zone	Moist, ash-influenced mountains	1:250,000	N/A
Land form	Unstable uplands	1:60,000	N/A
Formation	Forest lands	1:60,000	0-2,000
Series	Grand fir forests	1:60,000	50-1,500
Habitat type	Grand fir/wild ginger	1:24,000	200-1,000
Habitat type phase	Grand fir/wild ginger/yew	1:24,000	300-800
Site type	Grand fir/wild ginger/yew—sandy substrate	1:15,840	500-600

and similarity indices (Gauch 1982) are commonly used in such analyses. Dependent upon analysis objectives, existing vegetation classification groupings may be broadly (cover type) or narrowly (community type) defined (Hann and others 1988).

Prediction of plant community response following disturbance within ecological units may be facilitated by empirical or mechanistic succession models (Keane 1987). The application of "expert systems" technology to plant succession prediction is particularly useful in situations where limited data exist for the development of empirically based models (Keane and others 1988).

Once the existing vegetation types are described for an ecological unit, they are arrayed to display successional pathway relationships and correlated to type of disturbance. The "cone model" of plant succession (Huschle and Hironaka 1980) is a useful method for conceptualizing successional relationships within an ecological unit. This model assumes that, following disturbance, numerous "early seral" plant communities may develop on a site dependent on type of treatment, pretreatment vegetation composition, and gene pool access to the treated site. With increasing time after disturbance, species replacement occurs, which acts to narrow the range of communities that may exist on a given ecological unit. Given sufficient time (and absence of major disturbance), one plant community (potential vegetation) will be found on an ecological unit.

The cone model concept is illustrated in figure 1, which displays some generalized plant succession relationships within the grand fir/wild ginger (*Abies grandis/Asarum caudatum*) habitat type of northern Idaho (Green and Jensen 1989, this proceedings). Different types of disturbance contribute to multiple-plant successional pathways

in this habitat type. Heavy soil displacement (removal of surface-soil ash cap) commonly results in the development of a forb-rich community (table 2) with few tree species present. This community type (CT 4) is persistent and does not experience significant species replacement with time. Low soil displacement in this habitat type initiates a successional sequence (CT 3 to CT 2 to CT 1 to PNC), which favors the establishment of tree and shrub species (fig. 1, table 2). Grass seeding (CT 5) delays the establishment of shrub species on low-soil-disturbance sites.

Documentation of plant successional pathways can only be developed within a reasonably defined ecological unit (Green and Jensen, this proceedings). Since the establishment of a given community type is a function of disturbance type and environmental variables (for example, climate and soil), it is critical that successional pathway predictions be developed within narrowly defined ecological units (the variability due to environment must be accounted for before disturbance relationships can be elucidated). The development of successional pathway predictions by ecological units provides a powerful tool for assessing the cumulative effects of management practices on vegetation, which in turn influences the land's value for multiple-use management.

VALUE RATINGS AND DESIRED COMMUNITY IDENTIFICATION

Each of the plant communities displayed in figure 1 possesses different values for a variety of resource uses (table 3). Such values are referred to as "Resource Value Ratings-RVR's" by RISC (1983) and are defined as "the

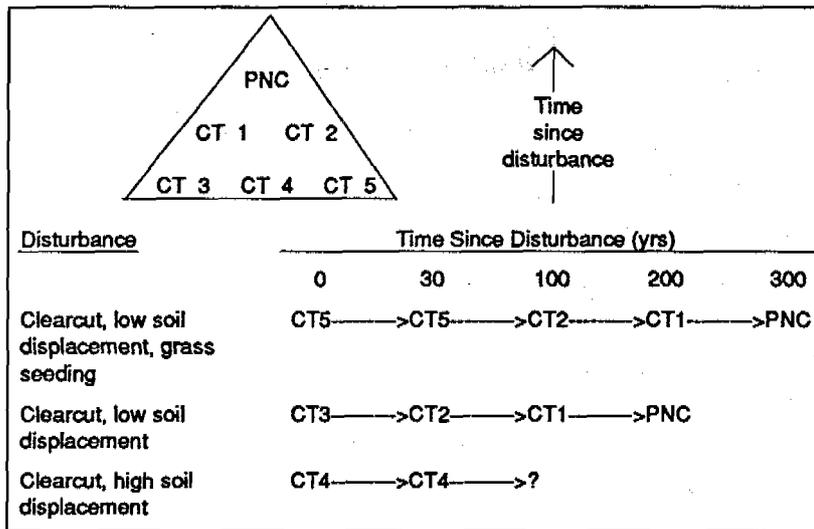


Figure 1—Cone model representation of plant community type successional pathway development within the grand fir/wild ginger habitat type.

Table 2—Generalized vegetation description of plant community types found on the grand fir/wild ginger habitat type illustrated in figure 1. The numbers provided indicate percent foliar canopy cover

Dominant species	Community type					
	PNC	CT1	CT2	CT3	CT4	CT5
Grand fir (<i>Abies grandis</i>)	80	64	20	3	0	4
Douglas-fir (<i>Pseudotsuga menziesii</i>)	0	16	40	4	1	3
Twinflower (<i>Linnaea borealis</i>)	5	5	5	2	0	0
Blue huckleberry (<i>Vaccinium globulare</i>)	5	10	15	24	0	2
Thimbleberry (<i>Rhubus parviflora</i>)	0	0	2	2	5	7
Mountain maple (<i>Acer glabrum</i>)	2	5	20	5	0	0
Columbia brome (<i>Bromus vulgare</i>)	2	2	3	1	3	20
Bracted strawberry (<i>Fragaria vesca</i>)	0	0	0	3	30	4
Canadian thistle (<i>Cirsium arvense</i>)	0	0	0	3	10	0
Wild ginger (<i>Asarum caudatum</i>)	2	1	1	0	0	0

Table 3—Resource Value Ratings associated with several plant community types of the grand fir/wild ginger habitat type. The first number in each column represents the community types' absolute RVR value and the second number represents its relativized RVR value (percent of maximum in the column for the habitat type)

Community type	Resource Value Ratings				
	Tree basal Area	Elk hiding	Elk forage	Cattle forage	Basal vegetation and litter ground cover
	<i>Ft²/acre</i>	<i>Percent</i>	<i>----- Lb/acre/yr -----</i>		<i>Percent</i>
PNC	200 (80)	12 (20)	400 (52)	200 (33)	97 (100)
CT1	250 (100)	20 (33)	450 (59)	200 (33)	96 (99)
CT2	150 (60)	60 (100)	600 (78)	220 (37)	95 (98)
CT3	10 (4)	10 (17)	700 (91)	400 (67)	85 (88)
CT4	2 (1)	0 (0)	650 (84)	380 (63)	70 (72)
CT5	8 (3)	1 (2)	770 (100)	600 (100)	80 (82)

value of vegetation present on an ecological site for a particular use or benefit." RISC further states that "RVR's may be established for each plant community capable of being produced on an ecological site, including exotic or cultivated species."

Displaying RVR's by plant community groupings allows the user to decide which plant community best meets management objectives for a given analysis area. Such plant communities are referred to as the "Desired Plant Community" of the ecological unit (USDA FS 1988) and may be used to rate the floristic similarity of other community types (ecological status) to the target community in an analysis area. Low similarity measurements would indicate a need for management action; a high similarity measurement would indicate little or no need for management action in this approach. The RVR's associated with the existing plant communities of the grand fir/wild ginger habitat type (table 3) are useful in illustrating these points.

The grand fir/wild ginger habitat type is an important component of managed forestlands of northern Idaho (Green and Jensen 1989). Timber harvesting is common in this habitat type; however, elk habitat, livestock grazing, and watershed hydrologic function are also important issues in multiple-use management in this type. The desired plant community of this habitat type should provide optimum timber, wildlife, range, and watershed resource values.

The forb-rich community type (CT 4), which is promoted by high soil displacement, is clearly not the desired plant community of this type, since it has the lowest relativized resource values (table 3) for elk hiding cover (0 percent), tree basal area (1 percent), and ground cover (72 percent). In this example CT 2 is the desired plant community, since it has the optimum combination of resource values given the management issues of concern. Management practices that promote the development of this community type include clearcutting with low soil displacement. Accordingly, timber harvesting in this habitat type should avoid heavy soil displacement and grass seeding. This will promote rapid development of the desired plant community.

This example is simplified. In practice, more than one desired plant community expression of an ecological unit may be required to meet management objectives for an

area. For example, 60 percent of an analysis area may be targeted for maximum timber production and 40 percent for elk habitat emphasis. In this situation, 60 percent of the area would have the CT 1 community type as the desired plant community for timber objectives, and 40 percent of the area would have CT 2 as the desired plant community for elk management objectives (table 3). Management practices would then be scheduled that promoted establishment of the desired plant communities (for example, clearcutting or thinning of PNC stands with minimal soil displacement) and trend monitoring would be conducted over time to ensure that desired plant succession pathways were being followed. The spatial distribution of the desired plant communities in an analysis area is important to many wildlife species (for example, those needing migration routes) and must be considered in the planning process. Digitization of existing vegetation and ecological unit maps for geographic information systems analysis is extremely useful in addressing spatial questions related to desired plant community distribution.

FOREST SERVICE APPLICATION EXAMPLE

The Northern Region of the Forest Service utilizes ecological classification in describing the cumulative effects of management practices on a variety of ecosystems (for example, grasslands, forestlands, and riparian areas). Multiple-use management of these lands requires that the effects of management activities be documented in a consistent, efficient manner. The first step in meeting this task is to ensure that different resource functions (for example, wildlife, timber, and soils) utilize common terms and databases when characterizing and analyzing the ecosystems they manage. Standards for ecosystem characterization (for example, soils, vegetation, and climate) have been developed for use throughout the Region by the Ecosystem Management Group (Hann and others 1988) and the Timber Management Group (USDA FS 1989b, 1986c). Data analysis and prediction systems (Keane and others 1988) have also been developed to ensure consistent interpretation of ecosystem data.

Some of the various databases and analysis programs (Keane and others 1988) utilized by Northern Region personnel in cumulative effects analysis are displayed in figure 2. Two basic types of polygon map level information are utilized in cumulative effects analysis in the Region. One of these polygons is land potential (ecological unit), which is delineated by soil survey map units (SOILMUD). Attribute data linked to these polygons include soils, geology, climate, and ecological classification. The second polygon represents existing vegetation, which is documented through vegetation stand mapping units (VEGSTAND).

Vegetation stands consist of vegetation based polygon delineations that have unique automated data processing (ADP) code identifiers (for example, timber stands). Management activities and plot-level information are linked to these polygons for data analysis. The combination of these two polygons through relational databases and geographic information systems software allows the user to identify site potential, successional pathways, and resource values of an analysis area in an efficient manner.

Classification databases are constructed from plot data and published information and are used to characterize

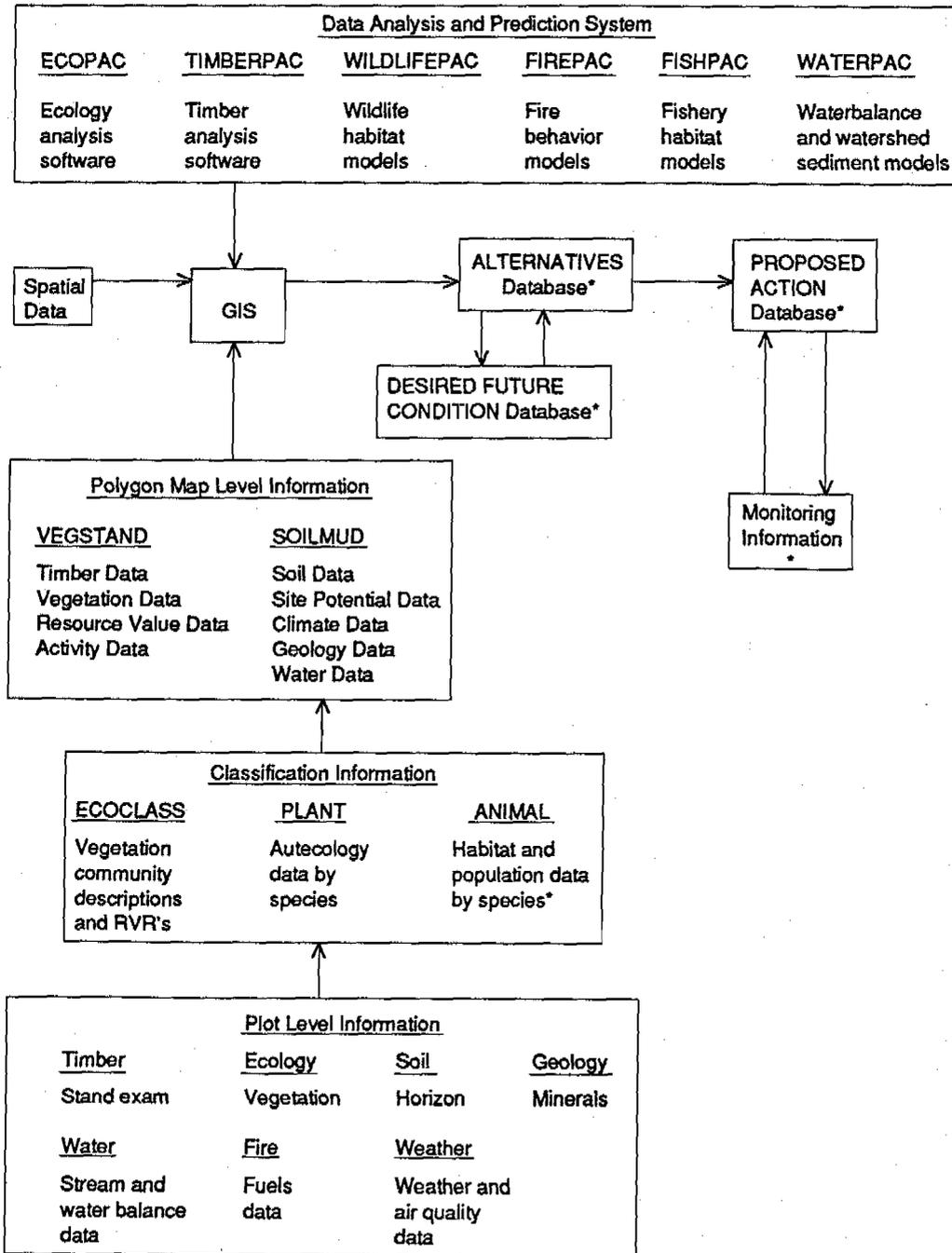


Figure 2—Listing of some of the databases and analysis programs used by the Forest Service Northern Region in cumulative effects analysis. * indicates databases that are being developed.

both the vegetation stand and soil survey map units. The ECOCLASS database (fig. 2) contains information on resource value ratings for seral plant communities; the PLANT database contains information on plant species autecological relationships, which is used to predict plant succession through "expert systems" technology; and the ANIMAL database contains information concerning wildlife species habitat requirements and population dynamics.

Numerous data analysis and prediction systems are linked to the polygon map level databases to facilitate interpretation of management effects on various resources (for example, fire behavior, watershed hydrologic function, and wildlife habitat suitability). Outputs from such analyses are stored in an ALTERNATIVES database, which allows the user to document the types of resource response associated with different management activities on a given map unit. Such output is contrasted to the DESIRED FUTURE CONDITION database which displays the desired characteristics of a map unit given management objectives for an area. Selected alternatives for management are documented by map polygon in the PROPOSED ACTION database. Monitoring information is linked to the PROPOSED ACTION database to ensure that proposed activities are implemented and that data analysis and prediction systems output for the proposed action were reasonable. The process used by Northern Region personnel in applying ecological classification concepts to cumulative effects analysis is outlined by Jensen and others (1991).

CONCLUSIONS

Utilization of ecological classification concepts in cumulative effects analysis provides an improved method for development of documents required by the National Environmental Policy Act. Since many management activities on Federal land alter vegetation, which in turn influences the land's value for a variety of resource uses, it is important that reasonable predictions of plant community successional response be made prior to scheduling management actions. The approach to cumulative effects analysis presented in this paper has proven useful in describing the effects of management activities on lands managed by the Forest Service.

REFERENCES

- Arno, S.; Simmerman, D.; Keane, R. 1986. Characterizing succession within a forest habitat type—an approach designed for resource managers. Res. Note INT-357. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 8 p.
- Daubenmire, R. 1952. Forest vegetation of northern Idaho and adjacent Washington, and its bearing on concepts of vegetation classification. *Ecological Monographs*. 22: 301-330.
- Daubenmire, R. 1968. *Plant communities: a textbook of plant synecology*. New York: Harper and Row. 300 p.
- Gauch, H. G. 1982. *Multivariate analysis in community ecology*. New York: Cambridge University Press.
- Green, P.; Jensen, M. E. 1989. Ecological type and seral plant community relationships within the grand fir/wild ginger habitat type of northern Idaho. Special Pub. 1. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region, Ecosystem Management Group. 100 p.
- Hann, W. J.; Jensen, M. E.; Keane, R. E. 1988. *Ecosystem classification handbook*, chapter 4—ECODATA sampling methods. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region. 120 p.
- Hill, M. D. 1979a. DECORANA—a FORTRAN program for detrended correspondence analysis and reciprocal averaging. Ithaca, NY: Cornell University, Department of Ecology.
- Hill, M. D. 1979b. TWINSPAN—a FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. Ithaca, NY: Cornell University, Department of Ecology.
- Hironaka, M.; Fosberg, M. A.; Winward, A. H. 1983. Sagebrush-grass habitat types of southern Idaho. *Bull.* 35. Moscow, ID: University of Idaho Forestry Wildlife and Range Experiment Station.
- Huschle, G.; Hironaka, M. 1980. Classification and ordination of seral plant communities. *Journal of Range Management*. 33: 179-182.
- Jensen, M. E.; Peck, L. S.; Wilson, M. V. 1988. A sagebrush community type classification for mountainous north-eastern Nevada rangelands. *Great Basin Naturalist*. 48: 422-433.
- Jensen, M. E.; McNicoll, C.; Prather, M. [In press]. Application of ecological classification to cumulative effects analysis. *Journal of Environmental Quality*. vol. 20.
- Keane, R. E. 1987. Forest succession in western Montana—a computer model designed for resource managers. Res. Note INT-376. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 8 p.
- Keane, R. E.; Jensen, M. E.; Hann, W. J. 1988. *Ecosystem classification handbook chapter 5—Data entry and analysis*. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region. 56 p.
- Pfister, R. D.; Kovalchik, B. L.; Arno, S. F.; Presby, P. C. 1977. Forest habitat types of Montana. Gen. Tech. Rep. INT-34. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 174 p.
- RISC. 1983. Guidelines and terminology for range inventories and monitoring. Report of the Range Inventory Standardization Committee. Denver, CO: Society for Range Management. 9 p.
- Shiflet, T. N. 1973. Range sites and soils in the United States. In: *Arid shrublands. Proceedings, 3rd Workshop of the U.S./Australian Rangeland Panel*; Tucson, AZ. Denver, CO: Society for Range Management: 26-33. U.S. Department of Agriculture, Forest Service. 1988. *Ecosystem classification, interpretation and application*. Forest Service Manual 2060. Washington, DC: U.S. Department of Agriculture, Forest Service.
- U.S. Department of Agriculture, Forest Service. 1989. *Timber management control handbook*. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region.
- U.S. Department of Agriculture, Forest Service. 1986. *Timber management data handbook*. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Region.

Proceedings—Management and Productivity of Western-Montane Forest Soils

Boise, ID, April 10-12, 1990

Compilers:

Alan E. Harvey, Project Leader
Intermountain Research Station,
Forest Service, U.S. Department of Agriculture

Leon F. Neuenschwander, Associate Dean for Research,
College of Forestry, Wildlife and Range Sciences,
University of Idaho

Symposium Sponsors:

Intermountain Research Station
University of Idaho

