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Distribution of Permanent Plots to Evaluate Silvicultural Treatments in the Inland Empire

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ABSTRACT

To assess the adequacy of a permanent-plot data base for estimating growth and yield, one first needs to know how the plots in the data base are distributed in relation to the population they are presumed to represent. The distribution of permanent plots to study forest growth in the Inland Empire (northeastern Washington, northern Idaho, and western Montana) is displayed using a method that relates the permanent plots to the land base. The permanent plots are quantified into classes defined using inventory data that describe the land base. Five stand attributes are used to define the classes: geographic location, habitat type, aspect, slope, and elevation. The assessment also includes the silvicultural treatments of the plots.

KEYWORDS: forest management, inventory, forest growth

This report presents a method for displaying the distribution of permanent plots that have been established to study forest growth and of the land base to which the information is to be applied. Inevitably, there are gaps in the distribution, which may indicate a need for establishment of additional plots. But before new plots are installed, the types and conditions of stands in which these data are needed should be assessed to avoid waste of effort and money. In this note, we summarize the distribution of data for the forests of the Inland Empire (northeastern Washington, northern Idaho, and western Montana).

This assessment of data quantifies the number of existing permanent plots within classes, which are defined using inventory data that describe the land base. Insofar as possible, each class was defined to represent a meaningful area. Five stand attributes are used in defining the classes: geographic location, habitat type, aspect, slope,

and elevation. The total acreage in the land base within each class is calculated. Silvicultural treatments represented by the permanent plots are included in the assessment. A set of tables documenting the number of permanent plots and the inventory acreage in each class is generated as a result of this analysis.

In this note, silvicultural treatments are defined very broadly, and species growing on the plots are not defined at all. But when the method is applied, the user first selects the subset of the available permanent plots that are germane to the problem being considered. This selection process may use any number of variables commonly measured on permanent plots. See papers by Curtis (1983) or Sweet and Byrne (1988) for description of these variables. Finally, the selected permanent plots can be viewed against the inventory, using the method described in this note, and any omissions in the distribution can then be observed.

PERMANENT PLOT DATA

The permanent plot data sources used in this assessment are of two general types: research plots and monitoring plots. Research plots are usually established as part of experiments designed to find out the relationships between forest growth, stand condition, and stand treatments, whereas monitoring plots are established to measure the actual growth and mortality of operationally treated stands (Curtis and others 1986). Henceforth, whenever we refer to research plots, we are referring to both research and monitoring plots.

A variety of sampling designs are represented in the research data base, ranging from single, fixed-area plots to clusters of variable radius points in a stand. In this analysis, we consider the definition of a "research plot" to be an area of ground with relatively uniform conditions that has received a unique treatment combination and has been measured at successive intervals. Therefore, a

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stand with a unique treatment but with a cluster of 10 plots is considered to be one "research plot."

Existing research plot data have been acquired from both Forest Service research units and National Forests within the Inland Empire. In addition, plot information from research studies maintained by several other agencies, including the University of Montana (Sweet 1988) and the University of Idaho (Moore 1988; Hanley and Adams 1976), has been obtained. The data from agencies outside the Forest Service are a result of a continuing effort within the Inland Northwest Growth and Yield Cooperative (INGY) to compile existing permanent plot data from governmental, university, and forest industry sources in the region. This note reports the distribution of data acquired to March 1988. Listed below are general descriptions of the research plot data.

USFS-INT North Idaho Permanent Sample

Plots—A series of 118 permanent sample plots maintained by the Intermountain Research Station (INT) in the Idaho Panhandle (Kaniksu, Coeur d'Alene, and St. Joe) and Clearwater National Forests. Purpose: to monitor growth, mortality, and yield of second growth natural stands, managed stands after initial spacing control or thinning, and plantations.

USFS-Region 1 Birgenheier Plots—A group of 35 managed stands with clusters of sample plots established in 1970-71 in the National Forests of the Inland Empire. Purpose: to monitor the growth and yield of managed stands, including how stands growing under various conditions respond to thinning.

USFS-INT Regeneration Development and Thinning Study—A group of 160 managed stands with sample plots established in 1974-76 in National Forests and State and private lands in the Inland Empire. Purpose: on regenerated stands, monitor development of regeneration until pole size is attained; for thinned stands, monitor growth and mortality of stands thinned with varying methods and intensity.

USFS-INT Western Montana Silviculture

Research Plots—A series of 286 permanent sample plots from a variety of silviculture research studies, including spacing of western larch (*Larix occidentalis*) and lodgepole pine (*Pinus contorta*), harvesting and silvicultural alternatives in lodgepole pine, western larch, and Douglas-fir (*Pseudotsuga menziesii*) stands, and stand development after seed tree cuts and thinning in western larch.

USFS-Region 4 Growth Monitoring Plots—A group of 41 stands with permanent growth sample plots established in 1983-84 on the Boise and Payette National Forests in central Idaho. Each stand has a control area and a thinned area. Purpose: to monitor the growth and mortality of stands treated with various silvicultural methods in order to check yield model accuracy.

USFS-Region 1 Growth Monitoring Plots—A group of 628 stands with permanent growth sample plots, established from 1984 to 1986 in the National Forests in northern Idaho and Montana. Each stand has a control area

and another treatment (in most cases, a thinning). Purpose: to monitor the growth and mortality of stands treated with various silvicultural methods in order to check yield model accuracy.

University of Montana Levels of Growing Stock Study—A set of seven installations (total of 27 plots), each with two or three different tree spacings and a control, located in western Montana. Purpose: to compare growth and yield at four density levels in second-growth western larch, lodgepole pine, ponderosa pine (*Pinus ponderosa*), and mixed-species forests.

University of Montana Napa Ponderosa Pine Study—A set of 17 plots with various thinning regimes located in western Montana. Purpose: to determine productivity relationships for ponderosa pine on a high site over a range of densities.

University of Montana Von Deichmann's Lodgepole Spacing Study—Four plots established at various spacings in western Montana. Purpose: to compare growth and yield in a lodgepole pine stand at four density levels.

University of Montana Brun's Ponderosa Pine Spacing Study—Three plots established at various spacings in western Montana. Purpose: to compare growth and yield in a ponderosa pine stand at three density levels.

University of Montana Ponderosa Pine Site Quality Plots (Martin)—Six installations, each with two plots at each of three different density levels, established in 70-year-old ponderosa pine stands in western Montana. Purpose: to study diameter and height growth as well as tree taper change over time in ponderosa pine stands.

University of Montana Sanders County/Lubrecht Experimental Forest Permanent Plots—A set of 198 permanent plots, located in Sanders and Missoula Counties, MT, established in stands with a range of stand density, timber type, and age. Purpose: to inventory and monitor long-term growth and yield of partially cut and postwildfire second-growth stands.

University of Idaho Intermountain Forest Tree Nutrition Cooperative Douglas-fir Permanent Growth and Yield Plots—A set of 94 installations, each with six plots (two controls, four fertilized), established in 1981-82 in eastern Washington, eastern Oregon, Idaho, and western Montana. Installations were located in second-growth, even-aged, managed, 40- to 80-year-old stands of Douglas-fir, over a broad range of sites and densities. Purpose: to test response of managed Douglas-fir stands to nitrogen fertilization.

University of Idaho Intermountain Forest Tree Nutrition Cooperative Ponderosa Pine Permanent Growth and Yield Plots—A set of 12 installations, each with five or six control and fertilized plots (total of 68 plots in this data set), established from 1974 to 1979 in Idaho and northeastern Washington. Installations were

located in stands dominated by ponderosa pine, which represented a range in initial density, age, and site quality. Purpose: to test response of ponderosa pine stands to nitrogen and phosphorus fertilization.

University of Idaho Big Meadows Ponderosa Pine Plantation Study—A set of 15 plots established in a young ponderosa pine plantation in northern Idaho. Purpose: to test the response of a young ponderosa pine plantation to several thinning levels.

INVENTORY DATA

Forest inventory data are used to represent actual forest conditions for the summary tables generated in this report. The inventory data come from three sources:

National Forest Inventories—Each National Forest in the Inland Empire conducted a forest inventory on its lands between 1971 and 1976. Data from the following National Forests are included: Colville in northeastern Washington; Kaniksu, Coeur d'Alene, St. Joe, Clearwater, and Nez Perce in northern Idaho; and Kootenai, Flathead, Lolo, and Bitterroot in western Montana.

Forest Survey Unit, Intermountain Research Station, Ogden, UT—Inventories of non-National Forest lands (other Federal, State, and private lands) in Idaho and Montana are conducted on a continual basis by this working group. The most recent inventories were conducted in 1980 for northern Idaho and in 1977-78 for western Montana.

Forest Survey Unit, Pacific Northwest Forest and Range Experiment Station, Portland, OR—Inventories of non-National Forest lands in northeastern Washington were provided by this working group. The last inventory was conducted in 1980.

Because these inventories were conducted in a random or systematic fashion, each inventory plot represents a particular land area. Acre expansion factors were provided for each plot along with the variables used in the classification.

ANALYSIS PROCEDURES

Five stand attributes known to influence regeneration and yield (Ferguson and others 1986; Stage 1973; Wykoff and others 1982) were used to classify the inventory data. These are: geographic location (State and county), habitat type, aspect, slope percentage, and elevation. Because of correlations among these variables, a method of summarizing the data into classes was needed for clear presentation of the data. The data were first tabulated in this hierarchical order: State, county, habitat type, aspect, slope percentage, and elevation.

State and county are used as the basic geographical location indicators because they were most easily obtained for both inventory and research plot data. For summarization, the data were divided into county groups that roughly correspond to National Forest boundaries. These county groups are defined below and their locations are shown in figure 1.

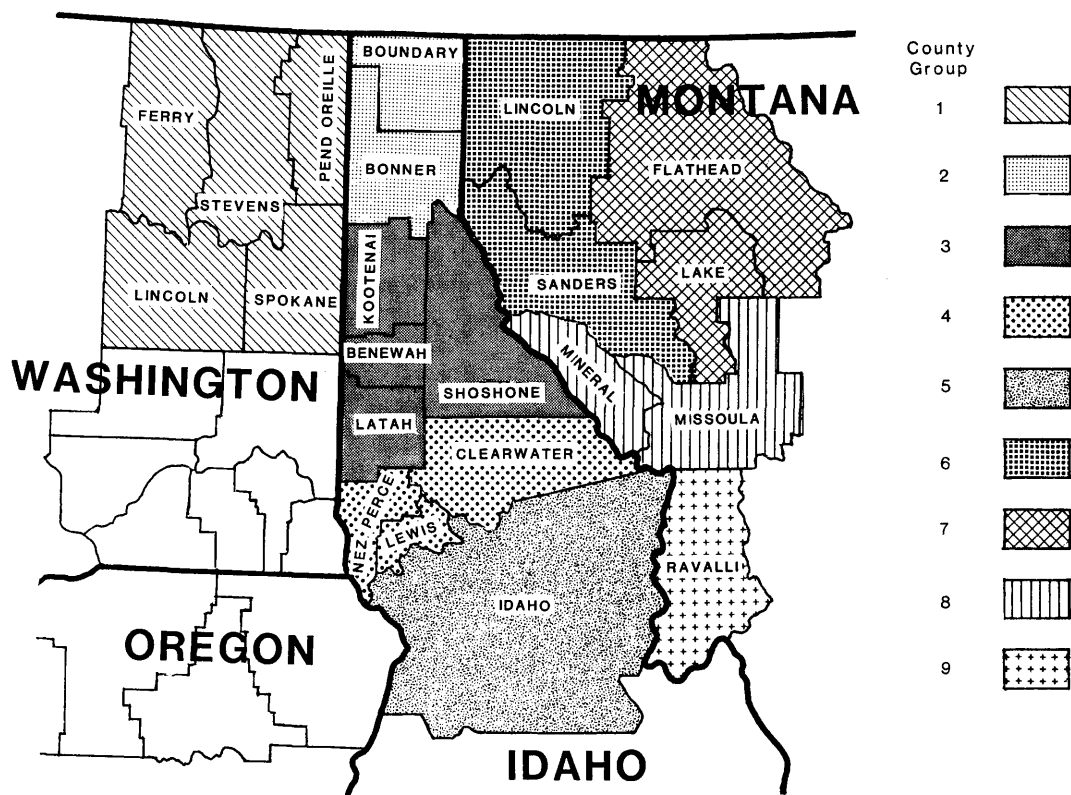


Figure 1—Location of county groups.

County group	State	Counties
1	Washington	Ferry, Stevens, Pend Oreille, Lincoln, Spokane
2	Idaho	Boundary, Bonner
3	Idaho	Kootenai, Shoshone, Benewah, Latah
4	Idaho	Clearwater, Nez Perce, Lewis
5	Idaho	Idaho
6	Montana	Lincoln, Sanders
7	Montana	Flathead, Lake
8	Montana	Mineral, Missoula
9	Montana	Ravalli

Habitat series and type (Cooper and others 1987; Pfister and others 1977; Steele and others 1981) are available for all research plots and inventory locations, except for the northeastern Washington inventory data, where ecoclass (Hall 1984) is available. Since habitat series and ecoclass codes for coniferous forest areas are generally comparable (Hall 1984), all research and inventory data were summarized by habitat series. The 12 habitat series represented in the data and common codes used for each are listed below.

Code	Habitat series
PIPO	<i>Pinus ponderosa</i> (ponderosa pine)
PSME	<i>Pseudotsuga menziesii</i> (Douglas-fir)
PIEN	<i>Picea engelmannii</i> (Engelmann spruce)
ABGR	<i>Abies grandis</i> (grand fir)
THPL	<i>Thuja plicata</i> (western redcedar)
TSHE	<i>Tsuga heterophylla</i> (western hemlock)
ABLA	<i>Abies lasiocarpa</i> (subalpine fir)
TSME	<i>Tsuga mertensiana</i> (mountain hemlock)
PIAL	<i>Pinus albicaulis</i> (whitebark pine)
LALY	<i>Larix lyallii</i> (alpine larch)
PICO	<i>Pinus contorta</i> (lodgepole pine)

Based on previous analysis of growth for purposes of constructing yield tables (Stage and Renner 1988), three different groupings of aspect were used: NE (292.6° through north to 112.5°), SW (112.6° to 292.5°), and level. Slopes were divided into three groups: 0-5 percent for level aspects, and 6-35 percent and ≥36 percent for NE and SW aspects.

Because different habitat series occur at different elevations on each aspect, a more complex method of dividing elevations was needed. The inventory plot locations were grouped into combinations of habitat series, aspect, and slope classes previously defined. The elevation data for each of these combinations were divided into low, medium, and high groups by using the average and standard deviation of the elevations in each combination. The averages and standard deviations were rounded to the nearest 100 feet before creating the elevation groups. The medium-elevation group is bounded by the average minus one-half standard deviation and the average plus one-half standard deviation. The low- and high-elevation groups are below and above these elevation breakpoints.

FORTTRAN programs were written that generate tables showing the number of existing research plots and total land base acreage within classes developed from the inventory data as described above. A variety of tables can be produced using these programs, including an overall table for the entire geographic area of interest and all possible treatment types, as shown in table 1. Within each class, research plots are reported along with land base area.

Tables similar to table 1 can be produced for each county group and for each of several broad treatment types. Such tables are not included in this note but may be acquired from the authors. These tables are easily updated as new research plot data are obtained. In addition, more detailed tables, such as plots and acreage by small groups of habitat types instead of habitat series, are easily produced if necessary.

Less-detailed summary tables have also been produced. Table 2 summarizes the acreage and plots by habitat series only for each county group and the entire area. Table 3 summarizes, within each habitat series, the number of plots within each of six common treatment types, including control (no treatment), thinning, and four regeneration methods: clearcut, seed tree, shelterwood, and selection. These types of tables may be helpful in initial assessments of data deficiencies.

Table 1—Distribution of research plots in relation to the land base (approximate) for the nine county groups, all treatments

Habitat series	Aspect	Slope	Low elevation		Elevation breakpoint	Medium elevation		Elevation breakpoint	High elevation	
			Land base	Plots		Land base	Plots		Land base	Plots
		Percent	1,000 acres		100 ft	1,000 acres		100 ft	1,000 acres	
PIPO	Level	0-5	89	—	21	117	—	29	14	3
	NE	6-35	56	—	22	118	—	32	21	1
		36+	24	—	22	12	—	32	7	—
	SW	6-35	120	—	24	64	—	33	41	1
		36+	70	—	28	45	—	39	46	—
PSME	Level	0-5	236	25	26	106	12	35	128	10
	NE	6-35	547	35	32	525	95	44	244	23
		36+	439	8	35	404	23	47	321	7
	SW	6-35	592	63	34	669	60	45	542	33
		36+	715	6	39	722	29	50	658	15
PIEN	Level	0-5	32	—	33	30	—	39	25	—
	NE	6-35	24	1	39	47	—	45	22	—
		36+	3	—	39	7	—	50	3	—
	SW	6-35	20	2	38	26	1	47	19	—
		36+	4	—	34	0	—	44	1	—
ABGR	Level	0-5	110	4	26	67	9	33	68	3
	NE	6-35	300	19	31	178	26	41	295	23
		36+	227	17	37	205	19	45	254	11
	SW	6-35	236	29	32	250	75	41	241	24
		36+	222	7	38	274	13	47	298	3
THPL	Level	0-5	31	7	29	35	12	34	33	4
	NE	6-35	135	41	33	235	20	40	159	7
		36+	244	23	36	286	14	43	277	4
	SW	6-35	127	20	32	203	55	39	151	7
		36+	177	5	34	331	15	42	245	12
TSHE	Level	0-5	33	27	25	74	17	30	72	8
	NE	6-35	232	50	33	286	20	40	218	9
		36+	235	46	36	206	45	43	264	7
	SW	6-35	220	27	33	322	31	40	167	8
		36+	109	7	35	141	14	42	92	4
ABLA	Level	0-5	74	4	39	144	12	49	67	2
	NE	6-35	411	58	49	684	48	58	544	37
		36+	232	32	50	646	18	59	386	8
	SW	6-35	276	10	48	542	16	56	370	18
		36+	237	4	51	491	6	59	344	3
TSME	Level	0-5	0	—	58	7	—	58	0	—
	NE	6-35	31	—	54	86	—	58	31	—
		36+	38	11	54	94	—	59	72	—
	SW	6-35	12	—	52	76	—	58	36	—
		36+	34	—	54	100	—	59	53	—
PIAL	NE	36+	3	—	63	16	—	75	5	—
	SW	36+	9	—	60	18	—	65	9	—
LALY	NE	36+	0	—	82	5	—	82	0	—
PICO	Level	0-5	0	—	20	15	—	23	0	—
	NE	6-35	7	—	38	0	—	49	7	—
	SW	6-35	0	—	28	7	—	28	0	—

Table 2—Distribution of research plots in relation to the land base (in 1,000's of acres) by habitat series

Habitat series		County group ¹									Total
		Northeastern Washington	Northern Idaho				Western Montana				
		1	2	3	4	5	6	7	8	9	
PIPO	Land base	620	14	33	27	71	9	8	13	48	844
	Plots	0	0	0	0	0	0	0	4	1	5
PSME	Land base	1,624	416	370	98	706	1,208	655	910	860	6,848
	Plots	68	17	14	0	6	100	28	184	27	444
PIEN	Land base	0	0	0	0	0	71	141	33	18	263
	Plots	0	0	0	0	0	2	1	1	0	4
ABGR	Land base	618	115	464	224	969	429	238	155	15	3,225
	Plots	30	7	48	34	64	60	14	23	2	282
THPL	Land base	170	231	591	706	534	186	157	96	0	2,669
	Plots	25	17	47	86	40	29	0	2	0	246
TSHE	Land base	373	958	794	0	0	527	14	0	0	2,671
	Plots	15	100	131	0	0	67	1	6	0	320
ABLA	Land base	253	431	332	252	868	591	1,259	740	722	5,448
	Plots	0	0	8	8	8	42	89	80	41	276
TSME	Land base	0	0	332	139	91	92	0	25	0	670
	Plots	0	0	10	0	0	1	0	0	0	11
PIAL	Land base	0	18	0	0	14	22	1	0	5	60
	Plots	0	0	0	0	0	0	0	0	0	0
LALY	Land base	0	0	0	0	0	0	0	0	5	5
	Plots	0	0	0	0	0	0	0	0	0	0
PICO	Land base	36	0	0	0	0	0	0	0	0	36
	Plots	0	0	0	0	0	0	0	0	0	0

¹County groups defined in text.

Table 3—Distribution of research plots in relation to the land base by habitat series and treatment type for the nine county groups combined

Habitat series	Land base, 1,000 acres	Treatment type						
		Control	Thinning	Clearecut	Seed tree	Shelterwood	Selection	Fertilized
		----- Number of plots -----						
PIPO	844	4	1	0	0	0	0	0
PSME	6,848	245	97	0	3	1	0	92
PIEN	263	3	1	0	0	0	0	0
ABGR	3,225	109	76	13	4	6	1	71
THPL	2,669	89	62	20	3	10	2	59
TSHE	2,671	136	131	23	0	2	6	21
ABLA	5,448	97	132	7	0	8	9	0
TSME	670	5	6	0	0	0	0	0
PIAL	60	0	0	0	0	0	0	0
LALY	5	0	0	0	0	0	0	0
PICO	36	0	0	0	0	0	0	0

INTERPRETATION

If costs could be ignored, the ideal situation would be to have research plots representing each treatment within each class, especially those classes representing considerable acreage. Proportional representation, however, would not be efficient because the precision of the yield estimates depends on number, not the sampling fraction, the finite population corrections in this context being trivial.

The number of plots needed in each class poses an experimental design problem of great complexity. First, the desired accuracy of yield estimates varies, depending on the resource management decisions that are contemplated and the ecological domain being managed (Newberry and Stage 1987). For example, the gap in dry ponderosa pine plots (table 1) is serious only if you have substantial lands of that type to manage. Second, equal representation may not be as efficient as one in which the distribution of data is determined by optimizing the design used to estimate the response surface (Myers 1971). For example, the target for middle-elevation classes might be only half the number of plots sought in the high- and low-elevation classes.

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