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**Intermountain
Forest and Range
Experiment Station
Ogden, UT 84401**

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# Handbook for Inventorying Surface Fuels and Biomass in the Interior West

**James K. Brown, Rick D. Oberheu,
and Cameron M. Johnston**

# THE AUTHORS

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# RESEARCH SUMMARY

Comprehensive procedures for inventorying weight per unit area of living and dead surface vegetation are presented to facilitate estimation of biomass and appraisal of fuels. The authors show how to conduct fieldwork and estimate weight per unit area of downed woody material, forest floor litter and duff, herbaceous vegetation, shrubs, and small conifers. Weights by species are determined for shrubs and small conifers. Coverage of shrubs and herbaceous vegetation are estimated. The several sampling methods involve the counting and measuring diameters of downed woody pieces that intersect vertical sampling planes, comparing quantities of litter and herbaceous vegetation against standard plots that are clipped and weighed, tallying shrub stems by basal diameter classes, tallying conifers by height classes, and measuring duff depth. The procedures apply most accurately in the Interior West; however, techniques for herbaceous vegetation, litter, and downed woody material apply anywhere. A computer program and card punching instructions are included for processing inventory data.

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## INTRODUCTION

This publication describes procedures for inventorying weight of forest floor duff, forest floor litter, herbaceous vegetation, shrubs, small conifers, and downed woody material (fig. 1). The procedures furnish estimates for live and dead vegetation by diameter classes. The inventory methods have application to several facets of forest and range management and to research investigations.

The procedures were initially developed to provide estimates of fuel loading (weight per unit area) as part of an effort to appraise fire behavior potential for planning fire strategies in wilderness areas (Habeck and Mutch 1973; Aldrich and Mutch 1972). Although the methodology emphasizes forest fuels, estimates of aboveground biomass of herbaceous vegetation, shrubs, and small conifers may be useful for purposes other than fuel
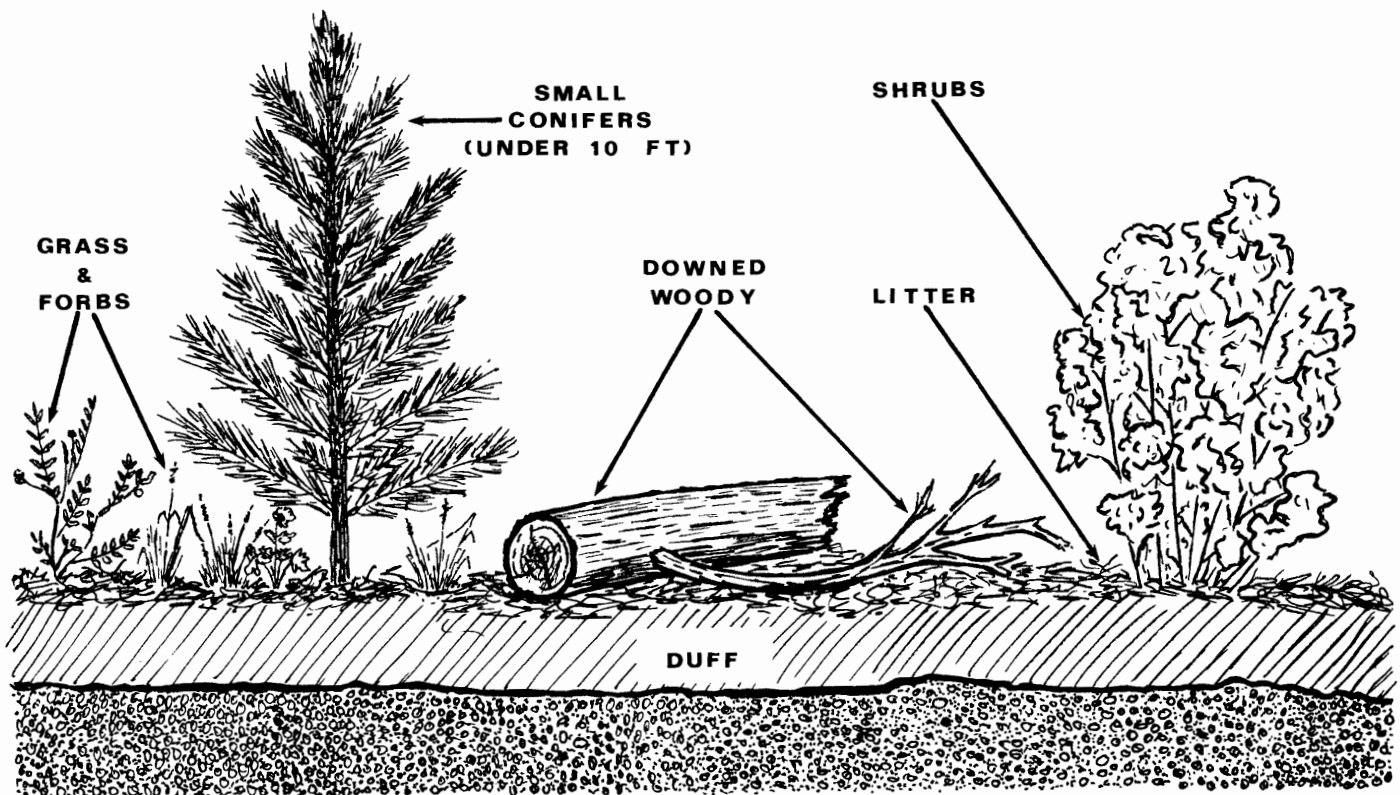


Figure 1.—Vegetative components included in procedures for estimating biomass and fuel loading.

appraisal. The procedures were used by numerous field crews for several years. This experience aided considerably in developing the step-by-step procedures reported here.

The inventory procedures are useful for determining biomass of any vegetation up to about 10 ft (3 m) in height. The entire set of procedures or a part of them can be applied to estimate all or any one of the vegetative components.

The procedures apply most accurately in the Interior West. The techniques for estimating biomass of herbaceous vegetation, litter, and downed woody material, however, apply anywhere. The shrub techniques apply most accurately to shrubs in the Northern Rocky Mountains. Considering sampling efficiency as attainment of desired precision by the most practical means, the most efficient methods of sampling vegetation vary by plant species and purpose. Different techniques are required to most efficiently sample all vegetation. Thus, the single set of procedures assembled here may not be the most efficient for some situations. Nevertheless, the procedures are appropriate for sampling each category of vegetation and can be widely applied with a minimum of training and experience. Further discussion on applicability of techniques is in appendix I.

The inventory procedures specify sampling of branch and stemwood under 3 inches in diameter by diameter classes of 0 to 0.25 inches (0 to 0.6 cm), 0.26 to 1.0 inches (0.6 to 2.5 cm), and 1.0 to 3.0 inches (2.5 to 7.6 cm). The size classes correspond in increasing size to 1-, 10-, and 100-hour average moisture timelag classes for many woody materials (Fosberg 1970). The size classes are used as moisture timelag standards in the U.S. National Fire-Danger Rating System (Deeming and others 1977). A moisture timelag is the amount of time for a substance to lose or gain approximately two-thirds of the moisture above or below its equilibrium moisture content. Appraisal of forest fuels is greatly facilitated when data on biomass are assimilated by these size classes.

Fuel depth was originally included in the procedures but was removed because interpretation of fuel depth was complex and required trained people to evaluate the reasonableness of depth observations. Although Albini (1975) developed an algorithm that was largely successful in processing fuel depth data for input to Rothermel's (1972) fire spread model, spurious depth measurements coupled with the fact that fire behavior predictions were highly sensitive to depth, continued to cause erratic predictions. In predicting fire behavior using Rothermel's model, depth together with loading is required to determine fuel bulk density. Recent research (Brown 1981) indicates that characterization of bulk density for understory vegetation and fuel groups may eliminate the need for measurement of fuel depth in inventorying fuel for practical applications.

To assure reasonable fire behavior predictions, inventoried fuel loadings should be interpreted by fire behavior modeling specialists for proper input to Rothermel's model. Estimates of certain fuel components such as downed woody material and duff can be used without interpretation in operating Albini's (1976) burnout model. This model is incorporated in a computer program called

HAZARD, which appraises slash fuels (Puckett and others 1979). As the technology in fire behavior modeling grows, other direct applications of fuel inventory may arise.

## CHOICE OF TECHNIQUES

An efficient inventory of all fuel and understory vegetation requires several techniques because of the varied physical attributes of vegetation. Forest vegetation is comprised of living and dead plants, both standing and downed. Plants range in size from small grasses and forbs to large shrubs and trees. Pieces of vegetation considered as fuel particles range in size from small leaves, needles, and twigs to large branches and tree boles. Vegetation and fuels having similar physical characteristics, which can be appropriately sampled using the same technique, can be grouped as follows:

1. Standing trees
2. Shrubs
3. Herbaceous vegetation (grasses and forbs)
4. Forest floor litter (01 horizon)
5. Forest floor duff (02 horizon)
6. Downed woody material.

The inventory procedures assembled here are made up of different techniques for each category of vegetation. Before presenting the procedures, methods of sampling and reasons why certain techniques were chosen are discussed for each category of vegetation.

## Standing Trees

A method for estimating biomass of conifers less than 10 ft (3 m) in height was included in the procedures presented here because small trees can contribute significantly to propagation of both surface and crown fires. The method requires measurement of number of trees per acre by species and height. Biomass of foliage and branchwood by size class is calculated from weight and height relationships developed by Brown (1978).

Biomass of trees over 2 inches (5 cm) d.b.h. can be estimated from biomass tables or from tree volume estimates converted to weight using wood densities (USDA 1974). To determine volumes from tree volume tables, estimates of the number of trees per acre or basal area per acre by d.b.h. and species required to access the tables can be determined from commonly used plot and plotless sampling methods. Procedures for inventorying trees greater than 10 ft (3 m) in height are not included here because they are commonly understood and used in forestry. If desired, they can be readily applied along with the procedures for surface vegetation.

## Shrubs

Shrub biomass can be estimated nondestructively by one of two basic methods. One approach relates biomass to stem diameters as described by Telfer (1969) for shrubs in eastern Canada, and Brown (1976) for shrubs in the Northern Rocky Mountains. High correlations between stem diameters and weights of various shrub parts have been reported (Lyon 1970; Buckman 1966; Whittaker 1965). This approach requires a tally of number of stems by stem diameter on plots of known size. Another method relies on the relationships between biomass, canopy area,

and canopy volume as described for semidesert shrubs in New Mexico (Ludwig and others 1975), sagebrush (*Artemisia tridentata*) (Rittenhouse and Sneva 1977), and low shrubs in California (Bently and others 1970). This method requires measurements of crown diameters and shrub height.

The method involving measurement of stem diameters has the advantage of applying easily to tall shrubs compared to the method of measuring crown dimensions. Measurement of stem diameters probably permits the most accurate estimation of biomass because stem diameters should relate more directly to biomass than does space occupied by shrubs. A disadvantage of measuring stem diameters is that fieldwork can involve considerable time, especially for small shrubs comprised of many stems such as grouse whortleberry (*Vaccinium scoparium*). The fieldwork can be minimized by recording diameters by size classes. The method requiring measurement of crown dimensions is rapid and well suited to small- and medium-size shrubs. The method involving measurement of stem diameters was incorporated in these procedures because it applies to shrubs of all sizes, and relationships for estimating biomass of leaves and stemwood by diameter class were available for 25 species (Brown 1976).

## Herbaceous Vegetation

An extensive body of literature exists on estimating weight and production of range vegetation. Techniques for estimating weight basically fall into three categories: (1) clipping and weighing, (2) estimation, and (3) a combination of weighing and estimation.

To aid in extensive surveys, a quick, easy-to-use method is needed for estimating weight. Studies in pasture grasses (Pasto and others 1957) and annual range species (Reppert and others 1962) gave reasonably high correlations between weight per unit area, and ground cover and height. Similar investigation of grasses, forbs, and small woody plants in forest areas showed that as more plant sizes and shapes are included in plots, poorer accuracy can be expected (Brown and Marsden 1976). Unless relationships of suitable accuracy are known for specific sites, some clipping and weighing is desirable for estimating herbaceous vegetation.

The weight-estimate method has been widely used and tested in the southern and western United States in a variety of vegetation including large and small grasses and understory vegetation. It requires an estimate of actual weights and can be effectively used with double sampling on clipped and weighed plots. Trained observers can estimate within 10 percent of actual weights (Hughes 1959). When used with double sampling, variance of estimates can be reduced (Francis and others 1979). This method, coupled with double sampling, has proved very useful in estimating forest floor litter and herbaceous fuels for research purposes.

Another similar technique, the relative-weight estimate method (Hutchins and Schmautz 1969) has been useful in estimating fuels. This method is based on the assumption that it is easier to compare weights than estimate weights. It involves identifying a base plot having the most weight from a set of four or five plots. The weight on the other plots is estimated as a fraction of the base plot. The base plot is then clipped and weighted and weights on other plots calculated as a fraction of the base plot.

The relative weight-estimate method was incorporated in these procedues because it is easy to use, requires a minimum of training, and is based on some clipping and weighing. The advantages and disadvantages of this method include:

### Advantages
1. Requires little training or experience to learn the method; remembering weight images is minimal.
2. Checking weight estimates against actual weights is unnecessary.
3. Estimates are not affected by changes in light and moisture content as can happen with the weight-estimate technique.
4. Quantities of vegetation can be rated on a relative basis more easily than they can be actually estimated.

### Disadvantages
1. The set of plots must all be readily visible to the observer to permit accurate comparisons.
2. Clipping and bagging on one out of every four or five plots is necessary.
3. Accuracy of the method has had little study.
4. Probably not as accurate as weight-estimate method used by trained and experienced observers.

## Litter and Duff

Sampling the forest floor litter separately from the duff is desirable because the litter is usually much less dense than the duff and frequently burns independently of the duff. The most accurate method of estimating forest floor weights is by collecting and weighing samples. This necessitates a cumbersome field procedure involving transport of soil containers and eventual ovendrying. Attempts to correlate stand characteristics and forest floor weights and depths have not always been successful. For example, forest floor weights in red pine plantations (Dieterich 1963) and ponderosa pine stands (Ffolliott and others 1968) were highly correlated with tree basal area. On the other hand, relationships between forest floor weights and basal area, site index, and stand age were insignificant in natural stands of red pine and jack pine (Brown 1966), and poorly correlated in eastern white pine (Mader and Lull 1968). In an extensive study of southwestern ponderosa pine and mixed conifers, Sackett (1979) found a lack of reliable relationships for predicting forest floor quantities from basal area or duff depth. Factors such as fire history, decay rates, and storms can strongly influence forest floor quantities. Thus, high correlations between forest floor quantities and basal area, site index, and stand age appear to have a limited basis—low correlations should not be surprising. The relationship between depth and weight of duff can be used to estimate weight recognizing that accuracy can be low. Measurement of duff depth was adopted for these procedures because:
1. Collecting and weighting duff would be impractical for large inventories.
2. The literature on duff bulk density seemed substantial enough to use in estimating weight from depth.

3. Depth is easily measured and can be a useful measurement itself for planning and evaluating prescribed fires conducted for fuel reduction and site preparation.

The bulk densities in table 1 served as a basis for establishing the following bulk densities that are used in the computer program to calculate duff loadings from duff depth:

| Cover type | Bulk density |
|---|---|
| | Lb/ft³ |
| 1. Ponderosa pine | 5 |
| 2. Lodgepole pine | 8 |
| Douglas-fir | |
| Shrubfields | |
| Grand fir | |
| 3. Others | 10 |

Because the bulk densities used to calculate duff weights are approximations, the weights are approximations and must be interpreted accordingly. If desired, bulk densities other than those above can be used to calculate duff loadings as described in the section on calculations.

Litter depth was not adopted as a basis for estimating litter weight because the literature on bulk density of litter was scant. More important, perhaps, is that considerable judgment is required to identify the top of litter. This problem is serious because the litter layer is often very thin and large errors in depth measurement could result. The relative weight-estimate technique was chosen for litter because it applies readily to litter and was also being used for herbaceous vegetation.

## Downed Woody Material

Downed woody material is the dead twigs, branches, stems, and boles of trees and shrubs that have fallen and lie on or above the ground. Loadings of downed woody material vary considerably among stands due primarily to site productivity and stand history (Brown and See 1981).

Collecting and weighing downed woody material is impractical in most forest stands. The planar intersect technique (Brown 1974b; Brown and Roussopoulos 1974) adopted here is nondestructive and avoids the time-consuming and costly task of collecting and weighing large quantities of downed woody material. It has the same theoretical basis as the line intersect technique (Van Wagner 1968). The planar intersect technique involves counting intersections of woody pieces with vertical sampling planes that resemble guillotines dropped through the downed debris. Volume is estimated; then weight is calculated from volume by applying estimates of specific gravity of woody material.

## PROCEDURES

The procedures in this section are an assembly of sampling techniques that provide estimates of the following variables:
1. Biomass and fuel loading on an ovendry basis of:
   a. Downed woody material
   b. Forest floor litter and duff
   c. Herbaceous vegetation
   d. Shrubs
   e. Conifers less than 10 ft (2 m) in height.
2. Depth of duff and height of shrubs and small trees.
3. Percentage cover of herbaceous vegetation and shrubs.
4. Percentage of dead in herbaceous vegetation and shrubs.
5. Percentage cover of forest floor litter.
6. Number of small trees per acre by species.
7. Stand age.
In addition, provision is made for recording and summarizing slope, elevation, aspect, cover type, and habitat type.

The field procedures involve counting shrub and small tree stems and intersected pieces of downed woody

Table 1.—Bulk densities of forest floor duff summarized from literature

| Forest type | Location | Forest floor layer | Bulk density | | Source |
|---|---|---|---|---|---|
| | | | Mean | Standard deviation | |
| | | | ------------ Lb/ft³ ------------ | | |
| Ponderosa pine | Mont. | F, H | 4.8 | 2.10 | Brown (1970) |
| | Ariz. | F | 1.8 | 0.15 | Ffolliott and others (1968) |
| | | H | 7.4 | .44 | |
| Ponderosa pine | Wash. | Basalt (F,H) | 6.9 | | Wooldridge (1968) |
| | | other soil (F,H) | 4.9 | | |
| Mixed conifers | Wash. | Basalt (F,H) | 6.9 | | Wooldridge (1968) |
| | | other soil (F,H) | 6.0 | | |
| Eastern white pine | Mass. | F | 4.5 | | Mader and Lull (1968) |
| | | H | 9.0 | | |
| Lodgepole pine | Wyo. | F. H | 8.7 | 1.9 | Brown (1974a) |
| Fir – hemlock | Wash. | Mull (F,H) | 9.1 | | Williams and Dyrness (1967) |
| Fir – hemlock | Wash. | Mull (F,H) | 11.2 | | Mader (1953) |
| White spruce, balsam, poplar | Ontario | Mull (F,H) | 10.0 | | Mader (1953) |
| White pine | Wisc. | Mull (F,H) | 8.7 | | Mader (1953) |
| White pine/hemlock | N.Y. | Greasy Mor (F,H) | 11.9 | | Mader (1953) |
| Red pine | Minn. | F,H | 4.3 | | Brown (1966) |
| Jack pine | Mich. | F,H | 6.1 | | Brown (1966) |

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material; measuring diameters, depth, and height of vegetation; ocularly estimating percentage of cover and percentage of dead vegetation; and extracting increment cores for determining tree age. All the procedures may be followed to furnish estimates of all vegetation, or a subset of the procedures may be used to furnish an estimate of any single variable such as duff depth or shrub biomass. For an average amount of vegetation, about 15 minutes per sample point are required to complete measurements. Counting shrubs and clipping herbaceous vegetation and litter require the most time.

**Deciding when to sample.**—The time of year when vegetation, especially grasses and forbs, is sampled has a large influence on results. Grasses and forbs may not be fully developed during late spring or early summer. Sampling at that time will result in low estimates. During late summer, some annuals may have cured and deteriorated to such an extent that their biomass cannot be accurately estimated. The time of year when sampling is done must agree with the purpose of inventory. For appraising fuels, sampling during the normal fire season, such as late July and August in the western United States, is recommended.

# Number of Sample Points

For any area where estimates are desired, at least 15 to 20 sample points should be located. This sampling intensity will often yield estimates having standard errors within 20 percent of the mean estimates (appendix II). Areas larger than approximately 50 acres containing a high diversity in amount and distribution of fuel and vegetation, should be sampled with more than 20 points to achieve standard errors within 20 percent of mean estimates.

Changing the size of plots also influences the desired number of sample points. For sampling downed woody material, these procedures accommodate a variable length sampling plane. Choose sampling plane lengths from the following tabulation:

| Downed material | Diameter of debris | | |
| --- | --- | --- | --- |
| | 0-1 inch | 1-3 inches | >3 inches |
| | ----- Sampling plane (ft) ----- | | |
| Nonslash (naturally fallen material) | 6 | 10-12 | 35-50 |
| Discontinuous light slash | 6 | 10-12 | 35-50 |
| Continuous heavy slash | 3 | 6 | 15-25 |

If material larger than 3 inches (7.6 cm) in diameter is scanty or unevenly distributed, the longer sampling planes in the tabulation should be used.

For fuel and vegetation other than downed woody material, plot sizes could be changed. If the computer program listed in appendix III is used to calculate loadings, however, it would have to be modified or its output corrected to adjust for different plot sizes. Variable sampling plane lengths are accounted for in the program.

The amount and distribution of vegetation, especially downed woody material, varies greatly among and within stands. Thus, these sampling recommendations should be considered approximate because a greater or fewer

number of sample points may be required to furnish adequate precision for any given area. Sampling intensities are discussed further in appendix II.

# Fieldwork

### Locating Sample Points

After determining sampling area, such as a stand, delineate or describe its boundaries. Definition of the area and its boundaries should satisfy a sampling design based on a clear objective for the sampling. Sample points may be systematically or randomly located; however, systematic placement is usually the most practical. Two methods are:

1. Locate plots at a fixed interval along transects that lace regularly across a sample area (uniform sampling grid). For example, on a sample area, mark off parallel transects that are 5 to 10 chains (100 to 200 m) apart. Then, along the transects, locate plots at 1- to 5-chain (20- to 100-m) intervals.

2. Locate plots at a fixed interval along a transect that runs diagonally through the sample area. To minimize bias, have the transect cross areas where changes in fuels or biomass are suspected. Before entering the sample area, determine a transect azimuth and distance between plots. Distance between plots can be paced by foot or sampling rod. If variations in biomass across an area are obvious and significant, it may be desirable to divide the area into recognizable strata and sample each stratum separately.

Hints for conducting fieldwork are listed in appendix IV.

### Plot Layout

The plot layout at a sample point consists of a randomly positioned line transect for downed woody material and duff, a 1/300-acre plot for trees, two ¼-milacre plots for shrubs, and four 0.98 by 1.97-ft (30 by 60-cm) plots for herbaceous material and litter (fig. 2).

Downed woody material, litter, herbaceous vegetation, shrubs, and small trees are measured on plots laid out parallel to the slope. Thus, calculations of loading on a horizontal acre basis require slope correction. Duff depth is measured vertically so that slope adjustment is unnecessary for calculating loading.

*Step 1:* Mark the sampling point with a chaining pin (No. 9 wire or similar item). Avoid disturbing material around the point so that measurements can be accurately made.

*Step 2:* Randomly determine direction of the sampling plane in one of two ways:

(1) Toss a die to indicate one of six 30° angles between 0° and 150°. The 0° heading is the direction of travel. Turn a fixed direction, such as clockwise, to position the sampling plane.

(2) Orient the sampling plane in the direction indicated by the second hand of a watch at a given instant. To avoid bias in placement of the sampling plane, do not look at the fuel or ground while turning the interval.

*Step 3:* Denote position of sampling plane by placing a 6.8-ft inventory rod (diameter of 1/300-acre plot) out from the chaining pin parallel to the ground in the direction determined in step 2 (fig. 2). A

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50-foot tape is used along this same line to measure large pieces. The tape and rod fix the position of vertical sampling planes.
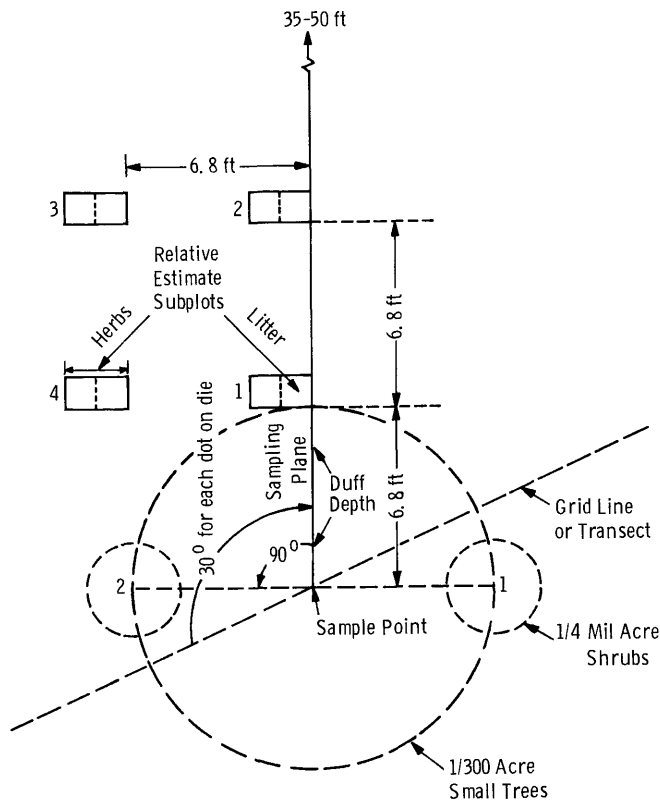


Figure 2.—Plot layout at a sample point.

*Step 4:* Next, locate four relative estimate subplots and two ¼-milacre shrub plots on the ground as shown in figure 2. Mark the two shrub plots with chaining pins or similar devices. They are located 90° to the sampling plane. Place the relative estimate frames parallel to the slope, and maintain this position when collecting samples (fig. 3). Similarly, count shrub stems from plots delineated parallel to the slope.

Vegetation to be sampled by each technique is summarized in table 2. Some vegetation could be sampled by more than one technique. To avoid double sampling of any component, definitions of vegetation to be sampled by each technique must be consistently and closely followed.



Figure 3.—Positioning sample frames for the relative estimate technique on the surface of the forest floor.

Table 2.—Vegetation to be sampled by different biomass techniques

| Vegetation category | Technique | Sampled vegetation |
|---|---|---|
| Downed woody material | Planar Intersect | Twigs, branches, stems, and tree boles in and above the litter. |
| Litter | Relative-weight | Litter is the 01 horizon or "L" layer of the floor and includes freshly fallen leaves, needles, bark flakes, cone scales, fruits, dead matted grass, and a variety of miscellaneous vegetative parts. Include cones that are more than one-half in or above the litter. If they are more than one-half below the litter, treat as duff. Omit sampling downed woody material as part of the litter because it is sampled by the planar intersect method. |
| Duff | Depth measurement | Duff is the 02 horizon or fermentation and humus layers of the forest floor. It lies below the litter and above mineral soil |
| Herbaceous plants | Relative-weight estimate | All live and dead grasses, sedges, and forbs. Dead grasses and forbs detached and fallen from their growing point should be considered litter. Some small woody plants such as bunchberry *(Cornus canadensis)*, twinflower *(Linnea borealis)*, prince's pine *(Chimaphila umbellata)*, and kinnikinnick *(Arctostaphylos uva-ursi)*, should be sampled as herbs because the shrub method is inapplicable. If desired, small woody plants can be sampled separately using an extra form. |
| Shrubs | Stem counts | All woody shrubs except those included in the herbaceous sample. Include common juniper *(Juniperus communis)* as a shrub. |
| Small conifers | Tree counts | All conifers except common juniper. Small deciduous trees such as aspen, cottonwood, and birch can be handled as tall shrubs. |

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**Measurements**

   After the subplots and line transects have been established on the ground, begin recording general information at the top of the inventory form (fig. 4).

# INVENTORY FORM

CREW :



Figure 4.—Ground fuel and vegetation inventory form.

PERCENT CODES

1 = 0- 5 %
2 = 6- 20
3 = 21- 40
4 = 41- 60
5 = 61- 80
6 = 81- 95
7 = 96- 100%

General Information:

| DATE | 7,8,0 | STAND NO. | 1,1 | PLOT NO. | 1,1,0 | TERRAIN SLOPE | 5,0 | ASPECT | 2,1,0 |
|------|-------|-----------|-----|----------|-------|---------------|-----|--------|-------|
| ELEV. | 5,2,4,0 | STAND AGE | 5,0 | COVER TYPE | D,F, | H.T. | 2,6,0 | PLANER SLOPE | 3,5 |

*Step 1:* Date can be recorded as month and year, or day and month.

*Step 2:* Identify stands and plots by consecutive number. Stand numbers can be placed on a field map for referencing locations (e.g., stand No. 1, plots numbered 1-10; stand No. 2, plots numbered 11-20).

*Step 3:* Determine topographic slope in percent. A Relaskop, Abney, or a clinometer is useful for measuring slope.

*Step 4:* Using a compass, record aspect of the area near the sample point in degrees.

*Step 5:* Determine elevation by an altimeter or from reading a contour map. If an altimeter is used, calibrate it daily to a known elevation.

*Step 6:* Determine stand age by extracting increment cores from three or four dominant or codominant trees in the stand. Take the cores at d.b.h. on the uphill side of the tree. Average the ages and enter the average on the form. Age needs to be recorded on only one plot per stand.

*Step 7:* Cover type is used to determine duff loading. For proper duff calculations, record the cover type that most resembles one of the following species categories (left justify the codes, see data form insert):

| **Cover type is most like:** | **Code** |
|---|---|
| 1. Long-needled pine (except ponderosa pine) | PP |
| 2. Intermediate-needled conifer (except lodgepole pine) and other conifers that typically occur in mixed pine-fir types (except Douglas-fir) | LP DF |
| 3. Predominantly short-needled conifers (except true fir, spruce, and hemlock) | Any other code |

*Step 8:* Record habitat type using a 3-digit code. The habitat type system developed by Pfister and others (1977) is appropriate here.

*Step 9:* Estimate or measure the slope of the planar intersect sampling plane by sighting along the transect pole or tape previously positioned on the ground. Record this as a percentage.

*Step 10:* Record the transect lengths. (Refer to the discussion on sampling plane lengths.) Note on the inventory form that sampling plane lengths for 0- to 1-inch (0- to 2.5-cm) and 1- to 3-inch (2.5- to 7.6-cm) material require a decimal place.

| TRANSECT LENGTHS | | | NO. INTERSECTIONS < 3 IN | | | | | | | TRAN. LENGTH | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-1 IN | 4,8 | 1-3 IN | 1,0,0 | 0-¼ IN | 3,3 | ¼-1 IN | 5 | 1-3 IN | 0 | >3 IN | 3,5 |

Downed Woody Material:

**Less than 3-inch diameters.**—This material should be measured first to avoid disturbing it and causing inaccurate estimates.

*Step 1:* Count the number of 0- to 0.25-inch (0- to 0.6-cm) and 0.25- to 1-inch (0.6- to 2.5-cm) particles intersected by the sampling plane. This technique involves counting intersections of woody pieces with vertical sampling planes that resemble guillotines dropped through the downed debris. The vertical plane is a plot. Consequently, in counting particle intersections, it is very important to visualize the plane passing through one edge of the plot rod and terminating along an imaginary fixed line on the ground. Once visualized on the ground, the position of the line should not be changed while counting particles (fig. 5).
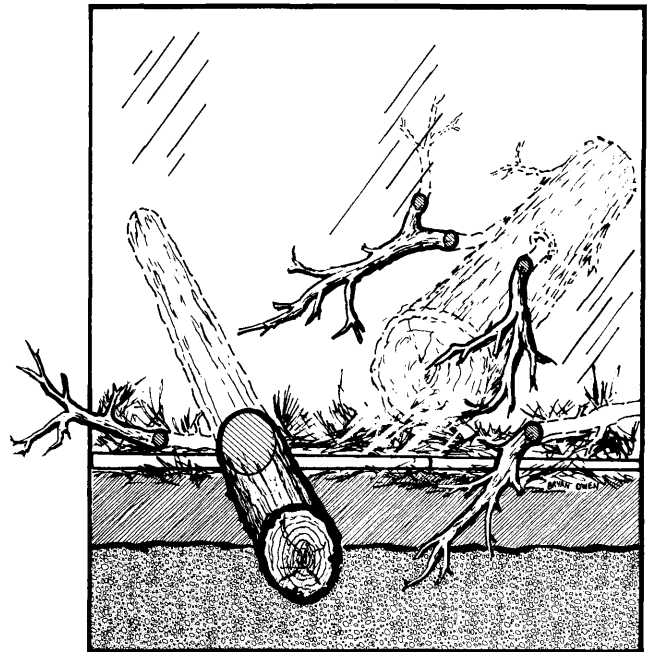


Figure 5.—The sampling plane is exactly defined by one edge of the plot rod.

The intersections can be counted one size class at a time or "dot tallied," which takes slightly longer than counting. The actual diameter of the particle at the point of intersection determines its size class. A go/no-go gage with openings of 0.25 inch (0.6 cm), 1 inch (2.5 cm), and 3 inches (7.6 cm) works well for training the eye to recognize size classes. Count the 0- to 1-inch (0- to 2.5-cm) intersections on the 6.8-ft (2.07-m) transect (or whatever length is chosen). See tally rules for qualifying particles.

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*Step 2:* Count the number of 1- to 3-inch (2.5- to 7.6-cm) particles. Proceed as in step 1, but use a longer sampling plane, such as 10 ft (3 m). The 50-foot tape can be used to mark the transect. Count the number of intersections of woody pieces between 1 and 3 inches (2.5 and 7.6 cm) in diameter. Refer to tally rules for qualifying particles.

**Three-inch and greater diameters.**—Measure or estimate the diameters of all pieces 3 inches (7.6 cm) and larger at the point of intersection with the sampling plane. Record true piece diameters to nearest whole inch regardless of angle of intersection. Record sound pieces and rotten pieces separately. For example, the data form insert shows that 5- and 6-inch sound pieces were intersected and that 4-, 10-, and 6-inch rotten pieces were intersected.



Consider pieces rotten when the piece at the inter-section is obviously punky or can be easily kicked apart.

A ruler laid perpendicular across a large piece of fuel works satisfactorily for measuring diameters (fig. 6). Be sure to avoid parallax in reading the ruler. See tally rules for qualifying particles.



Figure 6.—Diameters of large fuels can be estimated using a ruler laid perpendicularly across the pieces.

**Tally rules.**—These rules apply to pieces of all diameters:

1. Particles qualifying for tally include downed, dead, woody material (twigs, stems, branches, and bolewood) from trees and shrubs. Dead branches attached to boles of standing trees are omitted because they are not downed vegetation. Consider a particle downed when it has fallen to the ground or has been severed from its original growing point. Dead woody stems and branches still attached to standing shrubs and trees are not counted.

2. Twigs, and branches lying in the litter layer and above are counted. But they are not counted when the intersection between the central axis of the particle and the sampling plane lies in the duff (fig. 7).



Does Not Qualify          Qualifies

Litter

Duff

Mineral Soil

Planar Intersect: intersections qualify only in litter.

Figure 7.—Regardless of size, pieces are tallied only when intersection lies in and above the litter.

3. If the sampling plane intersects the end of a piece, tally only if the central axis is crossed (fig. 8). If the plane exactly intersects the central axis, tally every other such piece.



YES
NO
Top
Center
Sampling Planes

Figure 8.—An intersection at the end of a branch or log must include the central axis to be tallied.

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4. Do not tally any particle having a central axis that coincides perfectly with the sampling plane. (This should rarely happen.)

5. If the sampling plane intersects a curved piece more than once, tally each intersection (fig. 9).



Figure 9.—Count both intersections for a curved piece.

6. Tally wood slivers and chunks left after logging. Visually mold these pieces into cylinders for determining size class or recording diameters (fig. 6).

7. Tally uprooted stumps and roots not encased in dirt. For tallying, consider uprooted stumps as tree boles or individual roots, depending on where the sampling planes intersect the stumps. Do not tally undisturbed stumps.

8. For rotten logs that have fallen apart, visually construct a cylinder containing the rotten material and estimate its diameter. The cylinder will probably be smaller in diameter than the original log.

9. Be sure to look up from the ground when sampling because downed material can be tallied up to any height. A practical upper cutoff is about 6 ft. In deep slash, however, it may be necessary to tally above 6 ft.

Duff Depth:

Step 1: Measure depth of duff to the nearest 0.1 inch, using a ruler held vertically at two points along the sampling plane: (1) 1 ft (0.3 m) from the sample point; and (2) a fixed distance of 3 to 5 ft (1 to 1.5 m) from the first measurement.



Duff is the fermentation and humus layers on the forest floor. It does not include the freshly cast material in the litter layer. The top of the duff is where needles, leaves, and other castoff vegetative material have noticeably begun to decompose. Often the color of duff differs from the litter above. Individual particles usually will be bound by fungal mycelium. When moss is present, the top of the duff is just below the green portion of the moss. The bottom of the duff is mineral soil.

Carefully expose a profile of the forest floor for the measurement (fig. 10). A knife or hatchet helps but is not essential. Avoid compacting or loosening the duff where the depth is measured. Measure duff depth after sampling the downed woody material to avoid disturbing the downed woody material along the sampling plane.



Figure 10.—Measure duff depth along an exposed profile of the forest floor from the top of the mineral soil to the bottom of the 01 horizon.

When stumps, logs, and trees occur at the point of measurement, offset 1 ft (0.3 m) perpendicular to the right side of the sampling plane. Measure through rotten logs whose central axis is in the duff layer (fig. 11).

Yes= center of log is in duff layer or below.
No= center of log is above duff layer.



x = center of log
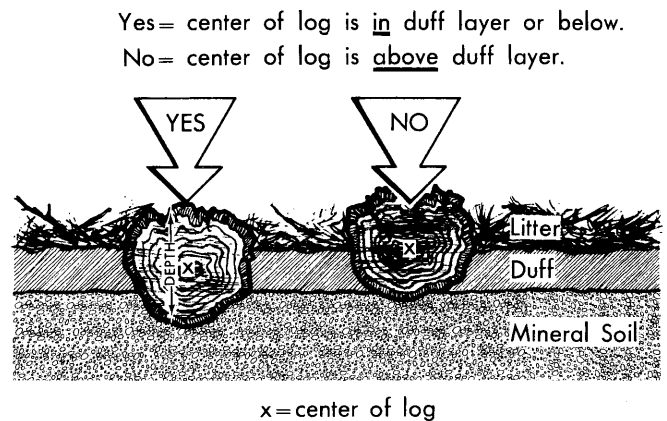
Figure 11.—Duff depth is measured through a rotten log when its central axis lies in or below the duff.

Herbaceous Vegetation and Litter:

*Step 1:* View all four subplots and judge which one has the greatest weight of herbaceous plants, both live and dead. See table 2 for discussion of plants to be sampled here. The subplot picked with the greatest weight is the standard subplot and is recorded as an 8.

Rate the amount of herbaceous plants on the remaining three subplots as a percentage of that on the standard subplot using the following codes established for these procedures:

| Percent | Code |
|---------|------|
| 0-5     | 1    |
| 6-20    | 2    |
| 21-40   | 3    |
| 41-60   | 4    |
| 61-80   | 5    |
| 81-95   | 6    |
| 96-100  | 7    |

| HERBS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| %STAND | | | | % DEAD | | | | % COV. | | BASE WT. | |
| 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | | |
| 7 | 8 | 5 | 3 | 1 | 1 | 2 | 1 | 5 | 6 | 112.07 | |

*Step 2:* For each individual subplot, ocularly estimate the percentage of herbaceous vegetation that is dead. Use the established percentage code.

*Step 3:* Ocularly estimate, in percentage, cover of herbaceous vegetation on subplots 1 and 2. (Percentage of cover is the percentage of subplot area covered by a vertical projection of herbaceous material.) Record cover using the established codes.

*Step 4:* View the right half of all four subplots and judge which one has the greatest quantity of litter. Occasional probing of the litter may help in judging quantities. Be sure to examine only material qualifying as litter. See table 2 for material to be included as litter. Record the standard litter subplot with an 8.

Rate the quantity of litter on the remaining three subplots as a percent of that on the standard subplot. Be sure to view only the right half of each subplot. Use the established codes.

| LITTER | | | | |
|---|---|---|---|---|
| % STAND | | | | BASE WT. |
| 1 | 2 | 3 | 4 | |
| 7 | 7 | 8 | 3 | 19.10 |

*Step 5:* Clip the herbaceous vegetation from the herb standard subplot and place in a paper bag. Collect litter from the litter standard subplot (right half only) and place in a paper bag. Label bags with date, stand number, plot number, and litter or herb.

The samples should be ovendried at 95° C for a period of 24 hours. Record the ovendry weights, labeled as base weights on the inventory form, to the nearest 0.01 gram. Gunnysacks work well for transporting and storing samples. Airtight containers, such as plastic sacks, may promote decay.

Shrubs:

*Step 1:* Shrubs are tallied on the two ¼-milacre subplots (fig. 2). Using a 1.86-ft (57-cm) rod (radius of ¼-milacre plot), swing around the subplot center parallel to the ground and note the species that occur. Within each subplot, ocularly estimate percent cover of all shrubs together, both live and dead, according to the established percentage classes.

| SHRUBS | | | | | |
|---|---|---|---|---|---|
| % COV. | | % DEAD | | AVE. HT. (IN) | |
| 1 | 2 | 1 | 2 | | |
| 4 | 3 | 1 | 1 | 24 | 12 |

*Step 2:* Ocularly estimate the percentage of shrub biomass that is dead according to the established percentage classes.

*Step 3:* Measure the height of shrubs within each subplot from the forest floor to what appears as the average top. Record to the nearest whole inch.

*Step 4:* On each subplot, count the number of stems by species and the following basal diameter classes:

    0 to 0.2 inch (0 to 0.5 cm)
    0.2 to 0.4 inch (0.5 to 1.0 cm)
    0.4 to 0.6 inch (1.0 to 1.5 cm)
    0.6 to 0.8 inch (1.5 to 2.0 cm)
    0.8 to 1.2 inches (2.0 to 3.0 cm)
    1.2 to 2.0 inches (3.0 to 5.0 cm)
    Over 2.0 inches (5.0 cm)

Determine basal diameters above the root crown or above the swelling of the root crown, which is usually within 1 or 2 inches above the top of the litter. A go/no-go gage is helpful for checking

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diameters (fig. 12). The basal diameter classes are identified on the data form in centimeter units because they can be visualized more easily than inches for estimating shrub diameters.



Figure 12.—A go/no-go gage used for tallying the number of shrub stems by basal diameter classes.

| Plot | SPECIES | NO. STEMS BY DIAMETER CLASS (CM) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 0-0.5 | 0.5-1 | 1-1.5 | 1.5-2 | 2-3 | 3-5 | 5+ | |
| 1 | CEVE | 13 | 4 | | | | | | |
| 1 | PHMA | 7 | 3 | 2 | | | | | |
| 1 | BERE | 2 | | | | | | | |
| 1 | SYAL | 8 | 0 | 3 | | | | | |
| 2 | BERE | 7 | | | | | | | |
| 2 | LOW | 2 | | | | | | | |

Record species using the abbreviations in the following tabulation. If a sampled species is not in the list, record it as a low, medium, or high shrub, depending on the group it most resembles. Whenever LOW or MED abbreviations are used, left justify them (see insert of inventory form).

| Shrubs | Abbreviation |
|---|---|
| **Low shrubs:** | |
| Snowberry (*Symphoricarpos albus*) | SYAL |
| Blue huckleberry (*Vaccinium globulare*) | VAGL |
| Grouse whortleberry (*Vaccinium scoparium*) | VASC |
| Wild rose (*Rosa* spp.) | ROSA |
| Gooseberry (*Ribes* spp.) | RILA |
| White spirea (*Spirea betulifolia*) | SPBE |
| Oregon grape (*Berberis repens*) | BERE |
| Thimbleberry (*Rubus parviflorus*) | RUPA |
| Red raspberry (*Rubus idaeus*) | RUID |
| Combined species | LOW |
| **Medium shrubs:** | |
| Ninebark (*Physocarpus malvaceus*) | PHMA |
| Smooth menziesia (*Menziesia ferruginea*) | MEFE |
| Utah honeysuckle (*Lonicera utahensis*) | LOUT |
| Oceanspray (*Holodiscus discolor*) | HODI |
| Evergreen ceanothus (*Ceanothus velutinus*) | CEVE |
| Mockorange (*Philadelphus lewisii*) | PHLE |
| Russet buffaloberry (*Shepherdia canadensis*) | SHCA |
| Big sagebrush (*Artemisia tridentata*) | ARTR |
| Common juniper (*Juniperus communis*) | JUCO |
| Combined species | MED |
| **High shrubs:** | |
| Serviceberry (*Amelanchier alnifolia*) | AMAL |
| Mountain maple (*Acer glabrum*) | ACGL |
| Mountain ash (*Sorbus scopulina*) | SOSC |
| Mountain alder (*Alnus sinuata*) | ALSI |
| Redosier dogwood (*Cornus stolonifera*) | COST |
| Willow (*Salix* spp.) | SASC |
| Chokecherry (*Prunus virginiana*) | PRVI |
| Combined species | HIGH |

Small trees

| SMALL TREE COUNT | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SP. | NO. | HT. | SP. | NO. | HT. | SP. | NO. | HT. | SP. | NO. | HT. | SP. | NO. | HT. |
| DF | 39 | 5 | LP | 3 | 10 | L | 1 | 0.5 | | | | | | |

Delineate the plot by swinging the 6.8-ft rod about the sample point pin and parallel to the slope. Within the 1/300-acre plot, count the number of trees less than 10 ft (3 m) in height by species. Record the number of trees within each species and average their height to the nearest 0.5 ft. To avoid the potential of a substantial bias, however, do not average heights differing by more than 5 ft. If trees of the same species differ by more than 5 ft in height, record them separately on the data form. If more than five species are identified, consolidate similar species. Tally only individual trees that have survived one growing season, are free to grow, have good coloration, and have root systems in mineral soil.

Use the following tree codes (single letter codes are left justified; see insert of inventory form):

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| Species | Code |
|---|---|
| Subalpine fir (*Abies lasiocarpa*) | AF |
| Douglas-fir (*Pseudotsuga menziesii*) | DF |
| Western redcedar (*Thuja plicata*) | C |
| Grand fir (*Abies grandis*) | GF |
| Juniper (*Juniperus scopularum*) | J |
| Western larch (*Larix occidentalis*) | L |
| Lodgepole pine (*Pinus contorta*) | LP |
| Ponderosa pine (*Pinus ponderosa*) | PP |
| Western white pine (*Pinus monticola*) | WP |
| Whitebark or limber pine (*Pinus albicaulis/ Pinus flexilis*) | WL |
| Engelmann spruce (*Picea engelmannii*) | S |
| Western hemlock (*Tsuga heterophylla*) | WH |
| Mountain hemlock (*Tsuga mertensiana*) | MH |
| Pacific yew (*Taxus brevifolia*) | Y |

# Field Equipment

| Item | Use |
|---|---|
| 1. 6.8-ft plot rod marked in 1-ft intervals (fiberglass rod, bamboo, or aluminum tubing works well) | Plot and transect layout, measure small tree and shrub heights |
| 2. 1-ft ruler or steel pocket tape | Measure duff depth and diameter of intersected pieces |
| 3. Go/no-go gage (can be cut from 1/16-1/8-inch sheet aluminum) or small caliper | Determine ¼-, 1-, and 3-inch diameters of downed woody pieces and 0.2-, 0.4-, 0.6-, 0.8-, 1.2-, and 2-inch basal stem diameters of shrubs |
| 4. 1.86-ft plot rod marked in 1-inch increments (wood dowel works well) | Shrub plot layout; measure height of small trees and shrubs |
| 5. Five chaining pins | Mark plot locations |
| 6. Four 0.98- by 1.97-ft (inside measurement) subplot frames, four pieces of ¼-inch square aluminum rod, loosely riveted at three corners, allows frame to be placed through and under vegetation. A solid frame is difficult to place without bias. | Sample herbaceous vegetation and litter |
| 7. Hand compass | Measure aspect. Locate sample points |
| 8. Relaskop, Abney, or clinometer | Measure slope |
| 9. Altimeter | Measure elevation |
| 10. Increment borer | Determine tree age |
| 11. 50-ft tape (reel up cloth works best) | Delineate sampling plane |
| 12. Gaming die or watch with second hand | Orient sampling plane |
| 13. Paper bags (size 10 or 12) and rubber bands | Collect herb and litter samples |
| 14. Grass clippers | Clip subplots |
| 15. Clipboard, forms, maps, and pencils | Record data |
| 16. Pack, map tube | Carry equipment. Map tube keeps small rods and subplot frames together. |

Sampling can be completed without a compass, slope instrument, or altimeter. If only a portion of the vegetation is to be sampled, other equipment may be unnecessary.

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## Calculations

The calculations of fuel loadings, biomass, and other inventoried properties are straightforward but detailed. To facilitate analysis, a computer program that calculates means, standard deviations, and standard errors as a percentage of means for the sampled properties is displayed in appendix III. An example of the program output is shown in figure 13. Loadings are calculated for land projected to a horizonal plane. The data can be readily analyzed using a desk calculator. The following discussion explains how average biomass and fuel loadings can be calculated.

```
PATTEE CANYON POSTFIRE 1980                                    PAGE    1

                        HABITAT TYPE CODE 260


                ********** FUEL LOADING SUMMARY **********
                         (FOR   64 PLOTS)
                  I  LOADING IN OVEN-DRY POUNDS/ACRE      I          I
     SIZE CLASS   I  AVERAGE             STD-DEV  %ERROR  I  KG/SQ-M  I
    --------------I----------------------------------------I----------I
        0-.25     I                112.    218.    24.3   I    .013   I
        .25-1     I               1014.   1867.    23.0   I    .114   I
       LITTER     I                830.    723.    10.9   I    .093   I
    DEAD HERBS    I                351.    339.    12.1   I    .039   I
    --------------I----------------------------------------I----------I
       FINES      I   2308.               2076.    11.2   I    .259   I
       1-3        I               2678.   4406.    20.6   I    .300   I
    LESS THAN 3   I   4986.               5457.    13.7   I    .559   I
    --------------I----------------------------------------I----------I
    3+   TOTAL    I  18519.              39346.    26.6   I  2.076   I
        SOUND 3-6 I               6245.   6357.    12.7   I    .700   I
        SOUND 6-10 I              4197.   8156.    24.3   I    .470   I
        SOUND 10-20 I             1456.   6715.    57.7   I    .163   I
        SOUND 20+  I              4757.  38059.   100.0   I    .533   I
    3+ SOUND TOTAL I  16654.             39060.    29.3   I  1.867   I
        ROTTEN 3-6 I                860.   1517.    22.1   I    .096   I
        ROTTEN 6-10 I               513.   2350.    57.3   I    .057   I
        ROTTEN 10-20 I              492.   3936.   100.0   I    .055   I
        ROTTEN 20+ I                  0       0       0   I      0   I
    3+ ROTTEN TOTAL I  1865.              5000.    33.5   I    .209   I
    --------------I----------------------------------------I----------I
    DUFF          I              12875.                    I  1.443   I
    DEAD SHRUB    I                 64.    171.    23.5   I    .007   I
    --------------I----------------------------------------I----------I
    DEADFUEL LOAD I  36444.             52161.    17.9   I  4.085   I
    LIVE HERBS    I               1132.    957.    10.6   I    .127   I
      LIVE SHRUB  I               1363.   3971.    25.7   I    .153   I
    TREE NEEDLES  I                  0.      2.    48.1   I    .000   I
        0-.25     I                  0.      1.    48.1   I    .000   I
        .25 +     I                  0.      2.    48.1   I    .000   I
    TOTAL TREE    I      1.                  4.    48.1   I    .000   I
    --------------I----------------------------------------I----------I
    TOTAL LOAD    I  38940.             52345.    16.8   I  4.365   I


                ********** DEPTH (INCHES)   **********

               I  AVERAGE  MINIMUM  MAXIMUM  STD-DEV  I
    -------------I----------------------------------------I
        DUFF     I    .38       0     6.50      .95    I
        SHRUB    I  22.20       0    96.00    16.97    I
```

Figure 13.—Output summary from computer program FUELS which analyzes the inventoried data in figure 4.

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HABITAT TYPE CODE 260

```
********** TOPOGRAPHIC CONDITIONS **********
                I  AVERAGE  MINIMUM  MAXIMUM  STD-DEV I
-----------------I-------------------------------------I
        SLOPE   I    20.5     7.0     53.0     12.32  I
        ASPECT  I   171.0                              I
     ELEVATION  I   4448.    3920.    5250.    395.3  I
```

```
******* AVERAGE LIVE AND DEAD SHRUB LOADINGS IN POUNDS/ACRE *******
                     (FOR  104 PLOTS)
              I           SIZE CLASS IN CENTIMETERS        I
SPECIES       I   0-.5   .5-1   1-1.5  1.5-2   2-3    3-5    5+ I  TOTAL
--------------I-------------------------------------------------I-------
SERVICEBERRY  I  12.0   33.6   59.8   31.6    0      0      0 I  137.0
MTN. MAPLE    I  57.2  151.8  137.2    0      0      0      0 I  346.2
DOGWOOD       I   6.1   24.2  108.0    0      0      0      0 I  138.3
MTN. WILLOW   I   1.2    2.2    4.6    0      0      0      0 I    8.0
NINEBARK      I  84.3  122.3   38.4    0      0      0      0 I  245.0
SNOWBERRY     I  58.3   54.1    4.7    0      0      0      0 I  117.1
HUCKLEBERRY   I  12.2    8.5     0     0      0      0      0 I   20.7
ROSE          I  25.3   25.0  239.0    0      0      0      0 I  289.3
GOOSEBERRY    I    .1    3.4     0     0      0      0      C I    3.6
W. SPIREA     I 112.9   13.9     0     0      0      0      0 I  126.8
OREGONGRAPE   I   7.9     .9     0     0      0      0      0 I    8.8
THIMBLEBERRY  I  18.2   52.7  245.6    0      0      0      0 I  316.5
--------------I-------------------------------------------------I-------
TOTAL         I 395.8  492.6  837.2   31.6    0      0      0 I 1757.1
```

```
***** PERCENTAGE ESTIMATES ********* 3+ VOLUME AND DIAMETER *****
I   SHRUB       I     HERBS      I       SOUND       I      ROTTEN      I
I %COVER  %DEAD I %COVER  %DEAD  I  CU-FT  AVG.DIA I  CU-FT  AVG.DIA I
I--------------I----------------I----------------I----------------I
I  34.3    4.4 I  49.8    27.6  I  667.    4.68  I  100.    4.87  I
```

```
********** SMALL TREES **********
        SPECIES  TREES/ACRE  AVG.HT.FT.
           LP      122.          .56
        TOTAL      122.
```

Figure 13. — (con.)

## Downed Woody Material

Besides the inventoried data on number of intersections and piece diameters, calculations of loading require estimates of specific gravity, average diameters of particle size and classes, and nonhorizontal correction factors. Precision of the calculated loadings depends on determination of these constants. Detailed instructions for computing loading are described by Brown (1974b).

When inventorying large areas that hold many species, it is practical to use values based on a composite of species for specific gravity, average particle diameters, and nonhorizonal correction factors. The following formulas for calculating loading assume fixed values for these variables:

1. 0- to 0.25-inch (0- to 0.6-cm)
   class: $\bar{w} = 190.7\, nc/(Nl)$ (1)
2. 0.25- to 1-inch (0.6- to 2.5-cm)
   class: $\bar{w} = 3,650\, nc/(Nl)$ (2)
3. 1- to 3-inch (2.5- to 7.6-cm)
   class: $\bar{w} = 29,040\, nc/(Nl)$ (3)
4. 3+-inch (7.6+-cm) sound:
   $\bar{w} = 9,312\, d^2c/(Nl)$ (4)
5. 3+-inch (7.6+-cm) rotten:
   $\bar{w} = 6,984\, d^2c/(Nl)$ (5)

where:

$\bar{w}$ = average loading, ovendry basis, lb/acre
$n$ = total number intersections by particle class per stand
$d^2$ = sum of diameters (inches squared for all intersected pieces per stand, inches$^2$
$c$ = planar slope correction factor
$N$ = number of sample points
$l$ = length of sampling plane.

The slope correction factor is

$$c = \sqrt{1 + \left(\frac{\text{percent slope of sampling plane}}{100}\right)^2} \quad (6)$$

When n, $d^2$, and c are totaled separately for a stand, a bias that is probably small could result. Summing (n) • (c) or $d^2$ • (c) over all plots would eliminate the biases.

## Litter and Herbaceous Vegetation

Litter loading is calculated as:

$$\bar{w} = 24.78 \sum_{i=1}^{N} c_i w_i (1 + P_2 + P_3 + P_4)_i/N \quad (7)$$

where:

$c$ = topographic slope correction
$w$ = weight on standard plot, grams
$P$ = fraction of weight on standard plot for individual subplots
$i$ = index for sample points.

Herbaceous vegetation loading is calculated as:

$$\bar{w} = 12.39 \sum_{i=1}^{N} c_i w_i (1 + P_2 + P_3 + P_4)_i/N \quad (8)$$

To calculate the amount of dead herbaceous vegetation, the fraction of weight on the standard plot is multiplied by the fraction dead:

$$\bar{w} = 12.39 \sum_{i=1}^{N} c_i w_i (D_1 + P_2 D_2 + P_3 D_3 + P_4 D_4)_i/N \quad (9)$$

where:

$D$ = fraction of dead on individual subplots.

Use the midpoints of the established percentage classes for fractions in the calculations.

The slope correction may be handled differently depending on the amount of slope and its variability. If slope is less than about 40 percent, the correction is 8 percent and, for practical purposes, could be ignored.

If the slope in a stand is steep and uniform, the slope correction factor can be multiplied times the average stand loading rather than times the loading at each sample point. This also applies to calculation of shrub loadings.

## Shrubs

Shrub loading is calculated by summing the weights of individual stems by species:

$$\bar{w} = 8.8185 \sum_{ijk}^{N,2,7} c_i (s_k w_k)_{ij}/(2N) \quad (10)$$

where:

$s$ = number of stems per basal diameter class
$w$ = weight per stem of foliage and wood by basal diameter class (table 3), grams
$j$ = index for shrub subplots
$k$ = index for basal diameter classes.

Dead shrub weight is calculated by multiplying the fraction dead on each subplot by estimated weight per subplot. Thus,

$$\bar{w} = 8.8185 \sum_{ijk}^{N,2,7} c_i D_{ij} (s_k w_k)_{ij}/(2N) \quad (11)$$

where:

$D$ = fraction of dead shrubs per subplot.

Weight per stem is summarized in table 3 based on data by Brown (1976). Brown also presents relationships for estimating foliage and stemwood separately.

## Duff

Duff loading is calculated as:

$$\bar{w} = 3,630\, Bd \quad (12)$$

where:

$B$ = bulk density, lb/ft$^3$
$d$ = average duff depth for a stand, inches.

Bulk densities can be obtained from table 1, the condensation of table 1 in the text, or from other sources.

## Small Trees

Small tree loadings can be computed by summing the weights of individual sample trees. The simplest approach is to first construct a table showing the total number of sample trees per stand by species and 1-ft height increments. Loading for each species can then be calculated by:

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$$\bar{w} = 300 \sum_{i=1}^{10} N_h w_h / N \qquad (13)$$

where:

$N_h$ = total number sampled trees by height class per stand

$w_h$ = weight per tree by height class, pounds

$i$ = index for height classes.

Weights per tree as determined by Brown (1978) are

summarized in table 4. The 300 in equation (13) expands 1/300-acre plot estimates to a per-acre basis. If other plot sizes are used, the 300 should be replaced with appropriate expansion factors.

The procedures in this publication permit estimation of total biomass and fuel loading of forest floor and understory vegetation. The estimates are appropriate for intensive land management and studies involving biomass and forest fuels.

Table 3.—Total aboveground weight of shrubs by basal diameter classes

| Species | Stem basal diameters (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0-0.5 | 0.5-1.0 | 1.0-1.5 | 1.5-2.0 | 2-3 | 3-5 | 5-6 |
| | *Grams* | | | | | | |
| **Low shrubs** | | | | | | | |
| Snowberry | 2.8 | 17.0 | 54.6 | 118.0 | 226 | — | — |
| Blue huckleberry | 1.0 | 12.0 | 59.8 | 173.0 | 531 | — | — |
| Grouse whortleberry | 2.2 | 12.1 | 36.3 | 74.8 | 161 | — | — |
| Wild rose | 1.9 | 16.9 | 70.0 | 178.0 | 480 | — | — |
| Gooseberry | 1.7 | 20.0 | 98.4 | 281.0 | 856 | — | — |
| White spirea | 2.2 | 17.4 | 65.7 | 158.0 | 399 | — | — |
| Oregon grape | 2.0 | 10.7 | 31.3 | 63.2 | 133 | — | — |
| Thimbleberry | 2.1 | 15.5 | 56.6 | 133.0 | 328 | — | — |
| Red raspberry | 2.0 | 19.3 | 83.3 | 218.0 | 605 | — | — |
| Combined species | 2.0 | 16.4 | 64.1 | 157.0 | 407 | — | — |
| **Medium shrubs** | | | | | | | |
| Ninebark | 3.9 | 19.9 | 74.1 | 176.0 | 442 | 1 150 | — |
| Smooth menziesia | 1.2 | 8.7 | 43.6 | 126.0 | 387 | 1 240 | — |
| Utah honeysuckle | 2.9 | 18.5 | 83.8 | 226.0 | 650 | 1 940 | — |
| Oceanspray | 2.7 | 18.1 | 85.3 | 237.0 | 698 | 2 140 | — |
| Evergreen ceanothus | 2.9 | 17.3 | 74.1 | 193.0 | 533 | 1 530 | — |
| Mock orange | 2.6 | 17.2 | 79.6 | 218.0 | 636 | 1 930 | — |
| Russet buffaloberry | 3.6 | 16.5 | 56.5 | 127.0 | 300 | 730 | — |
| Big sagebrush | 3.0 | 12.4 | 38.9 | 82.7 | 184 | 422 | 871 |
| Common juniper | 7.9 | 31.4 | 96.8 | 203.0 | 445 | 1 010 | — |
| Combined species | 2.6 | 15.8 | 67.8 | 177.0 | 490 | 1 410 | — |
| **High shrubs** | | | | | | | |
| Serviceberry | 3.4 | 16.1 | 70.2 | 185.0 | 519 | 1 510 | 3 840 |
| Mountain maple | 4.0 | 17.2 | 70.0 | 177.0 | 417 | 1 310 | 3 180 |
| Mountain ash | 2.5 | 11.5 | 50.2 | 132.0 | 370 | 1 070 | 2 720 |
| Mountain alder | 4.5 | 16.7 | 58.8 | 135.0 | 325 | 809 | 1 790 |
| Redosier dogwood | 4.8 | 18.9 | 70.5 | 168.0 | 420 | 1 090 | 2 500 |
| Willow | 2.8 | 12.3 | 50.4 | 128.0 | 342 | 950 | 2 320 |
| Chokecherry | 2.7 | 12.9 | 57.4 | 153.0 | 434 | 1 280 | 3 290 |
| Combined species | 3.6 | 15.4 | 60.9 | 151.0 | 394 | 1 070 | 2 560 |

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Table 4.—Weight per tree of aboveground foliage, bark, and wood by 1-ft tree height increments

| Species | Height | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | Pounds | | | | | | | | | |
| DF,PP,S,AF | 0.03 | 0.20 | 0.56 | 1.18 | 2.09 | 3.33 | 4.94 | 6.95 | 9.39 | 12.30 |
| WP,GF,WL | .06 | .25 | .61 | 1.15 | 1.87 | 2.78 | 3.88 | 5.19 | 6.71 | 8.43 |
| C,L,LP | .02 | .13 | .34 | .69 | 1.17 | 1.82 | 2.64 | 3.65 | 4.84 | 6.24 |
| WH | .01 | .05 | .16 | .35 | .64 | 1.05 | 1.60 | 2.31 | 3.18 | 4.24 |

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# PUBLICATIONS CITED

Albini, Frank A. 1975. A computer algorithm for sorting field data on fuel depths. USDA For. Serv. Gen. Tech. Rep. INT-23, 25 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Albini, Frank A. 1976. Computer-based models of wildland fire behavior: a user's manual. 68 p. USDA For. Serv., Intermt. For. and Range Exp. Stn., Ogden, Utah.

Aldrich, David F., and Robert W. Mutch. 1972. Wilderness fires allowed to burn more naturally. U.S. Dep. Agric. Fire Control Notes 33(1):3-5.

Avery, T. Eugene. 1967. Forest measurements. p. 121-143. McGraw-Hill, New York.

Bentley, J. R., D. W. Seegrist, and D. A. Blakeman. 1970. A technique for sampling low shrub vegetation by crown volume classes. USDA For. Serv. Res. Note PSW-215, 11 p. Pac. Southwest For. and Range Exp. Stn., Berkeley, Calif.

Brown, James K. 1966. Forest floor fuels in red and jack pine stands. USDA For. Serv. Res. Note NC-9, 3 p. North Cent. For. Exp. Stn., St. Paul, Minn.

Brown, James K. 1970. Physical fuel properties of ponderosa pine forest floors and cheatgrass. USDA For. Serv. Res. Pap. INT-74, 16 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Brown, James K. 1974a. Reducing fire potential in lodgepole pine by increasing timber utilization. USDA For. Serv. Res. Note INT-181, 6 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Brown, James K. 1974b. Handbook for inventorying downed woody material. USDA For. Serv. Gen. Tech. Rep. INT-16, 24 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Brown, James K. 1976. Estimating shrub biomass from basal stem diameters. Can. J. For. Res. 6:153-158.

Brown, James K. 1978. Weight and density of crowns of Rocky Mountain conifers. USDA For. Serv. Res. Pap. INT-197, 56 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Brown, James K. 1981. Bulk densities of nonuniform surface fuels and their application to fire modeling. For. Sci. 27: 667-683.

Brown, James K., and Michael A. Marsden. 1976. Estimating fuel weights of grasses, forbs, and small woody plants. USDA For. Serv. Res. Note INT-210, 11 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Brown, James K., and Peter J. Roussopoulos. 1974. Eliminating biases in the planar intersect method for estimating volumes of small fuels. For. Sci. 20(4):350-356.

Brown, James K., and Thomas See. 1981. Downed dead woody fuel and biomass in the northern Rocky Mountains. USDA For. Serv. Gen. Tech. Rep. INT-117, 48 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Buckman, R. E. 1966. Estimation of cubic volume of shrubs (Corylus spp.). Ecology 47:858-860.

Deeming, John E., Robert E. Burgan, and Jack D. Cohen. 1977. The National Fire-Danger Rating System—1978. USDA For. Serv. Gen. Tech. Rep. INT-39, 63 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Dieterich, J. H. 1963. Litter fuels in red pine plantations. USDA For. Serv. Res. Note LS-14, 3 p.

Ffolliott, Peter F., Warren P. Clary, and James R. Davis. 1968. Some characteristics of the forest floor under ponderosa pine in Arizona. USDA For. Serv. Res. Note RM-127, 4 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

Fosberg, M. A. 1970. Drying rates of heartwood below fiber saturation. For. Sci. 16:57-63.

Francis, R. C., G. M. Van Dyne, and B. K. Williams. 1979. An evaluation of weight estimation double sampling as a method of botanical analysis. J. Environ. Manage. 8:55-72.

Habeck, James R., and Robert W. Mutch. 1973. Fire-dependent forests in the northern Rocky Mountains. Quat. Res. 3:408-424.

Hughes, Ralph H. 1959. The weight-estimate method in herbage production determination. In Techniques and Methods of Measuring Understory Vegetation, Proc. p. 17-19. For. Serv., South. and Southeast. For. Exp. Stns.

Hutchings, Selar S., and Jack E. Schmautz. 1969. A field test of the relative-weight estimate method for determining herbage production. J. Range Manage. 22(6):408-411.

Ludwig, John A., James F. Reynolds, and Paul D. Whitson. 1975. Size-biomass relationships of several Chichuahuan Desert shrubs. Am. Midland Nat. 94(2):451-461.

Lyon, L. Jack. 1970. Length- and weight-diameter relations of serviceberry twigs. J. Wildl. Manage. 34:456-460.

Mader, Donald L. 1953. Physical and chemical characteristics of the major types of forest humus found in the United States and Canada. Soil Sci. Soc. Proc. (1953), p. 155-158.

Mader, Donald L., and Howard W. Lull. 1968. Depth, weight, and water storage of the forest floor in white pine stands in Massachusetts. USDA For. Serv. Res. Pap. NE-109, 35 p. Northeast. For. Exp. Stn., Broomall, Pa.

Pasto, J. K., J. R. Allison, and J. B. Washko. 1957. Ground cover and height of sward as a means of estimating pasture production. Agron. J. 49:407-409.

Pfister, Robert D., Bernard L. Kovalchik, Stephen F. Arno, and others. 1977. Forest habitat types of Montana. USDA For. Serv. Gen. Tech. Rep. INT-34, 174 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Puckett, John V., Cameron M. Johnston, Frank A. Albini, and others. 1979. User's guide to debris prediction and hazard appraisal. USDA For. Serv., Northern Region, Missoula, Mont.

Reppert, J. N., M. J. Morris, and C. A. Graham. 1962. Estimation of herbage on California annual-type range. J. Range. Manage. 15:318-323.

Rittenhouse, L. R., and F. A. Sneva. 1977. A technique for estimating big sagebrush production. J. Range. Manage. 30(1):60-68.

Rothermel, Richard C. 1972. A mathematical model for predicting fire spread in wildland fuels. USDA For. Serv. Res. Pap. INT-115, 40 p. Intermt. For. and Range Exp. Stn., Ogden, Utah.

Sackett, Stephen S. 1979. Natural fuel loadings in ponderosa pine and mixed conifer forests of the Southwest. USDA For. Serv. Res. Pap. RM-213, 10 p. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.

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Telfer, E. S. 1969. Weight-diameter relationships for 22 woody plant species. Can. J. Bot. 47:1851-1855.

U.S. Department of Agriculture, Forest Service. 1974. Wood handbook: wood as an engineering material. U.S. Dep. Agric. Handb. 72, rev. U.S. Gov. Print. Off., Washington, D.C.

Van Wagner, C. E. 1968. The line intersect method in forest fuel sampling. For. Sci. 14(1):20-26.

Whittaker, R. H. 1965. Branch dimensions and estimation of branch production. Ecology 46:365-370.

Williams, Carroll B., and C. T. Dyrness. 1967. Some characteristics of forest floors and soils under true fir-hemlock stands in the Cascade Range. USDA For. Serv. Res. Pap. PNW-37, 19 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Wooldridge, David D. 1968. Chemical and physical properties of forest litter layers in central Washington. *In* Tree Growth and Forest Soils, Proc. Third North Am. For. Soils Conf. [N.C. State Univ., Aug. 1968]. p. 327-337.

# APPENDIX I
## APPLICABILITY OF TECHNIQUES

Some techniques can be applied more widely than others without any known loss of accuracy. Limitations in applying the techniques can be inferred from knowing the sources of data underlying their development. Applicability of the techniques is as follows:

1. **Downed woody material** - Average diameters of size classes less than 3 inches (7.6 cm) are based on an average of major western tree species. The estimates of this material are robust and should be reasonably accurate in coniferous forests. More precision can be obtained using the procedures in Brown (1974b). No limitations are built into the technique for material greater than 3 inches (7.6 cm) in diameter.

2. **Litter and herbaceous vegetation** - The relative estimate technique has no geographic restrictions.

3. **Duff** - Estimates of depth apply without geographic limitations. However, the duff bulk densities used to determine loading are based on a small amount of data from western coniferous forests. Although the loading estimates are probably applicable throughout coniferous forests in the United States and perhaps elsewhere, they should be viewed as crude approximations.

4. **Shrubs** - Biomass estimates are based on data from shrubs in western Montana and northern Idaho. The weight relationships for low, medium, and high shrubs may be used to estimate biomass of any species. Accuracy of these relationships outside of the Northern Rocky Mountains is unknown.

5. **Small trees** - Estimates of biomass for trees less than 10 ft (3 m) in height are based on data from western Montana and northern Idaho for Engelmann spruce, western hemlock, western white pine, whitebark pine, ponderosa pine, lodgepole pine, grand fir, western redcedar, western larch, Douglas-fir, and subalpine fir (Brown 1978). Equating a species not listed to one of the above may provide reasonable estimates of biomass; however, accuracy of this substitution is unknown.

# APPENDIX II
## SAMPLING PROCEDURES

Use of these procedures in the Selway-Bitterroot Wilderness (Habeck and Mutch 1973) provided a basis for determining desirable sampling intensities as shown by the coefficients of variation in table 5. Number of sample points can be calculated for any chosen percent error (Avery 1967) from:

$$n = \left[ \frac{cv}{percent\ error} \right]^2 \qquad (14)$$

where:

cv = (standard deviation/mean) 100

Percent error = (standard error of mean/mean)100.

Figure 14 shows sampling intensities for herbs and fine fuels, cv = 80; litter, cv = 100; and shrubs, cv = 140. Fine fuels consist of litter, herbs, and 0- to ¼-inch (0- to 0.6-cm) downed woody material. The sampling intensities for fines agree with those in Brown (1974b) for 0- to 1-inch (0- to 2.5-cm) downed woody material. Generally, for a given level of precision, estimates for combined vegetative categories require fewer sample points than for individual vegetative categories.

A scattergram of mean estimates and percent errors showed a lack of correlation. Thus, figure 14 should apply to loadings ranging from light to heavy. Cover types appeared to slightly influence coefficients of variation (table 5). For example, for a given percent error, fewer sample points are required to estimate litter in ponderosa pine and Douglas-fir than in the grand fir and spruce-fir types. This seems reasonable because litter is more uniform in ponderosa pine and Douglas-fir stands. For the most part, however, differences among cover types in table 5 provided little guidance on sampling intensities. Advance knowledge about the uniformity of fuels should be more useful in deciding upon sampling intensities than cover type.

Coefficients of variation for shrubs varied considerably from stand to stand. High coefficients of variation were due to occasional plots falling in clumps of large-sized shrubs. The number of plots required to achieve a given percent error might easily be twofold to fourfold more or less than suggested in figure 14.

Table 5.—Average coefficients of variation from stands sampled with 10 sample points in the Selway-Bitterrott Wilderness

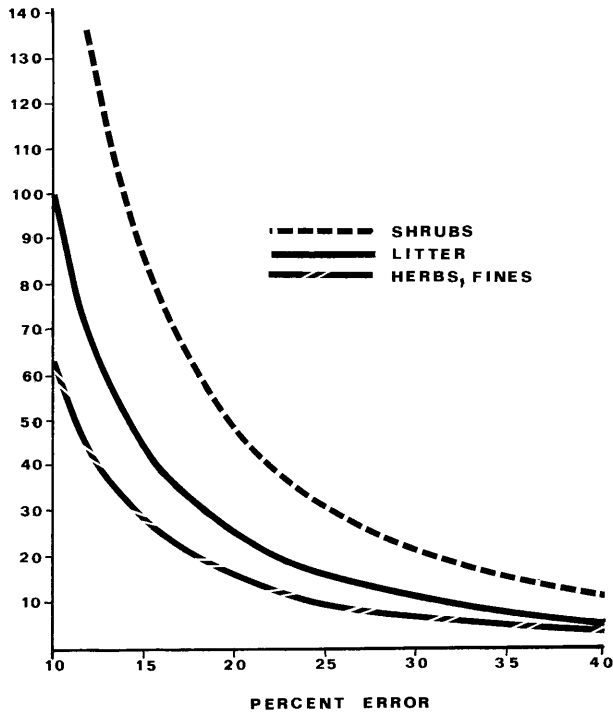| Cover type | Litter | Herbaceous vegetation | Fines | Shrubs | Duff | Number of stands |
|---|---|---|---|---|---|---|
| Ponderosa pine | 93 | 79 | 73 | 116 | 104 | 12 |
| Douglas-fir | 91 | 86 | 72 | 137 | 79 | 19 |
| Grand fir | 131 | 75 | 74 | 160 | 74 | 19 |
| Engelmann spruce-subalpine fir | 122 | 81 | 102 | 168 | 96 | 13 |
| Average | 109 | 80 | 80 | 145 | 88 | — |

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Figure 14.—Number of sample points related to percentage of error based on data from the Selway-Bitterroot Wilderness, Idaho.

Quantity of downed woody material larger than 3 inches (7.6 cm) in diameter can vary considerably with stands. As number of pieces per acre increases, variability among sample points tends to decrease and sampling effort can be reduced to achieve a given sampling precision. For large diameter pieces, the sampling plane should be long enough so that on the average, at least one intersection occurs with three-fourths or more of the planes. A large sampling variance results when many zeros are recorded for intersections. In areas where very little downed material exists, sampling planes should actually be one to several hundred feet long to provide respectable precision. As an average for coniferous cover types, use of 35- to 50-ft (10.8- to 15.2-m) sampling planes should require sampling intensities similar to litter (fig. 14).

# APPENDIX III
# COMPUTER INSTRUCTIONS

This appendix explains how to set up and operate a computer program for calculating results from the inventory data. It includes a listing of the computer program and instructions for punching and verifying data.

## ADP Program Writeup

### Description

| | |
|---|---|
| SYSTEM | STAND BIOMASS |
| PROGRAM | FUELS |
| LANGUAGE | ASCII FORTRAN V |
| MACHINE | PERKIN ELMER 3200 |
| USAGE | BATCH |

### Purpose

This program performs calculations of the sampling results shown in figure 13. The program produces weight in pounds per acre and kilograms per square meter of forest floor duff, forest floor litter, herbaceous vegetation, shrubs, small conifers, and downed woody material. Also, estimates for live and dead vegetation by diameter size classes are furnished. This information has application in research investigations and intensive forest management.

### Input

The program accepts data from the inventory form in figure 4. The input data must follow the sequence of the data form. The record order of Card 1 through Card 6 for each plot is required. The data must be on an input medium which will allow REWIND, i.e., a magnetic tape or disk file. The present program reads the parameter card from the card reader designated LU 60. The input data file is read from LU 5.

The first parameter card is a title card for the run. The second parameter card defines one of the three output options available. The options are:

1. Individual stands
2. Sorted by cover type
3. Sorted by habitat type.

All the acceptable cover type, habitat type, tree and shrub species codes are found in the text.

### Output

The program will produce two pages of output (fig. 13) for each stand of input. Also, two pages of output will be produced for each cover type or habitat type.

### Method

The program contains a set of constants tied to the sampling techniques described in the text: XLOAD, ZLOAD, YLOAD(1), YLOAD(2). They convert all units to tons per acre and also account for the nonhorizontal particle correction, particle density, and the $\pi^2/8$ portion of the planar intersect formula. YLIT and YGFS convert the plot weights to the proper weight units. If any variation of the sampling technique is used, these constants will require recalculation.

### Runstream

As stated earlier, the inventory data must be a file on disk, tape, or other medium that allows REWIND. The parameter cards are read from the card reader. The formats are:

| | |
|---|---|
| CARD 1 | TITLE CARD |
| cc | Description |
| 1-60 | Free field to identify run |
| CARD 2 | TYPE OF RUN |
| cc | Description |
| 1-19 | Sort desired on date, legal options are: |

cc

| 1 | 5 | 10 | 15 |
|---|---|---|---|
| STAND SEPARATELY | | | |
| COVER TYPE | | | |
| HABITAT TYPE | | | |

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# CARD PUNCHING AND VERIFYING INSTRUCTIONS

| FUNCTION * | | | | PROGRAM NAME | |
|---|---|---|---|---|---|
| D- DUPLICATE  S- SKIP  V- VERIFY | | | | PROGRAM NUMBER | DATE |
| P- PUNCH  L- LEFT JUSTIFY | | | | PREPARED BY | PAGE 1 of 6 |

| CARD FIELD | COLUMNS | | NO. | FUNC. | REMARKS |
|---|---|---|---|---|---|
| | FROM | TO | COLS. | * | |
| STAND NO. | 1 | 4 | 4 | P | |
| PLOT NO. | 5 | 8 | 4 | P | |
| TERRAIN SLOPE | 9 | 10 | 2 | P | |
| ASPECT | 11 | 13 | 3 | P | |
| ELEVATION | 14 | 17 | 4 | P | |
| STAND AGE | 18 | 20 | 3 | P | |
| COVER TYPE | 21 | 23 | 3 | L | ALPHA |
| HABITAT TYPE | 24 | 26 | 3 | P | |
| PLANER SLOPE | 27 | 28 | 2 | P | |
| TRANSECT LENGTH (0-1) | 29 | 30 | 2 | P | |
| TRANSECT LENGTH (1-3) | 31 | 33 | 3 | P | |
| NO INTERSECTS 0-1/4 in. | 34 | 36 | 3 | P | |
| NO INTERSECTS 1/4-1 in. | 37 | 38 | 2 | P | |
| NO INTERSECTS 1-3 in. | 39 | 40 | 2 | P | |
| TRANSECT LENGTH >3 in. | 41 | 43 | 3 | P | |
| DIA. >3 in. SOUND | 44 | 73 | 30 | P | 10 3-DIGIT NOS. |
| SKIP | 74 | 79 | 6 | | |
| CARD NO. | | 80 | | | PUNCH "1" |
| | | | | | |
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# CARD PUNCHING AND VERIFYING INSTRUCTIONS

| FUNCTION * | | PROGRAM NAME | | |
|---|---|---|---|---|

| D- DUPLICATE  S- SKIP  V- VERIFY | PROGRAM NUMBER | DATE |
|---|---|---|
| P- PUNCH        L- LEFT JUSTIFY | PREPARED BY | PAGE 2 of 6 |

| CARD FIELD | COLUMNS | | NO. COLS. | FUNC. * | REMARKS |
|---|---|---|---|---|---|
| | FROM | TO | | | |
| STAND NO. | 1 | 4 | 4 | D | |
| PLOT NO. | 5 | 8 | 4 | D | |
| DIA. >3 in. ROTTEN | 9 | 38 | 30 | P | 10 3-digit nos. |
| DUFF DEPTH | 39 | 44 | 6 | P | 2 3-digit nos. |
| HERBS % STANDARD | 45 | 48 | 4 | P | 4 1-digit nos. |
| HERBS % DEAD | 49 | 52 | 4 | P | 4 1-digit nos. |
| HERBS COVER | 53 | 54 | 2 | P | 2 1-digit nos. |
| HERB BASE WEIGHT | 55 | 59 | 5 | P | |
| LITTER % STANDARD | 60 | 63 | 4 | P | 4 1-digit nos. |
| LITTER BASE WEIGHT | 64 | 68 | 5 | P | |
| SHRUBS % COVER | 69 | 70 | 2 | P | 2 1-digit nos. |
| SHRUBS % DEAD | 71 | 72 | 2 | P | 2 1-digit nos. |
| SHRUBS AVERAGE HEIGHT | 73 | 78 | 6 | P | 2 3-digit nos. |
| SKIP | 79 | | | | |
| CARD NO. | | 80 | | | PUNCH "2" |
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# CARD PUNCHING AND VERIFYING INSTRUCTIONS

| FUNCTION * | | | | PROGRAM NAME | | |
|---|---|---|---|---|---|---|

| D- DUPLICATE   S- SKIP   V- VERIFY    P- PUNCH               L- LEFT JUSTIFY | PROGRAM NUMBER | DATE |
|---|---|---|

PREPARED BY — PAGE 3 of 6

| CARD FIELD | COLUMNS | | NO. COLS. | FUNC. * | REMARKS |
|---|---|---|---|---|---|
| | FROM | TO | | | |
| STAND NO. | 1 | 4 | 4 | D | |
| PLOT NO. | 5 | 8 | 4 | D | |
| SUB-PLOT | 9 | | 1 | P | If no stems recorded do not punch these. |
| SPECIES | 10 | 13 | 4 | L | ALPHA |
| NO STEMS 0-0.5 | 14 | 16 | 3 | P | |
| NO STEMS 0.5-5+ | 17 | 28 | 12 | P | 6 2-digit nos. |
| SUB-PLOT | | 29 | 1 | P | |
| SPECIES | 30 | 33 | 4 | L | ALPHA |
| NO. STEMS 0-0.5 | 34 | 36 | 3 | P | |
| NO. STEMS 0.5-5+ | 37 | 48 | 12 | P | 6 2-digit nos. |
| SUB-PLOT | | 49 | 1 | P | |
| SPECIES | 50 | 53 | 4 | L | ALPHA |
| NO. STEMS 0-0.5 | 54 | 56 | 3 | P | |
| NO. STEMS 0.5-5+ | 57 | 68 | 12 | P | 6 2-digit nos. |
| SKIP | 69 | 79 | 11 | | |
| CARD NO. | | 80 | | | PUNCH "3" |
| | | | | | |
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# CARD PUNCHING AND VERIFYING INSTRUCTIONS

| FUNCTION * | | | | PROGRAM NAME | |
|---|---|---|---|---|---|

| D- DUPLICATE  S- SKIP  V- VERIFY | PROGRAM NUMBER | DATE |
|---|---|---|
| P- PUNCH            L- LEFT JUSTIFY | PREPARED BY | PAGE 4 of 6 |

| CARD FIELD | COLUMNS | | NO. | FUNC. | REMARKS |
|---|---|---|---|---|---|
| | FROM | TO | COLS. | * | |
| STAND NO. | 1 | 4 | 4 | D | |
| PLOT NO. | 5 | 8 | 4 | D | |
| SUB-PLOT | | 9 | 1 | P | |
| SPECIES | 10 | 13 | 4 | L | ALPHA |
| NO STEMS 0-0.5 | 14 | 16 | 3 | P | |
| NO STEMS 0.5-5+ | 17 | 28 | 12 | P | 6 2-digit nos. |
| SUB-PLOT | | 29 | 1 | P | |
| SPECIES | 30 | 33 | 4 | L | ALPHA |
| NO STEMS 0-0.5 | 34 | 36 | 3 | P | |
| NO STEMS 0.5-5+ | 37 | 48 | 12 | P | 6 2-digit nos. |
| SUB-PLOT | | 49 | 1 | P | |
| SPECIES | 50 | 53 | 4 | L | ALPHA |
| NO STEMS 0-0.5 | 54 | 56 | 3 | P | |
| NO STEMS 0.5-5+ | 57 | 68 | 12 | P | 6 2-digit nos. |
| SKIP | 69 | 79 | 11 | | |
| CARD NO. | | 80 | 1 | | PUNCH "4" |
| | | | | | |
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# CARD PUNCHING AND VERIFYING INSTRUCTIONS

| FUNCTION * | | | | PROGRAM NAME | |
|---|---|---|---|---|---|

| D- DUPLICATE  S- SKIP  V- VERIFY  P- PUNCH  L- LEFT JUSTIFY | PROGRAM NUMBER | DATE |
|---|---|---|
| | PREPARED BY | PAGE 5 of 6 |

| CARD FIELD | COLUMNS | | NO. COLS. | FUNC. * | REMARKS |
|---|---|---|---|---|---|
| | FROM | TO | | | |
| STAND NO. | 1 | 4 | 4 | D | |
| PLOT NO. | 5 | 8 | 4 | D | |
| SUB-PLOT | | 9 | 1 | P | |
| SPECIES | 10 | 13 | 4 | L | ALPHA |
| NO. STEMS 0-0.5 | 14 | 16 | 3 | P | |
| NO. STEMS 0.5-5+ | 17 | 28 | 12 | P | 6 2-digit nos. |
| SUB-PLOT | | 29 | 1 | P | |
| SPECIES | 30 | 33 | 4 | L | ALPHA |
| NO. STEMS 0-0.5 | 34 | 36 | 3 | P | |
| NO. STEMS 0.5-5+ | 37 | 48 | 12 | P | 6 2-digit nos. |
| SUB-PLOT | | 49 | 1 | P | |
| SPECIES | 50 | 53 | 4 | L | ALPHA |
| NO. STEMS 0-0.5 | 54 | 56 | 3 | P | |
| NO. STEMS 0.5-5+ | 57 | 68 | 12 | P | 6 2-digit nos. |
| SKIP | 69 | 79 | 11 | | |
| CARD NO. | | 80 | 1 | | PUNCH "5" |
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# CARD PUNCHING AND VERIFYING INSTRUCTIONS

| FUNCTION * | | | | PROGRAM NAME | | |
|---|---|---|---|---|---|---|
| D- DUPLICATE  S- SKIP   V- VERIFY | | | | PROGRAM NUMBER | | DATE |
| P- PUNCH               L- LEFT JUSTIFY | | | | PREPARED BY | | PAGE  6  of  6 |

| CARD FIELD | COLUMNS | | NO. | FUNC. | REMARKS |
|---|---|---|---|---|---|
| | FROM | TO | COLS. | * | |
| STAND NO. | 1 | 4 | 4 | D | |
| PLOT NO. | 5 | 8 | 4 | D | |
| SUB-PLOT | | 9 | 1 | P | |
| SPECIES | 10 | 13 | 4 | L | ALPHA |
| NO. STEMS 0-0.5 | 14 | 16 | 3 | P | |
| NO. STEMS 0.5-5+ | 17 | 28 | 12 | P | 6 2-digit nos. |
| TREE COUNT SPECIES | 29 | 30 | 2 | L | ALPHA |
| "        NO. | 31 | 32 | 2 | P | |
| "        HT. | 33 | 34 | 2 | P | |
| "        SPECIES | 35 | 36 | 2 | L | ALPHA |
| "        NO. | 37 | 38 | 2 | P | |
| "        HT. | 39 | 40 | 2 | P | |
| "        SPECIES | 41 | 42 | 2 | L | ALPHA |
| "        NO. | 43 | 44 | 2 | P | |
| "        HT. | 45 | 46 | 2 | P | |
| "        SPECIES | 47 | 48 | 2 | L | ALPHA |
| "        NO. | 49 | 50 | 2 | P | |
| "        HT. | 51 | 52 | 2 | P | |
| "        SPECIES | 53 | 54 | 2 | L | ALPHA |
| "        NO. | 55 | 56 | 2 | P | |
| "        HT. | 57 | 58 | 2 | P | |
| SKIP | 59 | 79 | 21 | | |

CARD NO.                                            80      1              PUNCH "6"

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I-VIID R04-00

I VIID: LICENSED RESTRICTED RIGHTS AS STATED IN LICENSE E-0156          ***, SEE DOCU

        $BATCH
        C***************************************************************************
        C
        C       INPUT DATA FROM UNIT TIP
        C
        C       CARD NO. 1
        C       COLUMN VARIABLE                          DESCRIPTION
        C        1-4   ISTN      - STAND NUMBER
        C        5-8   IPLT      - PLOT NUMBER
        C        9-10  TRSL      - TERRAIN SLOPE IN PERCENT
        C       11-13  ASPT      - ASPECT IN DEGREES
        C       14-17  FLEV      - ELEVATION IN FEET
        C       18-20  SAGE      - STAND AGE
        C       21-23  ICVT      - COVER TYPE
        C       24-26  IHBT      - HABITAT TYPE
        C       27-28  PLSL      - PLANER SLOPE IN PERCENT
        C       29-30  TSL1      - TRANSECT LENGTH 0-1
        C       31-33  TSL3      - TRANSECT LENGTH 1-3
        C       34-36  XNI1      - NUMBER OF INTERSECTS 0-1/4
        C       37-38  XNT2      - NUMBER OF INTERSECTS 1/4-1
        C       39-40  XNT3      - NUMBER OF INTERSECTS 1-3
        C       41-43  TSL4      - TRANSECT LENGTH 3+
        C       44-73  DIA(I,1)  - DIAMETER 3+ SOUND (10 3-DIGIT NOS. IE.I=1,10)
        C
        C       CARD NO. 2
        C       COLUMN VARIABLE                          DESCRIPTION
        C        9-38  DIA(I,2)  - DIAMETER 3+ ROTTEN (10 3-DIGIT NOS. IE.I=1,10)
        C       39-44  DDP(I)    - DUFF DEPTH (2 3-DIGIT NOS. IE.I=1,2)
        C       45-52  IGF(I,J)  - GRASS-FORBS COVER AS PERCENT OF STANDARD
        C                         I=1,4 REPLICATIONS
        C                         J=1 FOR % STANDARD , J=2 FOR % DEAD
        C       53-54  IGFC(I)   - PERCENT GRASS-FORB COVER
        C                         I=1,2 REPLICATIONS
        C       55-59  WGFB      - WEIGHT OF GRASS-FORB BASE
        C       60-63  TLTS(I)   - LITTER COVER AS PERCENT OF STANDARD
        C                         I=1,4 REPLICATIONS
        C       64-68  WLTB      - WEIGHT OF LITTER BASE
        C       69-72  IBC(I,J)  - PERCENT BRUSH COVER
        C                         I=1,2  REPLICATIONS
        C                         J=1 FOR TOTAL COVER , J=2 FOR DEAD
        C       73-78  ABRH(I)    -AVERAGE BRUSH HEIGHT
        C                         I=1,2  REPLICATIONS
        C
        C       CARD NO. 3
        C       CARDS 3,4,5
        C       COLUM VARIABLE
        C       10-13  ISP(I)    - BRUSH SPECIES FOR PLOT I
        C       14-28  NST(I,J)  - NUMBER OF STEMS BY DIAMETR CLASS J FOR PLOT I
        C                         J=1,7 CLASSES
        C       30-33  ISP(I)
        C       34-48  NST(I,J)
        C       50-53  ISP(I)
        C       54-68  NST(I,J)
        C              +++++++   THIS INPUT DATA IS REPEATED 10 TIMES
        C                        I=1,10
        C       CARD 6
        C       COLUMN VARIABLE
```

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      C         10-13 ISP(I)
      C         14-28 NST(I,J)
      C         29-30 ISPY(I)  - SEEDLING SPECIES CODE
      C         31-32 NSTEM(I) - NUMBER OF STEMS
      C         33-34 ASP(I)   - AVERAGE SPECIES HEIGHT
      C         35-58 +++++++  - REPEAT 29-34
      C
      C
      C***********************************************************************
[          CHARACTER NAME*6,IICL*5,ICON*5
      C
      C
[          DIMENSION DIA(10,2), DDP(2),  IGF(4,2), ILTS(4)
      *,
      1IBC(2,2),ABRH(2),ISP(20),NST(10,7),ISPY(4),NSTM(4),HSP(4),IGFC(2)
      2,BDC(5),EDC(4),CODE(9),YLOAD(2),TCOI(3),IICL(9),REG(7,28)
      3IFTP(5),NSP(28),STCI(2),A(7,12),B(7,16),ISPX(19),NAME(2,28)
      C
[          COMMON XLDS(28,20),XLD2(28,20),DEP(12,20),PCV(4,20),XNDP(8,20),X(2
      18),ADIA(2,20),XND(2,20),DEP2(2,20),SHWT(7,28,20),XN(20),DMX(2,20),
      2XNLT(20),XNGF(20),DMN(2,20),NSDL(19,20),SDLH(19,20),XDLH(19,20),TC
      30A(3,20),TCON(2,20),TCOX(2,20),TCO2(2,20),STCA(2,20),STCN(2,20),ST
      4CX(2,20),STC2(2,20)
      C
[          COMMON /HED/ IHEAD(15),ICLT(144),ICON(2),ILAST,KEY,XINC,NPS,IC1,IP
      1S(144),ICVT,IHBT,SAGE,IDUM1(100),IY
      C
[          EQUIVALENCE (BDC(2),EDC)
      C
!          EQUIVALENCE (TCOI(1),TRSL), (TCOI(2),ELEV), (TCOI(3),ASPT)
      C
[          EQUIVALENCE (STCI(1),SAGE), (STCI(2),HCRB)
[          EQUIVALENCE (A(1,1),REG(1,1)),  (B(1,1),REG(1,13))
      C
[          DATA IICL/ 'STAND', 'COVER', 'HABIT',6* '     ' /
      C
[          DATA BDC/3.0, 6.0, 10.0, 20.0,999.9/
      C
[          DATA IFTP/1HG, 1HH, 1HS, 1HL, 1HT/
      C
[          DATA ISPX/'AF', 'AH', 'AP', 'B ', 'C ', 'CW', 'DF', 'GF', 'J ',
      1'L ', 'LP', 'MH', 'OH', 'PP', 'S ', 'WH', 'WL', 'WP', 'Y '/
      C
[          DATA A/
      * 3.44,16.06,70.19,185.4,519.2,1512.,3840.,
      * 3.95,17.16,69.97,176.6,417.4,1306.,3175.,
      * 2.48,11.52,50.19,132.3,369.8,1074.,2724.,
      * 2.72,12.92,57.43,153.4,434.7,1281.,1071.,
      * 4.47,16.67,58.75,134.7,324.6, 809.,1793.,
      * 4.79,18.92,70.50,167.7,420.1,1090.,2503.,
      * 2.82,12.29,50.37,127.6,341.6, 950.,2318.,
      * 3.93,19.86,74.06,176.2,441.6,1146.,  -1.,
      * 1.21, 8.73,43.64,125.9,387.4,1243.,  -1.,
      * 2.88,18.49,83.75,226.5,650.3,1943.,  -1.,
      * 2.69,18.11,85.27,236.6,697.9,2145.,  -1.,
      * 2.89,17.30,74.09,193.1,533.1,1529.,  -1.  /
      C
```

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        DATA B/
      * 2.61,17.21,79.62,218.4,636.5,1932.,  -1.,
      * 3.64,16.52,56.49,127.0,299.6, 730.,  -1.,
      * 3.02,12.38,38.91,82.74,184.1, 422., 871.,
      * 7.87,31.42,96.77,203.0,445.3,1006.,  -1.,
      * 2.22,12.12,36.22,74.82,161.0,  -1.,  -1.,
      * 2.79,16.99,54.59,117.8,266.1,  -1.,  -1.,
      *  .99,11.96,59.79,172.6,530.8,  -1.,  -1.,
      * 1.88,16.92,69.97,178.2,480.3,  -1.,  -1.,
      * 1.69,19.96,98.36,281.2,856.3,  -1.,  -1.,
      * 2.21,17.37,65.70,157.8,399.4,  -1.,  -1.,
      * 2.05,10.74,31.27, 63.7,133.3,  -1.,  -1.,
      * 2.08,15.47,56.56,132.9,328.5,  -1.,  -1.,
      * 2.01,19.32,83.28,218.0,604.6,  -1.,  -1.,
      * 1.99,16.41,64.08,157.2,407.0,  -1.,  -1.,
      * 2.63,15.79,67.80,177.1,489.9,1408.,  -1.,
      * 3.64,15.35,60.87,150.8,394.7,1071.,2560.  /
C
C
        DATA NSP/4HAMAL, 4HACGL, 4HSOSC, 4HPRVI, 4HALSI,
     1          4HCOST, 4HSASC, 4HPHMA, 4HMEFE, 4HLOUT,
     2          4HHODI, 4HCEVE, 4HPHLE, 4HSHCA, 4HARTR,
     3          4HJUCO, 4HVASC, 4HSYAL, 4HVAGL, 4HROSA,
     44HRILA,4HSPBE,4HBERE,4HRUPA,4HRUID,4HLOW ,4HMED ,4HHIGH /
C
        DATA NAME/ 'SERVIC','EBERRY','MTN. M','APLE  ','MTN. A','SH    ',
     1             'CHOKEC','HERRY ','MTN. A','LDER  ','DOGWOO','D     ',
     2             'MTN. W','ILLOW ','NINEBA','RK    ','MENIES','IA    ',
     3             'HONEYS','UCKLE ','OCEANS','PRAY  ','CEANOT','HUS   ',
     4             'MOCKOR','ANGE  ','BUFFAL','OBERRY','SAGEBR','USH   ',
     5             'JUNIPE','R     ','WHORTL','EBERRY','SNOWBE','RRY   ',
     6             'HUCKLE','BERRY ','ROSE  ','      ','GOOSEB','ERRY  ',
     7             'W. SPI','REA   ','OREGON','GRAPE ','THIMBL','EBERRY',
     8 'RASPBE','RRY   ','LOW   ','      ','MEDIUM','      ',
     9 'HIGH  ','      ' /
C
C *** SET ALL CONSTANTS
C
        IBN = 0
        IIP=5
        IN=4
        IC=6
        ACRE=43560.
        XLOAD=12651.29072
        ZLOAD=10542.74226
        YLOAD(1)=9329.86042
        YLOAD(2) = 6984.0
        YLIT=0.002276
        YGFS=0.001138
        GRAM=12.00
        CODE(1)=0.025
        CODE(2)=0.125
        CODE(3)=0.300
        CODE(4)=0.500
        CODE(5)=0.700
        CODE(6)=0.875
        CODE(7)=0.975
```

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```
            CODE(8)=1.0
            CODE(9)=0.0
            ILAST=-9999
      C
      C *** READ IN THE TITLE CARD
      C
            READ(IN,10) (IHEAD(I),I=1,15)
        10 FORMAT(15A4)
      C
      C *** READ IN THE CONTROL CARD
      C
        20 I2=12
            READ(IN,30,END=197)
           * (ICON(I),I=1,2),(IPS(I),ICLT(I),I=1,I2),IX
        30 FORMAT(2A5,9X,12(A1,A4),A1)
            IF(ICON(1 ).EQ.'STOP ') CALL EXIT
      C
      C *** INTERPRET CONTROL CARD AND SET PARAMETERS
      C
            NC = 1
            NPS = 1
            IC1 = 1
            DO 40 I=1,3
            IF(IICL(I).EQ.ICON(1) ) GO TO 45
        40 CONTINUE
            GO TO 50
        45 KEY=I
            IF (KEY.LE.8) GO TO 90
      C
      C   * CHECK FOR CONTINUATION AND READ THEM IN
      C
        50 WRITE(IO,60)
        60 FORMAT (///,52H*********** ERROR  ********** ERROR ************
           1// 10X,'CONTROL CARD IN ERROR  -  THE CORRECT CODES ARE STAND , HA
           2BITAT TYPE , COVER TYPE' // 30H**** PROGRAM TERMINATED  **** )
            CALL EXIT
      C   * SET THE CONTROL KEY
      C
        90 GO TO (170,120,120),KEY
      C
      C   * SLOPE, ELEVATION, ASPECT, AND STAND AGE CLASSES
      C
      C
      C   * COVER TYPE AND HABITAT TYPE
      C
       120 I2=0
      C
      C
      C *** REWIND THE DATA TAPE
      C
       170 REWIND IIP
      C
      C *** ZERO OUT ALL STORAGE ARRAYS
      C
            CALL ZERO (20)
            IC=1
            IY = 0
```

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      C
      C *** READ IN SOME DATA
      C
      180 READ(IIP,190,END=580)
          * ISTN,IPLT,TRSL,ASPT,ELEV,SAGE,ICVT,IHBT,PLSL,TSL1,
          1TSL3,XNI1,XNI2,XNI3,TSL4,(DIA(I,1),I=1,10)
      190 FORMAT(2I4,F2.0,F3.0,F4.0,F3.0,A3,I3,F2.0,F2.1,F3.1,F3.0,2F2.0,F3.
          10,10F3.0)
      C
      C
      C *** IF THIS READ MARKS END-OF-FILE ON ITP CALL OUTPUT
      C
            IF (TSL1*TSL3*TSL4.GT.0.0) GO TO 196
            WRITE (IO,195) ISTN,IPLT,TSL1,TSL3,TSL4
      195 FORMAT (1H1,10X,46H**  ERROR  *****  DATA ERROR  *****  ERROR  **,
          1//,16X,'STAND NUMBER ',I4,', PLOT NUMBER ',I4,/,18X,'0-1 TRANSECT
          2LENGTH =',F6.1,' FT',/,18X,'1-3 TRANSECT LENGTH =',F6.1,' FT',/,18
          3X,'3+  TRANSECT LENGTH =',F6.1,' FT',/,10X,'ALL TRANSECT LENGTHS M
          4UST BE GREATER THAN ZERO',//,10X,46H*********  CHECK CARD AND RESU
          5BMIT   *********)
      197 CALL EXIT
      196 IF (ASPT.GE.360.0) ASPT=ASPT-360.0
      C
      C *** READ IN THE REMAINING 5 CARDS OF DATA SET
      C
            READ(IIP,200) (DIA(1,2),I=1,10),(DDP(I),I=1,2),((IGF(I,J),I=1,4),J
          1=1,2),IGFC,WGFB,(ILTS(I),I=1,4),WLTB,((IBC(I,J),I=1,2),J=1,2),(ABR
          2H(I),I=1,2),(ISP(I),(NST(I,J),J=1,7),I=1,10),(ISPY(I),NSTM(I),HSP(
          1I),I=1,4)
      C
      200 FORMAT(8X,10F3.0,2F3.1,10I1,F5.2,4I1,F5.2,4I1,2F3.0 /
          *                                                 8X,3(1X,A4,I3,6I
          12)/8X,3(1X,A4,I3,6I2)/8X,3(1X,A4,I3,6I2)/8X,1X,A4,I3,6I2,4(A2,I2,F
          32.1) )
      C
      C
      C ,*** SET PARAMETERS BASED ON DESIRED ACTION
      C
            GO TO (210,250,260),KEY
      C
      C   * STANDS SEPERATE
      C
      210 IF (ILAST.EQ.ISTN) GO TO 330
            IF (ILAST.EQ.-9999) GO TO 220
            CALL OUTPUT(NC,IBN,ISPX,NAME,IO)
            IBN = 0
            IY = 0
            CALL ZERO (NC)
      220 ILAST=ISTN
            GO TO 330
      C
      C   * COVER TYPE
      C
      250 IK=ICVT
            GO TO 270
      C
      C   * HABITAT TYPE
```

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      C
        260 IK=IHBT
        270 DO 280 I=IC1,I2
            IF (IK.EQ.ICLT(I)) GO TO 290
        280 CONTINUE
            IF (IC1.GT.1.OR.I2.GE.144) GO TO 180
            I2=I2+1
            ICLT(I2)=IK
            NPS=I2
            IF (I2.GT.20) GO TO 180
            IC = I2
            NC = I2
            GO TO 330
        290 IC=I-IC1+1
            IF (IC.GT.20) GO TO 180
      C *** CALCULATE PLANER AND TERRAIN SLOPE CONSTANTS
      C
        330 PSLP=SQRT(1.0+(PLSL/100.0)**2.0)
            TSLP=SQRT(1.0+(TRSL/100.0)**2.0)
      C
      C *** CALCULATE THE LOAD IN POUNDS/ACRE FOR ALL SIZE CLASSES
      C
      C   * FIRST SET MULTIPLICATION CONSTANTS BASED ON COVER TYPE
      C
            DO 333 IJJ=1,19
            IF(ISPX(IJJ).EQ.ICVT) GO TO 336
        333 CONTINUE
            IJJ = 20
        336 CALL LOOK(IJJ,A1,A2,A3)
      C
      C
      C   * LOAD CASE 1:  0-1/4
      C
            X(1)=XLOAD*A1*XNI1*PSLP/TSL1
      C
      C   * LOAD CASE 2:  1/4-1
      C
            X(2)=XLOAD*A2*XNI2*PSLP/TSL1
      C
      C   * LOAD CASE 6:  1-3
      C
            X(6)=ZLOAD*A3*XNI3*PSLP/TSL3
      C
      C   * LOAD CASE 9-12:  3+ SOUND BY SIZE CLASS
      C   * LOAD CASE 14-17:  3+ ROTTEN BY SIZE CLASS
      C
            DO 360 L=1,2
            XX=0.0
            DO 350 J=1,4
            SMD2=0.0
            DO 340 I=1,10
            IF (DIA(I,L).LT.BDC(J).OR.DIA(I,L).GE.EDC(J)) GO TO 340
            SMD2=SMD2+DIA(I,L)*DIA(I,L)
            ADIA(L,IC)=ADIA(L,IC)+DIA(I,L)
            XND(L,IC)=XND(L,IC)+1.0
        340 CONTINUE
            K=J+5*L+3
```

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```
      X(K)=YLOAD(L)*SMD2*PSLP/TSL4
      XX=XX+X(K)
  350 CONTINUE
C
C    * LOAD CASE 13:   3+ SOUND TOTAL
C    * LOAD CASE 18:   3+ ROTTEN TOTAL
C
      K = K+1
      X(K) = XX
  360 CONTINUE
      IF(WLTB.EQ.0.0) GO TO 380
      XX=0.0
      DO 370 I=1,4
      J=ILTS(I)
      IF (J.LE.0) J=9
      XX=XX+CODE(J)
  370 CONTINUE
      X(3)=YLIT*ACRE*WLTB*XX*TSLP/4.0
      XNLT(IC)=XNLT(IC)+1.0
      GO TO 390
  380 X(3)=0.0
C
C    * LOAD CASE 4:   DEAD GRASS-FORBS
C    * LOAD CASE 22:   LIVE GRASS-FORBS
C
  390 XX = 0.0
      XY = 0.0
      YY = 0.0
      YX = 0.0
      IF (WGFB.EQ.0.0) GO TO 410
      DO 400 I=1,4
      J=IGF(I,1)
      K=IGF(I,2)
      IF (J.LE.0) J=9
      IF (K.LE.0) K=9
      YY=YY+CODE(K)
      YX=YX+CODE(J)
      CON=CODE(J)*CODE(K)
      XX=XX+CODE(J)-CON
      XY=XY+CON
  400 CONTINUE
      X(22)=YGFS*ACRE*WGFB*XX*TSLP/4.0
      X(4)=YGFS*ACRE*WGFB*XY*TSLP/4.0
      XNGF(IC)=XNGF(IC)+1.0
      GO TO 420
  410 X(4)=0.0
      X(22) = 0.0
C
C    * LOAD CASE 19:   DUFF
C
  420 CON = 10.0
      IF(ICVT.EQ.3HPP ) CON = 5.0
      IF(ICVT.EQ.3HLP .OR.ICVT.EQ.3HDF ) CON = 8.0
      DEPDF=(DDP(1)+DDP(2))/2.0
      X(19)=CON*DEPDF*ACRE/GRAM
      X(5) = X(1)+X(2)+X(3)+X(4)
      X(7) = X(5) + X(6)
```

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```
        DEP(1,IC)=DEP(1,IC)+DEPDF
        DEP2(1,IC)=DEP2(1,IC)+DDP(1)*DDP(1)+DDP(2)*DDP(2)
        DO 430 I=1,2
        IF (DMX(1,IC).LT.DDP(I)) DMX(1,IC)=DDP(I)
        IF (DMN(1,IC).GT.DDP(I)) DMN(1,IC)=DDP(I)
    430 CONTINUE


        IF(ABRH(1).GT.0) IBN = IBN + 1
        IF(ABRH(2).GT.0) IBN = IBN + 1
        DEP(2,IC) = DEP(2,IC) + (ABRH(1) + ABRH(2))
        DEP2(2,IC)=DEP2(2,IC)+ABRH(1)*ABRH(1)+ABRH(2)*ABRH(2)
        DO 460 I=1,2
        IF (DMX(2,IC).LT.ABRH(I)) DMX(2,IC)=ABRH(I)
        IF (DMN(2,IC).GT.ABRH(I)) DMN(2,IC)=ABRH(I)
    460 CONTINUE
C       * PERCENT CASE 1,2:  TOTAL,DEAD BRUSH COVER
        DO 470 I=1,2
        J=IBC(1,I)
        K=IBC(2,I)
        IF (J.EQ.0) J=9
        IF (K.EQ.0) K=9
        PD=(CODE(J)+CODE(K))/2.0
        PCV(I,IC)=PCV(I,IC)+PD
    470 CONTINUE
C
C       * PERCENT CASE 3,4:  TOTAL,DEAD GASS-FORBS
        IF(IGFC(1).EQ.0) IGFC(1) = 9
        IF(IGFC(2).EQ.0) IGFC(2) = 9
        CODEX = (CODE(IGFC(1)) + CODE(IGFC(2)))/ 2.0
        PCV(3,IC) = PCV(3,IC) + YX*CODEX/4.0
        PCV(4,IC)=PCV(4,IC)+YY/4.0
C   *** CALCULATE BRUSH LOADINGS BY SIZE CLASS AND SPECIES
        TOTBW=0.0
        DO 520 I=1,10
C       * CHECK AND COMBINE SIMILAR SPECIES
        IF (ISP(I).EQ.4H    ) GO TO 520
        IF (ISP(I).EQ.4HVAME) ISP(I)=NSP(19)
        DO 480 K=1,28
        IF (ISP(I).EQ.NSP(K)) GO TO 500
    480 CONTINUE
        IY = IY + 1
        IDUM1(IY) = ISP(I)
        GO TO 520
C       * SPECIES IS UNIDENTIFIED.  CHECK FOR SMALL OR LARGE STEM
C       * CALCULATE SHRUB WEIGHT
    500 KK = K
        DO 510 J=1,7
        IF (NST(I,J).EQ.0) GO TO 510
        XX = REG(J,K) * FLOAT(NST(I,J))* 8.8185
        IF (XX.GT.0.0) XX=XX*TSLP
        SHWT(J,KK,IC)=SHWT(J,KK,IC)+XX
        IF (XX.LE.0.0) GO TO 510
        TOTBW=TOTBW+XX
    510 CONTINUE
    520 CONTINUE
C       * LOAD CASE 20:  DEAD BRUSH
```

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          X(20)=TOTBW*PD
   C      * LOAD CASE 23:  LIVE BRUSH
          X(23)=TOTBW-X(20)
   C      * LOAD CASE 21:  TOTAL DEAD FUEL
          X(8) = X(13) + X(18)
          X(21) = X(7) + X(8) + X(19) + X(20)/2.0
          X(24) = 0.0
          X(25) = 0.0
          X(26) = 0.0
          DO 540 I=1,19
          DO 540 J=1,4
          IF(ISPY(J).NE.ISPX(I)) GO TO 540
          SDLH(I,IC) = SDLH(I,IC) + HSP(J)
          XDLH(I,IC)=XDLH(I,IC)+1.0
          NSDL(I,IC)=NSDL(I,IC)+NSTM(J)
          CALL SEEDL(I,HSP(J),NSTM(J)  )
      540 CONTINUE
          X(27)=X(24)+X(25)+X(26)
   C      * LOAD CASE 28:  TOTAL FUEL LOAD
          X(28)=X(21)+X(22)+X(23)/2.0+X(27)
   C  *** SUM THE LOADINGS BY SIZE CLASS
          DO 530 I=1,28
          XX=X(I)
          XLDS(I,IC)=XLDS(I,IC)+XX
          XLD2(I,IC)=XLD2(I,IC)+XX*XX
      530 CONTINUE
   C  *** ASPECT SLOPE AND ELEVATION
          DO 550 I=1,3
          TCOA(I,IC)=TCOA(I,IC)+TCOI(I)
          IF (I.GE.3) GO TO 550
          TCO2(I,IC)=TCO2(I,IC)+TCOI(I)*TCOI(I)
          IF (TCON(I,IC).GT.TCOI(I)) TCON(I,IC)=TCOI(I)
          IF (TCOX(I,IC).LT.TCOI(I)) TCOX(I,IC)=TCOI(I)
      550 CONTINUE
   C      * UPDATE THE COUNTER
          XN(IC)=XN(IC)+1.0
          GO TO 180
   C  *** OK  SPIT OUT ALL THAT GARBAGE
      580 CALL OUTPUT(NC,IBN,ISPX,NAME,IO)
          IBN = 0
          END FILE IO
          IF(KEY.EQ.1) GO TO 20
          IC1=IC1+20
          IF (IC1.GT.NPS) GO TO 20
          I2=IC1+19
          IF (I2.GT.NPS) I2=NPS
          NC=I2-IC1+1
          GO TO 170
          END
```

```
7D  R04-00      MAINPROG    .MAIN    03/04/82  15:27:44  TABLE SPACE:  11 KB
FFER:   20 LINES/1321 BYTES    STACK SPACE: 209 WORDS
SION FLOATING PT SUPPORT REQUIRED FOR EXECUTION
```

37

```
      SUBROUTINE OUTPUT(NC,IBN,ISPX,NAME,IO)
      CHARACTER NAME(2,28)*6,ICON*5
      DIMENSION ITO(4,28),ISPX(19)
      COMMON /HED/ IHEAD(15),ICLT(144),ICON(2),ILAST,KEY,XINC,NPS,IC1,
     1TPS(144),ICVT,IHBT,SAGE,IDUM1(100),IY
      COMMON XLDS(28,20),XLD2(28,20),DEP(12,20),PCV(4,20),XNDP(8,20),X(
     *28)
     1,ADIA(2,20),XND(2,20),DEP2(2,20),SHWT(7,28,20),XN(20),DMX(2,20),
     2XNLT(20),XNGF(20),DMN(2,20),NSDL(19,20),SDLH(19,20),XDLH(19,20),TC
     30A(3,20),TCON(2,20),TCOX(2,20),TCO2(2,20),STCA(2,20),STCN(2,20),ST
     4CX(2,20),STC2(2,20)
      DATA ITO/4H       ,4H 0-.,4H25  ,4H      ,
     *4H    ,4H .25,4H-1  ,4H     ,4H      ,4H LIT,4HTER ,4H          ,
     *4HDEAD,4H HER,4HBS  ,4H     ,4H      ,4H FIN,4HES   ,4H          ,
     *4H    ,4H 1-3,4H    ,4H     ,4H   LE,4HSS T,4HHAN ,4H3        ,
     *4H3+  ,4HTOTA,4HL   ,4H     ,4H    S,4HOUND,4H 3-6,4H          ,
     *4H   S,4HOUND,4H 6-1,4H0    ,4H    S,4HOUND,4H 10-,4H20       ,
     *4H   S,4HOUND,4H 20+,4H     ,4H3+ S,4HOUND,4H TOT,4HAL       ,
     *4H   R,4HOTTE,4HN 3-,4H6    ,4H    R,4HOTTE,4HN 6-,4H10       ,
     *4H   R,4HOTTE,4HN 10,4H-20  ,4H    R,4HOTTE,4HN 20,4H+        ,
     *4H3+ R,4HOTTE,4HN TO,4HTAL ,4HDUFF,4H    ,4H          ,4H         ,
     *4HDEAD,4H SHR,4HUB  ,4H     ,4HDEAD,4HFUEL,4H LOA,4HD        ,
     *4HLIVE,4H HER,4HBS   ,4H     ,4H    L,4HIVE ,4HSHRU,4HB        ,
     *4HTREE,4H NEE,4HDLES,4H     ,4H     ,4H 0-.,4H25  ,4H          ,
     *4H    ,4H .25,4H +  ,4H     ,4HTOTA,4HL TR,4HEE   ,4H          ,
     *4HTOTA,4HL LO,4HAD   ,4H          /
      DO 450 IC=1,NC
      IF (XN(IC).LE.0.0) GO TO 450
      XN2=XN(IC)*2.0
C   *** PRINT OUT FUEL LOADING SUMMARY
C      * TITLE AND HEADING
      INP=XN(IC)
      CALL HEAD (IC,IO)
      WRITE (IO,10) INP
   10 FORMAT (/,23X,44H********** FUEL LOADING SUMMARY **********,/,3
     17X,'(FOR',I5,' PLOTS)',/26X,'I',4X,'LOADING IN OVEN-DRY POUNDS/ACR
     2E'5X,'I',11X,'I' / 13X,'SIZE CLASS   I  AVERAGE',15X,'STD-DEV  %ER
     3ROR I  KG/SQ-M  I')
      WRITE (IO,20)
   20 FORMAT (10X,16('-'),'I',40('-'),'I',11('-'),'I')
      DO 90 IL=1,28
C      * AVERAGE THE LOADINGS BY SIZE CLASS
      XX=XN(IC)
      IF (IL.EQ.20.OR.IL.EQ.23) XX=XN2
      IF (XX.LE.0.0.OR.XLDS(IL,IC).LE.0.0) GO TO 30
      XLDS(IL,IC)=XLDS(IL,IC)/XX
C      * STANDARD DEVIATION
      IF (XX.LE.1.0.OR.XLDS(IL,IC).LE.0.0) GO TO 40
      XLD2(IL,IC)=STDV(XLD2(IL,IC),XLDS(IL,IC),XX)
C      * PERCENT ERROR
      X(IL)=XLD2(IL,IC)/(SQRT(XX)*XLDS(IL,IC))*100.0
      GO TO 50
   30 XLDS(IL,IC)=0.0
   40 XLD2(IL,IC)=0.0
      X(IL)=0.0
   50 PPSF =(XLDS(IL,IC) / 43560.0)* 4.8824
      IF(IL.EQ.19) WRITE(IO,20)
```

```
      IF (IL.EQ.5.OR.IL.EQ.8.OR.IL.EQ.21.OR.IL.EQ.28) WRITE(IO,20)
      IF ((IL.GT.8.AND.IL.LT.18.AND.IL.NE.13).OR.(IL.LE.4).OR.((IL.GE.
     124).AND.(IL.LE.26))) GO TO 70
      IF(IL.EQ.6) GO TO 70
      IF(IL.EQ.20) GO TO 70
      IF(IL.EQ.22) GO TO 70
      IF(IL.EQ.23) GO TO 70
      IF(IL.EQ.19) GO TO 85
C     * PRINT OUT FUEL LOADING
      WRITE(IO,60) (ITO(I,IL),I=1,4),XLDS(IL,IC),XLD2(IL,IC),X(IL),PPSF
   60 FORMAT(10X,4A4,'I',F10.0,11X,F10.0,F7.1,2X,'I',F10.3,' I')
      GO TO 90
   70 WRITE(IO,80) (ITO(I,IL),I=1,4),XLDS(IL,IC),XLD2(IL,IC),X(IL),PPSF
   80 FORMAT(10X,4A4,'I',10X,F10.0,1X,F10.0,F7.1,2X,'I',F10.3,' I')
      GO TO 90
   85 WRITE(IO,86) (ITO(I,IL),I=1,4),XLDS(IL,IC),PPSF
   86 FORMAT(10X,4A4,'I',10X,F10.0,20X,'I',F10.3,' I' )
   90 CONTINUE
C *** AVERAGE FUEL DEPTHS
C     * AVERAGE FUEL DEPTH
      DO 120 I=1,12
      XX=XN(IC)
      IF(I.EQ.2) XX = IBN
      IF (I.LT.3.OR.I.GT.10) GO TO 95
      J=I-2
      XX=XNDP(J,IC)
   95 IF (XX.LE.0.0) GO TO 110
      DEP(I,IC)=DEP(I,IC)/XX
      GO TO 120
  110 DEP(I,IC)=0.0
  120 CONTINUE
C     * STANDARD DEVIATION
      DO 130 I=1,2
      XN3=XN2
      IF(I.EQ.2) XN3=IBN
      DEP2(I,IC) = STDV(DEP2(I,IC),DEP(I,IC),XN3)


  130 CONTINUE
C     * PRINT OUT FUEL DEPTHS
      WRITE(IO,140)
  140 FORMAT(/,24X,42H**********    DEPTH (INCHES)    **********        )
      WRITE (IO,150)
      WRITE (IO,160) (DEP(I,IC),DMN(I,IC),DMX(I,IC),DEP2(I,IC),I=1,2)
  150 FORMAT (31X,'I AVERAGE  MINIMUM  MAXIMUM  STD-DEV I'/19X,12('-'
     1),'I',37('-'),'I')
  160 FORMAT(22X,'DUFF      I',4(F8.2,1X),' I' / 22X,'SHRUB     I',4(F8.2,
     11X)' I')
C  ''' PRINT OUT TOPO CONDITIONS
      CALL HEAD (IC,IO)
      DO 200 I=1,3
      TCOA(I,IC)=TCOA(I,IC)/XN(IC)
      IF (I.GE.3) GO TO 200
      TCO2(I,IC)=STDV(TCO2(I,IC),TCOA(I,IC),XN(IC))
  200 CONTINUE
      WRITE (IO,210)
  210 FORMAT (//,22X,46H**********   TOPOGRAPHIC CONDITIONS   **********)
```

```
        WRITE (IO,150)
        WRITE (IO,220) TCOA(1,IC),TCON(1,IC),TCOX(1,IC),TCO2(1,IC)
    220 FORMAT(23X,'SLOPE   I',3(F8.1,1X),F8.2,'   I')
        WRITE (IO,230) TCOA(3,IC)
    230 FORMAT (23X,'ASPECT  I',F8.1,29X,'I')
        WRITE (IO,240) TCOA(2,IC),TCON(2,IC),TCOX(2,IC),TCO2(2,IC)
    240 FORMAT (21X,'ELEVATION I',3(F8.0,1X),F8.1,'   I')
        IF(IY.LE.0) GO TO 15
        IF(IY.GT.26) IY = 26
        WRITE(IO,575) (IDUM1(I),I=1,IY)
    575 FORMAT(                        /10X'THESE CODES D
       1POND TO THE LIST OF ACCEPTABLE BRUSH SPECIES.'/  10X,'THIS DATA WA
       3S NOT USED IN THE CALCULATIONS. ' / 10X,13(A4,1X) / 10X,13(A4,1X))
     15 CONTINUE
C   *** PRINT OUT THE BRUSH LOADING HEADING
        INP2=XN2
        WRITE (IO,330) INP2
        WRITE (IO,340)
C       * CALCULATE SHRUB LOADING BY SPECIES
        DO 250 J=9,16
        X(J)=0.0
    250 CONTINUE
        DO 300 I=1,28
        X(8)=0.0
        DO 280 J=1,7
        IF (SHWT(J,I,IC).EQ.0.0) GO TO 270
        IF (SHWT(J,I,IC).LT.0.0) GO TO 260
        X(J)=SHWT(J,I,IC)/XN2
        X(8)=X(8)+X(J)
        GO TO 280
    260 X(J)=SHWT(J,I,IC)
        X(8)=X(8)+1E-20
        GO TO 280
    270 X(J)=0.0
    280 CONTINUE
        IF (X(8).EQ.0.0) GO TO 300
C       * SUM HIGH, MEDIUM, LOW, AND UNDEFINED BRUSH
C       * WRITE OUT THE BRUSH WEIGHTS
        WRITE (IO,350) (NAME(K,I),K=1,2),(X(J),J=1,8)
        DO 290 J=1,8
        IF (X(J).LE.0.0) GO TO 290
        K=J+8
        X(K)=X(K)+X(J)
    290 CONTINUE
    300 CONTINUE
        WRITE (IO,340)
        WRITE (IO,360) (X(J),J=9,16)
    330 FORMAT (//,10X,7H*******,2X,'AVERAGE LIVE AND DEAD SHRUB LOADINGS
       1IN POUNDS/ACRE',2X,7H*******,/,31X,'(FOR',I5,' PLOTS)',/,21X,'I',1
       23X,'SIZE CLASS IN CENTIMETERS',12X,'I',/,8X,'SPECIES',6X,'I   0-.5
       3  .5-1 1-1.5 1.5-2    2-3    3-5    5+ I  TOTAL')
    340 FORMAT (8X,13('-'),'I',50('-'),'I',7('-'))
    350 FORMAT (8X,2A6,' I',7F7.1,' I',F7.1)
    360 FORMAT (8X,'TOTAL',8X,'I',7F7.1,' I',F7.1)
C   *** PERCENTAGE ESTIMATES AND 3+ SOUND XND ROTTEN
C       * AVERAGE PERCENT BRUSH COVER
        DO 370 I=1,4
```

40

```
          PCV(I,IC)=PCV(I,IC)/XN(IC)*100.0
      370 CONTINUE
   C        * AVERAGE DIAMETERS
          DO 390 I=1,2
          IF (XND(I,IC).LE.0.0) GO TO 380
          ADIA(I,IC)=ADIA(I,IC)/XND(I,IC)
          GO TO 390
      380 ADIA(I,IC)=0.0
      390 CONTINUE
   C        * PRINT OUT ESTIMATES
          X(1)=XLDS(13,IC)/2000.0*80.12
          X(2)=XLDS(18,IC)/2000.0*106.83
          WRITE (IO,400) (PCV(I,IC),I=1,4),(X(I),ADIA(I,IC),I=1,2)
      400 FORMAT (//,9X,71H***** PERCENTAGE   ESTIMATES  ******* 3+  VOLU
         1ME AND DIAMETER ***** / 9X,'I      SHRUB      I      HERBS      I
         2     SOUND     I       ROTTEN    I',/,9X,'I',2(' %COVER   %DEAD  I'
         3),2('  CU-FT  AVG.DIA I'),/,9X,'I',2(16('-'),'I'),2(17('-'),'I'),/
         4,9X,'I',2(2(F6.1,2X),'I'),2(F7.0,F8.2,'  I'))
   C  *** SEEDLING COUNT
          WRITE (IO,410)
      410 FORMAT(// 23X,38H**********   SMALL   TREES   ********** / 28X,'SPE
         1CIES  TREES/ACRE  AVG.HT.FT.')
          TOTSED=0.0
          DO 430 I=1,19
          IF (NSDL(I,IC).EQ.0) GO TO 430
          SEED=FLOAT(NSDL(I,IC))*300.0/XN(IC)
          TOTSED=TOTSED+SEED
          AVHT=SDLH(I,IC)/XDLH(I,IC)
          WRITE (IO,420) ISPX(I),SEED,AVHT
      420 FORMAT (31X,A2,1X,F10.0,2X,F10.2)
      430 CONTINUE
          WRITE (IO,440) TOTSED
      440 FORMAT (29X,'TOTAL',F10.0)
      450 CONTINUE
          RETURN
          END
```

```
7D  R04-00      SUBROUTINE  OUTPUT    03/04/82  15:27:54  TABLE SPACE:   7 KB
FFER:   20 LINES/1321 BYTES     STACK SPACE: 185 WORDS
SION FLOATING PT SUPPORT REQUIRED FOR EXECUTION
```

41

```
      SUBROUTINE LOOK (I,D1,D2,D3)
C  *** SET MULTIPLICATION CONSTANTS BASED ON COVER
      IF (I.EQ.0) GO TO 140
      GO TO(30,140,140,140,30,140,30,140,140,40,20,140,140,10,30,140,40,
     1140,140,140),I
   10 D1=0.0342
      GO TO 50
   20 D1=0.0201
      GO TO 50
   30 D1=0.0122
      GO TO 50
   40 D1=0.0149
   50 GO TO(70,140,140,140,70,140,70,140,140,80,60,140,140,80,70,140,80,
     1140,140,140),I
   60 D2=0.344
      GO TO 90
   70 D2=0.304
      GO TO 90
   80 D2=0.238
   90 GO TO(100,140,140,140,110,140,110,140,140,120,110,140,140,100,110,
     1140,120,140,140,140),I
  100 D3=3.12
      GO TO 130
  110 D3=2.87
      GO TO 130
  120 D3=2.17
  130 RETURN
  140 D1=0.0151
      D2=0.289
      D3=2.76
      RETURN
      END
```

'D  R04-00     SUBROUTINE  LOOK     03/04/82  15:27:55  TABLE SPACE:   2 KB
FER:   20 LINES/1321 BYTES     STACK SPACE:  52 WORDS
SION FLOATING PT SUPPORT REQUIRED FOR EXECUTION

```
            SUBROUTINE ZERO (NC)
     C   *** ZERO OUT ALL STORAGE ARRAYS
            COMMON XLDS(28,20),XLD2(28,20),DEP(12,20),PCV(4,20),XNDP(8,20),X(2
           18),ADIA(2,20),XND(2,20),DEP2(2,20),SHWT(7,28,20),XN(20),DMX(2,20),
           2XNLT(20),XNGF(20),DMN(2,20),NSDL(19,20),SDLH(19,20),XDLH(19,20),TC
           30A(3,20),TCON(2,20),TCOX(2,20),TCO2(2,20),STCA(2,20),STCN(2,20),ST
           4CX(2,20),STC2(2,20)
            DO 80 IC=1,NC
            XN(IC)=0.0
            XNLT(IC)=0.0
             XNGF(IC)=0.0
            DO 10 J=1,28
            XLDS(J,IC) = 0.0
            XLD2(J,IC) = 0.0
     10 CONTINUE
            DO 20 J=1,12
            DEP(J,IC)=0.0
     20 CONTINUE
            DO 30 J=1,8
            XNDP(J,IC)=0.0
     30 CONTINUE
            DO 40 J=1,3
            TCOA(J,IC)=0.0
     40 CONTINUE
            DO 50 J=1,2
            DEP2(J,IC) = 0.0
            ADIA(J,IC) = 0.0
            XND(J,IC) = 0.0
            DMX(J,IC) = -1.0E+20
            STCX(J,IC) = -1.0E+20
            TCOX(J,IC) = -1.0E+20
            DMN(J,IC) = 1.0E+20
            STCN(J,IC) = 1.0E+20
            TCON(J,IC) = 1.0E+20
            STCA(J,IC) = 0.0
            STC2(J,IC) = 0.0
            TCO2(J,IC) = 0.0
     50 CONTINUE
            DO 60 I=1,28
            DO 60 J=1,7
            SHWT(J,I,IC)=0.0
     60 CONTINUE
            DO 70 J=1,4
            PCV(J,IC)=0.0
     70 CONTINUE
            DO 80 J=1,19
            SDLH(J,IC) = 0.0
            XDLH(J,IC) = 0.0
            NSDL(J,IC)=0
     80 CONTINUE
            RETURN
            END
```

```
       FUNCTION STDV (XX,XMN,XN)
       IF (XN.LE.1.0) GO TO 10
       STDV=SQRT((XX-XN*(XMN**2))/(XN-1.0))
       GO TO 20
    10 STDV=0.0
    20 RETURN
       END
```

```
'D  R04-00      FUNCTION     STDV      03/04/82  15:27:58  TABLE SPACE:    1 KB
'FER:    20 LINES/1321 BYTES     STACK SPACE: 151 WORDS
;ION FLOATING PT SUPPORT REQUIRED FOR EXECUTION
```

```
        SUBROUTINE HEAD (IC,IO)
        CHARACTER ICVTP*10,ICON*5
        DIMENSION ICVTP(2,12)
        COMMON/HED/ IHEAD(15),ICLT(144),ICON(2),ILAST,KEY,XINC,NPS,IC1,IP
       1S(144),ICVT,IHBT,SAGE,IDUM1(100),IY
        DATA ICVTP/  'PONDEROSA ',    'PINE       ',
       1             'LODGEPOLE ',    'PINE       ',
       2             'DOUGLAS-FI',    'R          ',
       3             'SPRUCE, SP',    'RUCE FIR   ',
       4             'ALPINE FIR',    '           ',
       5             'GRAND FIR ',    '           ',
       6             'WESTERN RE',    'D CEDER    ',
       7             'BRUSH     ',    '           ',
       8             'ALPINE LAR',    'CH         ',
       9             'WHITEBARK ',    'PINE       ',
       $             'GRASS     ',    '           ',
       3             'UNDEFINED ',    '           '  /
        DATA IPAGE/0/
        IPAGE=IPAGE+1
        IX=IC+IC1-1
C   *** PRINT OUT TITLE
        WRITE(IO,10) (IHEAD(I),I=1,15),IPAGE
        IF(KEY.EQ.1) WRITE(IO,15) ICVT,IHBT,SAGE
     10 FORMAT(1H1,9X,15A4,'  PAGE ',I3 /)
     15 FORMAT(                              10X,'COVER TYPE  ',A3,2X,'HABITA
       1T TYPE ',I3,2X,'STAND AGE ',F4.0 )
        GO TO(40,150,170),KEY
C       * STANDS SEPERATELY
     40 WRITE (IO,50) ILAST
     50 FORMAT(36X,'STAND NUMBER ',I4)
        GO TO 210
C       * COVER TYPE CODES
    150 I1=ICLT(IX)
        WRITE (IO,160) (ICVTP(I,I1),I=1,2)
    160 FORMAT (30X,'COVER TYPE  ',2A10)
        GO TO 210
C       * HABITAT TYPE CODE
    170 WRITE (IO,180) ICLT(IX)
    180 FORMAT (34X,'HABITAT TYPE CODE',I4)
    210 RETURN
        END
```

```
'7D  R04-00      SUBROUTINE  HEAD       03/04/82  15:27:59  TABLE SPACE:   2 KB
'FFER:   20 LINES/1321 BYTES     STACK SPACE: 122 WORDS
```

```
      SUBROUTINE SEEDL(ISP,XHT,NUM)
      DIMENSION Z1(3,19) , Z2(3,19) , Z(3)
      COMMON XLDS(28,20),XLD2(28,20),DEP(12,20),PCV(4,20),XNDP(8,20),X(2
     18),ADIA(2,20),XND(2,20),DEP2(2,20),SHWT(7,26,20),XN(20),DMX(2,20),
     2XNLT(20),XNGF(20),DMN(2,20),NSDL(19,20),SDLH(19,20),XDLH(19,20),TC
     30A(3,20),TCON(2,20),TCOX(2,20),TCO2(2,20),STCA(2,20),STCN(2,20),ST
     4CX(2,20),STC2(2,20)
      DATA Z1/.51,.21,.28,
     *          .0 ,.0 ,.0 ,
     *          .0 ,.0 ,.0 ,
     *          .0 ,.0 ,.0 ,
     *          .51,.21,.28,
     *          .0 ,.0 ,.0 ,
     *          .38,.18,.44,
     *          .51,.21,.28,
     *          .0 ,.0 ,.0 ,
     *          .26,.23,.51,
     *          .38,.18,.44,
     *          .38,.18,.44,
     *          .0 ,.0 ,.0 ,
     *          .38,.18,.44,
     *          .51,.21,.28,
     *          .38,.18,.44,
     *          .26,.23,.51,
     *          .48,.21,.31,
     *          .0 ,.0 ,.0 /
      DATA Z2/.40,.16,.44,
     *          .0 ,.0 ,.0 ,
     *          .0 ,.0 ,.0 ,
     *          .0 ,.0 ,.0 ,
     *          .40,.16,.44,
     *          .0 ,.0 ,.0 ,
     *          .31,.14,.55,
     *          .40,.16,.44,
     *          .0 ,.0 ,.0 ,
     *          .21,.19,.60,
     *          .31,.14,.55,
     *          .31,.14,.55,
     *          .0 ,.0 ,.0 ,
     *          .31,.14,.55,
     *          .40,.16,.44,
     *          .31,.14,.55,
     *          .21,.19,.60,
     *          .31,.16,.53,
     *          .0 ,.0 ,.0 /
      YN=NUM*300.
      GO TO (110,199,199,199,80,199,100,70,80,90,60,20,199,50,10,20,
     140,30,70) ISP
   10 CW=YN*.019604*XHT**2.571
      GO TO 200
   20 CW=YN*.005940*XHT**2.563


      GO TO 200
   30 CW=YN*.3292*XHT
      GO TO 200
   40 CW=YN*.070+.02446*XHT**2.0
```

```
          GO TO 200
    50 CW=YN*.3451*XHT
          GO TO 200
    60 CW=YN*.03111*XHT**2.0
          GO TO 200
    70 CW=YN*.4284*XHT
          GO TO 200
    80 CW=YN*.04833*XHT**2.0
          GO TO 200
    90 CW=YN*.1128*XHT+.00813*XHT**2
          GO TO 200
   100 CW=YN*.01482*XHT**2.7168
          GO TO 200
   110 CW=YN*.035615*XHT**2.303
          GO TO 200
   199 RETURN
   200 DO 210 I= 1,3
          IF(XHT.LE.4.9) Z(I) = Z1(I,ISP)
          IF(XHT.GE.5.0) Z(I) = Z2(I,ISP)
   210 CONTINUE
          X(24) = X(24) + CW * Z(1)
          X(25) = X(25) + CW * Z(2)
          X(26) = X(26) + CW * Z(3)
          RETURN
          END
```

```
7D  R04-00      SUBROUTINE  SEEDL      03/04/82  15:28:02  TABLE SPACE:   4 KB
FFER:   20 LINES/1321 BYTES      STACK SPACE: 144 WORDS
SION FLOATING PT SUPPORT REQUIRED FOR EXECUTION
```

# APPENDIX IV
# FIELDWORK HINTS

1. Steep slopes and heavy brush will slow procedures from 5 to 10 minutes per sample point. Keep this in mind when laying out the day's work.

2. In bogs or moist areas, it can be difficult to distinguish the division between duff and mineral soil. It may be desirable to establish a lower limit such as 12 inches. Below this, duff should not be measured.

3. Before going to the field, label bags for collecting herbs and litter.

4. Keep herb and litter samples in porous containers to prevent mildew. If the weather permits, hang samples where they can air-dry.

5. Approach sample point centers cautiously to avoid disturbing vegetation. At each point, lay out the sampling plane and subplots before doing any sampling. This will minimize disturbance of vegetation to be sampled.

6. In areas with abundant herbaceous vegetation, take larger bags for collecting samples.

7. Fill out the forms in pencil with dark lead. Mistakes can be easily erased.

8. Take care to enter data and label sacks clearly. Make sure all the recording is completed in the field at each plot while it is still fresh in your mind.

The Intermountain Station, headquarted in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

Field programs and research work units of the Station are maintained in:

Boise, Idaho

Bozeman, Montana (in cooperation with Montana State University)

Logan, Utah (in cooperation with Utah State University)

Missoula, Montana (in cooperation with the University of Montana)

Moscow, Idaho (in cooperation with the University of Idaho)

Provo, Utah (in cooperation with Brigham Young University)

Reno, Nevada (in cooperation with the University of Nevada)