



United States
Department of
Agriculture

Forest Service

Pacific Northwest
Research Station

General Technical
Report

PNW-GTR-372
September 1996



Estimating Live Fuels for Shrubs and Herbs With BIOPAK

Joseph E. Means, Olga N. Krankina, Hao Jiang,
and Hongyan Li



Disclaimer

The BIOPAK software is in the public domain and the recipient may neither assert any propriety rights thereto nor represent them to anyone as other than Government-produced programs.

The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

Authors

JOSEPH E. MEANS was a research forester, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, 3200 S.W. Jefferson Way, Corvallis, OR 97331; OLGA N. KRANKINA is research associate, Department of Forest Science, and HAO JANG is a graduate student, Department of Mathematics, Oregon State University, Corvallis, OR 97331; and HONGYAN LI is with Rogue Wave, 260 S.W. Madison Avenue, Corvallis, OR 97330.

Abstract

Means, Joseph E.; Krankina, Olga N; Jiang, Hao; Li, Hongyan. 1996. Estimating live fuels for shrubs and herbs with BIOPAK. Gen. Tech. Rep. PNW-GTR-372. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 21 p.

This paper describes use of BIOPAK to calculate size classes of live fuels for shrubs and herbs. A library of equations to estimate such fuels in the Pacific Northwest and northern Rocky Mountains is presented and used in an example. These methods can be used in other regions if the user first enters fuel size-class equations for a given region into a new library by using the library editor supplied with BIOPAK. Fuel size classes can be estimated in three ways: (1) When appropriate plant measurements are available, fuel classes can be estimated directly for species that have equations in the library or species with similar growth forms. (2) When appropriate plant measurements are not available, fuel classes can be estimated in two steps, first by estimating total aboveground biomass for individual plants and then by estimating biomass in fuel classes from total aboveground biomass. (3) The equations provided can be used to develop new equations that estimate fuels from plot-level estimates of species cover (and possibly other measures).

Keywords: Live fuels, fuel size classes, software, plant biomass, Pacific Northwest, northern Rocky Mountains.

Contents

1	Introduction
1	Methods Used To Build the Fuel Equation Library
1	Search for Equations and Data
2	Developing Equations
3	Automating Calculation of Sums of Fuel Size Classes
3	Construction of a Library of Fuel Size-Class Equations
4	Results: Techniques for Calculating Fuel Biomass
4	Installing the Fuel Equation Library FUELLIB3
5	Method 1, Direct Calculation of Fuel Biomass From Plant Measurement
7	Method 2, Two-Phase Calculation of Fuel Biomass
8	Method 3, Build Equations Based on Cover by Using New Field Data
10	Common and Scientific Names
10	Acknowledgments
10	Literature Cited
13	Appendix A-Species in the Fuel Equation Library, FUELLIB3
16	Appendix B-Example of Method 1
19	Appendix C-Forms

Obtaining the Software and

The software system described herein requires BIOPAK (Means and others 1994) to run. The BIOPAK users guide and additional copies of this publication can be obtained from:

Pacific Northwest Research Station
PNW Publications
P.O. Box 3890
Portland, OR 97230-3438

(503) 326-7128, Fax: (503) 326-2455

PNW Publication Request Address: FSWA/S=RIS/OU=RO6A@MHS.AITMAIL.COM

The fuels equation library described herein and BIOPAK software can be obtained (1) with technical support for a fee, or (2) without technical support for free (see below).

Obtaining Software and Manuals With Technical support

All BIOPAK software and manuals are distributed by the Forest Resources Systems Institute (FORS), a nonprofit organization that searches for and distributes software with forestry-related applications. Users who purchase from FORS will have the benefit of their technical support. The BIOPAK users guide (Means and others 1994) and software cost US\$50, except for users in countries with currency exchange problems (such as developing and third world countries), the fee is reduced to US\$25. The comparable prices for this publication and the accompanying fuels equation library are US\$20 and US\$10. FORS can be contacted at:

The Forest Resource Systems Institute
122 Helton Court
Florence, AL 35630

(205) 767-0250 Fax: (205) 767-3768 Internet: DaveFORS@AOL.COM

Obtaining the Software Without Technical support

The full BIOPAK software (to be used with the BIOPAK users guide, Means and others 1994) and the fuel size-class equation library (to be used with this publication) can be obtained for free. You may obtain them over the Internet by using a World Wide Web browser such as Netscape or Mosaic at URL: "<http://www.fsl.orst.edu/rogues/meansj/biopak.htm>". Please fill out the short registration form you will find when you download BIOPAK.

Introduction

Reliable predictions of fire behavior and effects require accurate estimates of fuels characteristics. Fuels characteristics are often broadly estimated as one of the 13 standard fuel models (Anderson 1982). When the best of these fuel models results in poor predictions of fire behavior, new fuel models can be constructed (Burgan and Rothermel 1984). This requires estimates of the mass per unit area of the different fuel components; for example, trees, slash, and natural residue.

Systems are available for estimating fuels for trees (for example, DEBMOD, Hilbruner and Wordell 1992) logging slash (Maxwell and Ward 1976a, 1976b; Van Wagner 1968), and natural residues (Blonski and Schramel 1981, Maxwell and Ward 1980) and predicting slash from stand treatments (Brown and others 1977, Hilbruner and Wordell 1992) given appropriate field measurements. In many forest plant communities, shrubs and herbs make up the majority of fuels available to carry surface fire, based on plant cover data for Cascade forests (Halvorson and others 1986, Hemstrom and others 1987) and Rocky Mountain forests (Cooper and others 1991, Steele and others 1983). No system has been available, however, for estimating live fuels of shrubs and herbs from field measurements until that described here.

Our goal was to provide a system for estimating dry mass of live fuels given measurements for shrubs and herbs in the Pacific Northwest and northern Rocky Mountains of the United States, and relying on existing sources of equations and data. A few species of grass also are included. We believe this system could be used in other areas of the world if equations predicting fuel size classes are developed for local species.

This tool can be used only with BIOPAK (Means and others 1994) a software package that links a library of equations that predicts plant components with vegetation data sets and estimates plant components by area. The library that comes with BIOPAK contains almost 1,200 equations from rain forests through deserts of the Pacific Northwest. Its library editor allows the building of new libraries for different regions and continents.¹

The terms "plant component biomass" and "plant component" refer to plant biomass (dry weight basis) separated by form and function into parts, such as leaves, stem, branch, wood, and bark. "Fuels" and "fuel size classes" refer to plant biomass (dry weight basis) separated into standard fuel size classes defined below.

Methods Used To Build the Fuel Equation Library

Our approach included surveying the literature, obtaining existing data, fitting new equations, building a new fuel equation library, testing this library, modifying BIOPAK software, and testing the combined library and software. We did no new field sampling to develop these equations. Our main concern was to create equations for above-ground biomass of shrub fuels. Equations giving total aboveground biomass for herbs (and grasses) can be used directly to estimate 1-hour time-lag fuels (term defined below).

Search for Equations and Data

We first surveyed the literature and contacted people who we believed might have fuel size-class equations or data from which equations could be built, or could lead us to others who had such data. Often, literature or contacts with people led us to more literature and additional contacts. We found four studies with useful data.

¹ Ordering information is at the front of this paper, "Obtaining the Software and BIOPAK."

Though some of these studies provided fuel tables, none provided suitable fuel size class equations. Each, however, had collected but did not publish data on biomass by size classes from which we could build equations. Brown (1976) collected data for 25 shrub species from the northern Rocky Mountains. Kauffman and Martin (1990) collected data for California black oak and tanoak in southwestern Oregon.² Sapsis and Kauffman (1991) obtained data for big sagebrush. Martin and others (1981) collected data for big sagebrush, bitterbrush, snowbrush ceanothus, and greenleaf manzanita in eastern Oregon.

Developing Equations

Equations were fit to estimate total aboveground biomass (BAT) and to estimate biomass of fuels in the following size classes when data were available:

Diameter range	Time lag	Plant component code in fuel equation library
Inches	Hours	
0 - 1/4 (including foliage)	1	FS1
1/4 - 1	10	FS2
1 - 3	100	FS3
3 - 8	1,000	FS4

Often several unique equations were fit to predict the same component from different predictor variables, thereby recognizing that different users may have different sets of plant measurements available as predictors. Most equations predict fuels or BAT for an individual plant from measurements such as diameter of the stem at the base, crown width, crown length, and crown height. Some equations use plant cover (in percent) on a plot as a predictor variable and predict fuels or BAT for a 1-square-meter plot. BIOPAK adjusts the output values to the plot size given by the user. Data sets for most species had no 100-hour or 1,000-hour fuels. Rarely, the available data had been separated into diameter classes slightly different from those above, but we judged these differences to be insignificant.

Equations to predict fuel size classes for individual plants were developed from the unpublished data, first by graphic examination of relations among variables and then by using standard regression techniques (Draper and Smith 1981, Neter and others 1983). We avoided poorly fitting model forms by examining residuals for bias. We transformed the dependent variable when needed to avoid nonuniform variance of the residuals.

² Scientific names for all species are given in appendix A

Automating Calculation of Sums of Fuel Size Classes

We modified BIOPAK (Means and others 1994) to allow automatic calculation of the following sums:

Plant component code in fuel equation library	Fuel size classes summed automatically by BIOPAK to calculate this plant component
FS1 for tree, shrub, and coppice life forms	BBS + BFT
FSI for herb, grass, and <i>Carex</i> life forms	BST + BFT + BIT
F02	FS1 + FS2
F03	FS1 + FS2 + FS3
F04	FS1 + FS2 + FS3 + FS4

In BIOPAK, BBS = small branch biomass, BFT = total foliage biomass, BST = total stem biomass, BIT = inflorescence biomass. Use of automatic summation is described briefly below and in the BIOPAK users guide (Means and others 1994).

Construction of a Library of Fuel Size-Class Equations

We extracted all the equations for BAT for shrubs, and for BAT, total foliage, and inflorescence biomass of herbs, grasses, and sedges from the BIOPAK (Means and others 1994) equation library. For the herb, grass, and sedge equations, we provided for the BAT equations to estimate 1-hour fuels by changing the code for the estimated plant component from BAT to FS1 they retain their original equation numbers. These equations came from the literature and unpublished sources, and some were fit from unpublished data.

Then we combined these with the equations for fuel size classes and BAT fit in this -- study, and placed them in an equation library for use by BIOPAK. This fuel equation library, FUELLIB (version FUELLIB3 at the time of this writing), contains documentation for each equation: equation form and coefficients as in BIOPAK and as in the original source, location of raw data (if known), source of the equation (for example, literature citation or person[s] responsible), and sources of the data (for example, geographic location, plant association). This library, as all BIOPAK equation libraries, can be viewed and edited with the library editor in BIOPAK.

At the time of this writing, FUELLIB contains 272 equations in the following categories:

Life form(s)	Plant component	Number of species	Number of equations
Grass and Carex	FS1	8	19
Herb	BFT	14	20
	BST	3	3
	FS1	47	96
Shrub	BFT	25	25
	FS1	25	52
	FS2	22	44
	FS3	8	15

The final library is projected to contain equations for the species in appendix A.

Results: Techniques for Calculating Fuel Biomass

We provide methods for calculating live fuel size classes for shrubs and herbs for which equations are available. Construction of modified or new fuel models will require additional information, including dead fuels and fuelbed depth (Burgan and Rothermel 1984). The live fuel estimates that BIOPAK can provide must be integrated with this additional information following a technique such as that of Burgan and Rothermel (1984; also Burgan 1987).

We provide three methods for estimating live fuels:

Method 1. Calculate fuels directly for species with fuel equations in FUELLIB and for species having similar growth forms, if the plant measurements required by the equations are available.

Method 2. Alternatively, first calculate BAT by using equations for a wide array of species and geographic areas and measurements on individual plants, then calculate fuels from BAT.

Method 3. For field plots, take plot cover by species and individual plant measurements, calculate fuels from the measurements, and build equations to predict fuels from estimates of-plot cover by species. This technique could allow estimation of fuels for the large number of existing inventory and ecology plots.

The following descriptions assume the user has knowledge and experience with BIOPAK and its users guide (Means and others 1994). Tutorials in the users guide can provide that background. In the following material, italic text indicates sections in the BIOPAK users guide.

Installing the Fuel Equation Library, FUELLIB3

Copy FUELS.EXE into the BIOPAK directory. Type "FUELS" at the DOS prompt to unpack the fuel library. This will allow you to run the example and use the library for your own work.

Method 1, Direct Calculation of Fuel Biomass From Plant Measurements

Requirements: The same plant measurements must be taken as the original investigator took. In FUELLIB, this usually means basal stem diameter and may additionally mean stem length, crown width, crown length, or crown height.

Advantage: Only one run through BIOPAK is required. Predictions are most likely to be reliable for those species and areas for which equations were developed.

Disadvantage: Particular plant measurements are required. Relative to method 2, predictions are more likely to be poor if equations are used for different species and outside the general areas from which plants were sampled to build the equations.

Planning-

Step 1: Determine the vegetation types, and their important species, for which you need modified or new fuel models. Usually these will be indicated by inaccurate fire behavior predictions when those fuel models are used in BEHAVE.

Step 2: Map the ranges of these vegetation types where they are important to-you.

Step 3: Ideally, before field sampling, examine and follow the *Suggestions for Using BIOPAK* (Means and others 1994).

Step 4: Field sampling should allow for making the desired estimates with known confidence by following a valid statistical design, using randomized, systematic, and stratified designs as appropriate (see, for example, Cochran 1977, Thompson 1992). Suggestions for doing this are outlined here. Other valid statistical designs also are possible.

Step 4a: Identify locales (four are probably sufficient) for sampling fuels throughout the range of each type.

Step 4b: On a map or aerial photo of each locale, identify locations for plots that span the range of variability in the type at that locale. Consider transects of plots that cross environmental gradients, such as from top to bottom of a hillslope or ridge to ridge across a watershed (fig. 1). The total number of plots for one fuel type should be at least 20, when the type is fairly uniform, and more than 40 plots would give very good coverage. Because the process of building a fuel model involves adjusting measured fuel characteristics until simulated fire behavior matches observed, many plots probably are not worthwhile.

Step 4c: Set the plot size so that every plot will include at least three of the large plants dominating the fuel type (fig. 2). Some plots may contain many such plants. This can be done on the first field day. If plot size is not corrected for slope, then slopes over 10 percent must be recorded for each plot.

Step 4d: For the species important in these types, determine the types of plant measurements you must take. First go into the *Library Editor*, bring in FUELLIB, find the equations you want to use for each species, and then note the parameters needed to drive these equations. Many shrubs take diameter at the base of the stem, and others take crown average diameter and height.

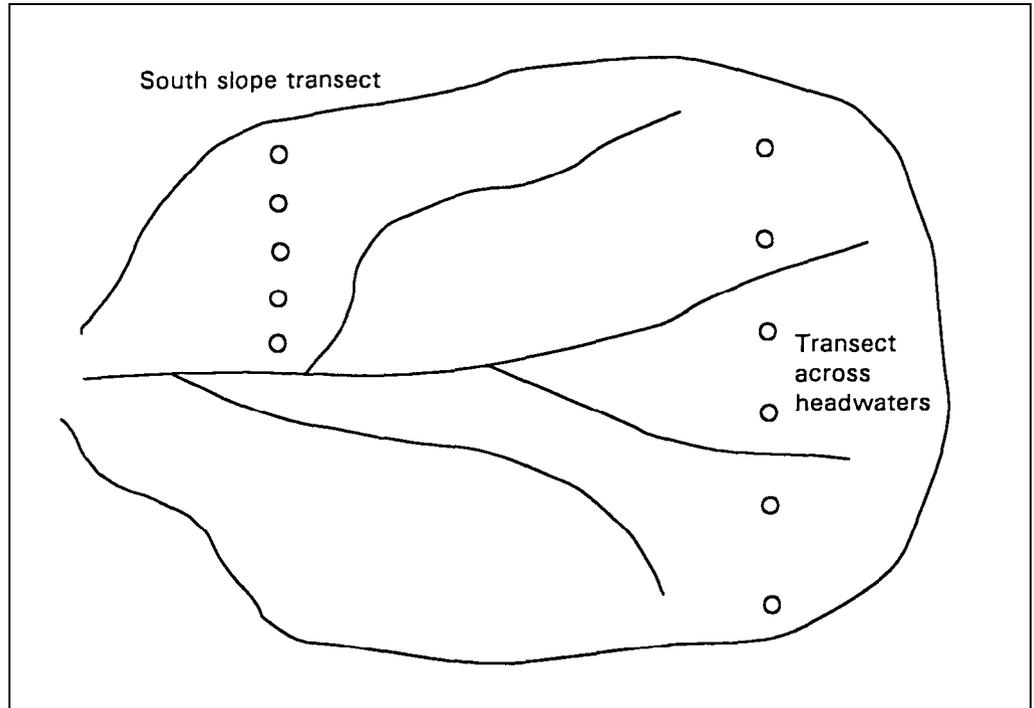


Figure 1-Transects of plots designed to sample the range of variability in fuels on a south slope and across the headwaters of a watershed.

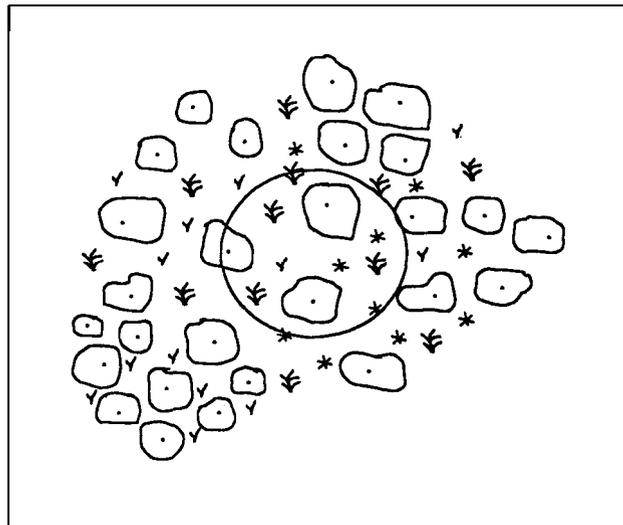


Figure 2-Example plot in vegetation dominated by shrubs.

Field and office work-

Items in italics refer to sections in Means et al. (1994).

Step 5: Collect data by following your plan. A field sheet such as that in appendix C can be used. Measure every plant in a plot or include in a cover estimate. You will also need to collect other data needed to build a complete fuel model as described by Burgan and Rothermel (1984; Burgan 1987). Such data include, for example, average shrub height, and dead and down fuels (methods are described by Hilbruner and Wordell 1992).

Step 6: Format the *Input Data File* in the manner required for BIOPAK (Means and others 1994). Data must be in fixed columns with one observation per record.

Step 7: *Design a Run*. Specify the input data format, request that BIOPAK calculate FS1, FS2, and FS3, and make any *Equation Reassignments* needed (for example, to obtain calculations for species not in FUELLIB).

Step 8: *Calculate Plant Components*. Title the run and specify the input data file, run design file, fuels equation library, and intermediate binary file. Request a *Summarized Equation Use Report* and examine it to see that BIOPAK used the equations you specified in *Equation Reassignments* and you are satisfied with the equations BIOPAK chose.

Step 9: *Generate Reports* for viewing or for use by other programs. Look at the *individual Plant Report(s)* and *Plot Summary Report(s)* carefully to ascertain that estimates are reasonable.

Step 10: Use the fuel estimates and other data you collect to make a new fuel model following procedures such as those in Burgan and Rothermel (1984; Burgan 1987).

An example of method 1 is given in appendix B.

Method 2, Two-Phase Calculation of Fuel Biomass

The user can first calculate BAT and then calculate fuels, using equations based on BAT. BAT is calculated using equations most suited for the species and locale. Fuels are calculated from BAT by using the fuel size-class equations that have more limited coverage of species and locales. This requires two runs through BIOPAK.

Requirements: Particular plant measurements for calculating BAT must be taken in the same way as those used to build the equations.

Advantages: (1) Users have greater choice of biomass equations and parameters to be measured in the field because there are BAT equations for many more species and locations than there are fuel equations. (2) This technique will likely provide better fuels estimates for species and locales in which plants have growth forms that are much different from those used to develop the fuels size-class equations.

Disadvantage: Requires two runs through BIOPAK.

First phase: Calculate total aboveground biomass (BAT)-

Step 1: Ideally, before field sampling, examine and follow the *Suggestions for Using BIOPAK* (Means and others 1994).

Step 2: Determine the parameters (plant measurements) needed in the input data by looking at the BAT equations you plan to use in FUELLIB, using the *Library Editor*. You can choose to use equations for one or more plant components other than BAT if you think they include a high enough proportion of BAT, to be an adequate estimate. Substituting one or more equations for another is described in *Equation Reassignments*. Plant components that are possible to substitute for BAT are:

- . total foliage (BFT) for some herbs
- . wood + bark, live and dead (BAE), when foliage is a small fraction of total biomass
- . live wood + bark + foliage (BAL)
- . live wood + bark (BAP), when foliage is a small fraction of total biomass

If a suitable equation for BAT is not available, BIOPAK will automatically attempt to sum components as mentioned above. If a species does not have an equation(s) in FUELLIB that you think is adequate, equation(s) for another species that you believe has similar form could be used.

Step 3: Field sampling should follow a valid statistical design that allows for making the desired estimates with known confidence (see, for example, Cochran 1977, Thompson 1992).

Step 4: Format the *Input Data File* in the manner required for BIOPAK. Data must be in fixed columns with one observation per record.

Step 5: Use *Design a Run* to specify the input data format, request that BIOPAK calculate BAT, and make any *Equation Reassignments* needed. Equation reassignments may be necessary to obtain estimates for species not in FUELLIB, and to estimate BAT by using equations for other plant components when appropriate (see step 2). In this step, you create your *Run Design File*.

Step 6: Under *Calculate Plant Components*, give a title to the run and specify your input data file, run design file, fuel equation library, and intermediate binary file.

Step 7: Use *Generate Reports* to create a machine-readable individual plant report. Its format is given at the top of the report.

Second phase: Calculate biomass in fuel size classes-

Step 8: Use the machine-readable individual plant report as input to a second run through BIOPAK to calculate fuel biomass; follow method 1.

This method involves estimating cover and fuels biomass by species on plots and building regression models for fuels from this data. You can then use these models to estimate biomass in fuel size classes. Care must be taken in statistical design of the field sampling (see, for example, Cochran 1977, Thompson 1992) and regression analysis (see, for example, Neter and others 1983).

Requirements: Field work to estimate total plant cover by species and to estimate fuel size class from individual plant measurements, for 20 to 40 plots spanning the range of conditions for which fuel estimates are needed.

Method 3, Build Equations Based on Cover by Using New Field Data

Advantages: (1) Users can measure plants in ways required by a wider range of equations than in methods 1 and 2. (2) New equations can be made to estimate fuels on the large number of ecology and inventory plots that have plant cover data.

Disadvantages: Requires new field work and the fitting of a potentially large number of regression models and entering them into an Equation *Library*.

First phase: Field sampling-

Step 1: Define the target population of stands for which you want to estimate fuels.

Step 2: Define an unbiased (for example, stratified random) sample of these stands such that all important shrub, herb, and grass species will be represented on at least 20 of the stands sampled.

Step 3: Establish a plot in each stand large enough so that random inclusion or exclusion of large plants (especially stems of large shrubs) will not cause great fluctuations in biomass estimated from measurements on individual plants. You may want to use separate, smaller plots for smaller plants. Preexisting plots can be used if of the appropriate size. In general, larger plots will give less "noise" in regressions but take more field time.

Step 4: For each plot, record whole-plot values for projected canopy cover (in percent) or other measure(s), such as height, by species. Take the same measure(s) available in your target population.

Step 5: For each plant in each plot, take the measurements needed by the fuel size-class equations in FUELLIB, as in method 1, or BAT equations, as in method 2, that you plan to use. You may plan to use Equation Reassignments to estimate fuels for some species not having their own equations.

Second phase: New regressions and an equation library-

Step 6: Use method 1 to estimate fuel biomass by size class for each species and plot. Save the machine-readable individual plot report for use in fitting regressions.

Step 7: For each fuel size class in each species, fit a regression to predict fuel biomass from plot cover, plant height or other predictor variables you may have measured. Take appropriate care to avoid poorly fitting models by examining residuals for bias and nonuniform variance and taking corrective measures (see, for example, Draper and Smith 1981, Neter and others 1983).

Step 8: Enter these new equations into an equation library following instructions in Library Editor in BIOPAK users guide (Means and others 1994). You can add them to FUELLIB or build a new library. If you add them to an existing equation library, be sure to avoid existing equation numbers and equation keys.

Third phase: Calculate biomass in fuel size classes-

Step 9: Biomass in fuel size classes can now be calculated by following method 1 or method 2, using data available for the target population as input, and the fuel equation library you just built.

Common and Scientific Names

Plant scientific nomenclature follows Little (1979) for trees and Hitchcock and Cronquist (1973) for shrubs.

big sagebrush	<i>Artemisia fridentata</i> Nutt.
bitter-brush	<i>Purshia tridentata</i> (Pursh) DC.
California black oak	<i>Quercus kelloggii</i> Newb.
greenleaf manzanita	<i>Arctosaphylos patula</i> Green
snowbrush ceanothus	<i>Ceanothus velutinus</i> Dougl. var. <i>velutinus</i>
tanoak	<i>Lithocarpus densiflorus</i> (Hook. & Am.) Rehd.

Acknowledgments

This publication was developed in cooperation with the Aviation and Fire Management Office, Pacific Northwest Region, USDA Forest Service, with additional support from the Deschutes and Malheur National Forests. The authors thank Howard C. Doane and Khalidullah Khan for entering and checking equations in the libraries.

Literature Cited

- Anderson, Hal E. 1982.** Aids to determining fuel models for estimating fire behavior. Res. Pap. INT-122. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 22 p.
- Andrews, Patricia L. 1986.** BEHAVE: fire behavior prediction and fuel modeling system-BURN subsystem Part 1. Res. Pap. INT-194. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 130 p.
- Blonski, Kenneth S.; Schramel, John L. 1981.** Photo series for quantifying natural forest residues: southern Cascades, northern Sierra Nevada. Gen. Tech. Rep. PSW-56. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station. 145 p.
- Brown, James K. 1976.** Estimating shrub biomass from basal stem diameters. Canadian Journal of Forest Research. 6(2):153-153-158.
- Brown, James K. 1978.** Weight and density of crowns of Rocky Mountain conifers. Res. Pap. INT-197. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 56 p.
- Brown, James K.; Snell, J.A. Kendall; Bunnell, David L. 1977.** Handbook for predicting slash weight of western conifers. Gen. Tech. Rep. INT-37. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 35 p.
- Burgan, Robert E. 1987.** Concepts and interpreted examples in advanced fuel modeling. Gen. Tech. Rep. INT-238. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest And Range Experiment Station. 40 p.
- Burgan, Robert E.; Rothermel, Richard C. 1984.** BEHAVE: fire behavior prediction and fuel modeling system-FUEL subsystem. Gen. Tech. Rep. INT-167. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 126 p.
- Cochran, William G. 1977.** Sampling techniques, 3d edition. New York, NY: John Wiley & Sons. 428 p.

- Cooper, Stephen V.; Neiman, Kenneth E.; Roberts, David W. 1991.** Forest habitat types of northern Idaho: a second approximation. Gen. Tech. Rep. INT-236. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 143 p.
- Draper, N.R.; Smith, H. 1981.** Applied regression analysis, 2d edition. New York, NY: John Wiley & Sons. 709 p.
- Halverson, Nancy M.; Topik, Christopher; Van Vickle, Robert. 1986.** Plant association and management guide for the western hemlock zone, Mt. Hood National Forest. R6-Ecol-232A-1986. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 111 p.
- Hemstrom, Miles A.; Logan, Sheila E.; Pavlat, Warren. 1987.** Plant association and management guide. RG-Ecol257-B-86. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Region. 312 p.
- Hilbruner, Michael W.; Wordell, Thomas A. 1992.** User's guide to fuel appraisal. Portland, OR: U. S. Department of Agriculture, Forest Service, Pacific Northwest Region. 119 p. [+ appendices].
- Hitchcock, C. Leo; Cronquist, Arthur. 1973.** Flora of the Pacific Northwest. Seattle, WA: University of Washington Press. 730 p.
- Kauffman, J.B.; Martin, R.E.. 1990.** Sprouting shrub response to different seasons and fuel consumption levels of prescribed fire in Sierra Nevada mixed conifer ecosystems. Forest Science. 36(3): 748-764.
- Little, Elbert L., Jr. 1979.** Checklist of United States trees. Agric. Handb. 541. Washington, DC: U.S. Department of Agriculture, Forest Service. 375 p.
- Maxwell, Wayne G.; Ward, Franklin R. 1976a.** Photo series for quantifying forest residues in the: coastal Douglas-fir-hemlock type, coastal Douglas-fir-hardwood type. Gen. Tech. Rep. PNW-51. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 103 p.
- Maxwell, Wayne G.; Ward, Franklin R. 1976b.** Photo series for quantifying forest residues in the: ponderosa pine type, ponderosa pine and associated species type. Gen. Tech. Rep. PNW-52. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 73 p.
- Maxwell, Wayne G.; Ward, Franklin R. 1980.** Photo series for quantifying natural forest residues in common vegetation types of the Pacific Northwest. Gen. Tech. Rep. PNW-105. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 230 p.
- Martin, R.E.; Frewing, D.W.; McClanahan, J.L. 1981.** Average biomass of four Northwest shrubs by fuel size class and crown cover. Res. Note PNW-374, Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 6 p.
- Means, Joseph E.; Hansen, Heather A.; Koerper, Greg J. [and others]. 1994.** Software for computing plant biomass-BIOPAK users guide. Gen. Tech. Rep. PNW-GTR340. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 184 p.

- Neter, John; Wasserman, William; Kutner, Michael H. 1983.** Applied linear regression models. Homewood, IL: Richard D. Irwin, Inc. 547 p.
- Ottmar, Roger D.; Hardy, Cohn C. 1989.** Stereo photo series for quantifying forest residues in coastal Oregon forests: second-growth Douglas-fir-western hemlock type, western hemlock-Sitka spruce type, and red alder type. Gen. Tech. Rep. PNW-231. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station.
- Ottmar, Roger D.; Hardy, Colin C. 1990.** Stereo photo series for quantifying forest residues in the Douglas-fir-hemlock type of the Willamette National Forest. Gen. Tech. Rep. PNW-258. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station.
- Rittenhouse, L.R.; Sneva, F.A. 1977.** A technique for estimating big sagebrush production. Journal of Range Management. 30: 68-70.
- Sapsis, David B.; Kauffman, J. Boone. 1991.** Fuel consumption and fire behavior associated with prescribed fires in sagebrush ecosystems. Northwest Science. 65(4):173-179.
- Snell, J.A. Kendall; Max, Timothy A. 1985.** Estimating the weight of crown segments for old-growth Douglas-fir and western hemlock. Res. Pap. PNW-329. Portland, OR: U.S. Department of Agriculture, Pacific Northwest Forest and Range Experiment Station. 22 p.
- Steele, Robert; Cooper, Stephen V.; Ondov, David M. [and others]. 1983.** Forest habitat types of eastern Idaho-western Wyoming. Gen. Tech. Rep. INT-144. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 122 p.
- Thompson, S.K. 1992.** Sampling. New York: John Wiley and Sons, Inc. 343 p.
- Uresk, D.W.; Gilbert, R.O.; Rickard, W.H. 1977.** Sampling big sagebrush for phytomass. Journal of Range Management. 30: 311-314.
- Van Wagner, C.E. 1968.** The line intersect method in forest fuel sampling. Forest Science. 14(1): 20-26.

**Appendix
A-Species in the
Fuel Equation
Library, FUELLIB3**

Code	Common name	Scientific name
Shrubs (29 species):		
ACGL	Rocky Mountain maple	<i>Acer glabrum</i>
ALSI	Tag alder	<i>Alnus sifchensis</i>
AMAL	Service berry	<i>Amelanchier alnifolia</i>
ARTR	Big sage brush	<i>Artemisia fridentata</i>
BERE	Creeping Oregongrape	<i>Berberis repens</i>
CEVE	Snowbrush ceanothus	<i>Ceanothus velutinus</i>
COST	Red-osier dogwood	<i>Cornus stolonifera</i>
HODI	Ocean-spray	<i>Holodiscus disco/or</i>
HSHRU	High shrubs, combined data	ACGL, ALSI, AMAL, COST, PRVI, SALIX, SOSC
JUCO	Common juniper	<i>Juniperus communis</i>
LOUT	Utah honeysuckle	<i>Lonicera utahensis</i>
MEFE	Menziesia	<i>Menziesia ferruginea</i>
PHLE2	Mockorange	<i>Philadelphus lewisii</i>
PHMA	Mallow ninebark	<i>Physocarpus malvaceus</i>
PRVI	Chokecherry	<i>Prunus virginiana</i>
RIBES	Gooseberry	<i>Ribes</i> spp.
ROSA	Rose	<i>Rosa</i> spp.
RUID	Red raspberry	<i>Rubus idaeus</i>
RUPA	Thimbleberry	<i>Rubus parviflorus</i>
SALIX	Willow	<i>Salix</i> spp.
SHCA	Soapberry	<i>Shepherdia canadensis</i>
s o s c	Cascade mountain-ash	<i>Sorbus scopulina</i>
SPBE	White spirea	<i>Spiraea betulifolia</i>
SYAL	Common snowberry	<i>Symphoricarpos albus</i>
VAGL	Globe huckleberry	<i>Vaccinium globulare</i>
VASC	Whortleberry	<i>Vaccinium scoparium</i>
Grasses (8 species):		
LUCA2	Field woodrush	<i>Luzula campestris</i>
LUZUL	Woodrush	<i>Luzula</i> spp.
AGROS	Bentgrass	<i>Agrostis</i> spp.

Code	Common name	Scientific name
CARU	Pinegrass	<i>Calamagrostis rubescens</i>
FEAR	Arizona fescue	<i>Festuca arizonica</i>
FESTU	Fescue	<i>Festuca</i> spp.
GRAMI	Grasses	<i>Graminae</i> spp.
MUM0	Mountain muhly	<i>Muhlenbergia montana</i>
POFE	Muttongrass	<i>Poa fendleriana</i>
SILO2	Squirreltail	<i>Sitanion longifolium</i>
Herbs (63 species):		
ADBI	Trail-plant	<i>Adenocaulon bicolor</i>
ADPE	Maidenhair fern	<i>Adiantum pedatum</i>
ANMA	Pearly-everlasting	<i>Anaphalis margaritacea</i>
ARCA	California aralia	<i>Aralia californica</i>
ATFI	Lady-fern	<i>Athyrium felix-femina</i>
BLSP	Deer-fern	<i>Blechnum spicant</i>
CASC2	Scouler's bellflower	<i>Campanula scouleri</i>
CIRSI	Thistle	<i>Cirsium</i> spp.
CIVU	Bull thistle	<i>Cirsium vulgare</i>
CLUN	Queen's cup	<i>Clintonia uniflora</i>
COAS	Goldthread	<i>Coptis asplenifolia</i>
COCA	Bunchberry dogwood	<i>Cornus canadensis</i>
COCA2	Horseweed	<i>Conyza canadensis</i>
COHE	Varied-leaf collomia	<i>Collomia heterophylla</i>
COLA	Cutleaf goldthread	<i>Coptis laciniata</i>
CRCA	Smooth hawksbeard	<i>Crepis capillaris</i>
DRAU2	Spreading wood-fern	<i>Dryopteris austriaca</i>
EPAN	Fireweed	<i>Epilobium angustifolium</i>
EPPA	Autumn willow-herb	<i>Epilobium paniculatum</i>
EPWA	Watson's willow-herb	<i>Epilobium watsonii</i>
EQUIS	Horsetail	<i>Equisetum</i> spp.
GATR	Sweetscented bedstraw	<i>Galium triflorum</i>
GNMI	Cudweed	<i>Gnaphalium microcephalum</i>
GOOB	Rattlesnake-plantain	<i>Goodyera oblongifolium</i>

Code	Common name	Scientific name
GYDR	Oak-fern	<i>Gymnocarpium dryopteris</i>
HAL	White-flowered hawkweed	<i>Hieracium albiflorum</i>
LAP0	Leafy peavine	<i>Lathyrus polyphyllus</i>
LIB02	Twinspur	<i>Linnaea borealis</i>
LOCR	Big deervetch	<i>Lotus crassifolius</i>
LOOB	Lotus	<i>Lotus oblongifolius</i>
LULA	Broadleaf lupine	<i>Lupinus latifolius</i>
MAD12	May-lily	<i>Maianthemum dilatatum</i>
MADIA	Tar-weed	<i>Madia</i> spp.
MIGU	Yellow monkey-flower	<i>Mimulus guttatus</i>
MOUN	Woodnymph	<i>Moneses uniflora</i>
OXOR	Oregon oxalis	<i>Oxalis oregana</i>
PEFR2	Sweet coltsfoot	<i>Petasites frigidus</i>
PERA	Leafy lousewort	<i>Pedicularis racemosa</i>
POMU	Sword-fern	<i>Polystichum munitum</i>
PTAQ	Bracken	<i>Pteridium aquilinum</i>
PYSE	Sidebells	<i>Pyrola secunda</i>
RUPE	Five-leaved bramble	<i>Rubus pedatus</i>
SEJA	Tansey ragwort	<i>Senecio jacobaea</i>
SESY	Wood groundsel	<i>Senecio sylvaticus</i>
SETR	Arrowleaf groundsel	<i>Senecio triangularis</i>
SMST	Starry Solomon's seal	<i>Smilacina stellata</i>
STC04	Cooley's hedge-nettle	<i>Stachys cooleyae</i>
THOC	Western meadowrue	<i>Thalictrum occidentale</i>
TITR	Trefoil foamflower	<i>Tiarella trifoliata</i> var. <i>trifoliata</i>
TRLA	Twin clover	<i>Trifolium latifolium</i>
TRLA2	Western starflower	<i>Trientalis latifolia</i>
WISE	Evergreen violet	<i>Viola sempervirens</i>
WHMO	Whipplevine	<i>Whipplea modesta</i>
XETE	Beargrass	<i>Xerophyllum tenax</i>

Appendix B- Example of Method 1

Run this example through BIOPAK to help understand method 1 by using the files provided on the BIOPAK fuel disk. This example assumes access to the BIOPAK users guide and software (Means and others 1994) and familiarity with its operations such as that obtained by running the tutorials in the users guide. *Italic text indicates sections in the BIOPAK users guide.*

Steps 1, 2 and 3: Jeff and Grace, ecologists along the west side of the Cascade Range in Oregon, determined that fire behavior in plant communities with dense growth of tall shrubs in the recent Sunny Beach Fire was not predicted well by BEHAVE (Andrews 1986). With lots of help from fire behavior analysts, they concluded that the fuel model used did not adequately include the live fuels contributed by tall shrubs. (This is an important judgment and you may disagree.) They decided to build a new fuel model that would include better estimates of live shrub fuels. They knew this vegetation type occurred throughout their district on low elevation sites. Their next step was to read *Suggestions for Using BIOPAK* in the BIOPAK users guide.

Steps 4a-4c: Based on their extensive experience with this type, they identified five locales for sampling where this type was common and that spanned their Calapooya National Forest. They knew the high cover of tall shrubs in this type did not differ greatly and decided to collect data for six plots at each locale and from a total of 30 plots. They knew plants were densely packed and chose 16-square-meter plots because they would always contain at least three tall shrubs.

Step 4d: They determined the shrub species important as live fuel and noted that fuel equations are available for very few of these species. They decided, for many of their species, to use equations for Rocky Mountain species they judged to be of similar form and thus assumed would have similar relations between measured plant dimensions and biomass of fuel classes. They then started BIOPAK, selected the library editor, brought in FUELLIB3, examined the *Original and Final Equations Window* and determined (most of) the plant measurements required by the fuel equations for these species (they missed on one species).

Step 5: Jeff and Grace sampled five stands, each having six plots of 16-square-meters, collecting data needed by BIOPAK and other data needed to build a complete fuel model for this type as described by Burgan and Rothermel (1984; Burgan 1987). This took 1 week.

Step 6: Jeff entered the data in a spreadsheet and produced an ASCII file as described in *Input Data File* with data in fixed-width fields. As they tried to make estimates they noted the crown length and width measurements they had taken for COCO¹ were not used by any equations for species (such as ALSI or SALIX) with form similar to COCO. So they went back to their plots and measured diameter at the base of all COCO. They wished they had determined the equations they wanted to use (step 4d) more carefully before field sampling. Part of the data from their final input data file (JEFFGRAC.DAT), for two plots, is shown:

¹ Codes for plant species are defined in appendix A.

Plot	Micro plot	Species code	Diameter at the base of the stem	Length of the crown (horizontal)	Width of the crown
				- - - - - Centimeters - - - - -	
5	1	HODI	1.1		
5		HODI	2.7		
5		c o c a	5.0	240	230
5	1	c o c a	1.4	70	90
5		VAPA	1.4		
5		VAPA	0.6		
5		c o c a	6.1	200	220
5		HODI	2.4		
5		HODI	1.1		
5	2	HODI	2.7		
5	2	RHMA	3.7		
5	2	COCO	1.6	70	60
5	2	COCO	2.8	80	99
5	2	VAPA	1.9		
5	2	VAPA	1.6		
5	2	COCO	1.9	60	50
5	2	COCO	2.3	90	80
5	2	VAPA	1.1		
5	2	VAPA	1.8		
5	2	HODI	2.8		
5	2	HODI	2.2		
5	2	HODI	2.5		
5	2	RHMA	3.9		
5	2	COCO	4.9	30	30

Step 7: Grace used the *Design a Run* section of BIOPAK to specify the format of their data, request calculations for 1-hour, 10-hour and 100-hour fuels (FS1, FS2, and FS3, respectively, in BIOPAK), and request use of equations for other species by *Equation Reassignments*. Grace produced a *Run Design Report* (JEFFGRACRDR) by selecting this on the File Menu in *Design a Run*. You can see the results of her work by examining JEFFGRACRD in the *Design a Run* module of BIOPAK or the ASCII file JEFFGRAC.RDR.

Step 8: Grace then used the *Calculate Plant Components* module to link their input data file (JEFFGRAC.DAT), run design file (JEFFGRAC.RD), and equation list file from the fuel equation library (FUELLIB3.EQN) to calculate the plant components and put them in an intermediate binary file (JEFFGRAC.IBF) with estimates of fuel biomass.

Step 9: Grace used the Generate Reports module of BIOPAK to produce a report formatted for people. The results for one stand are in JEFFGRAC.RPT. The results for the first plot are:

TITLE: Shrub fuels, W. Cascade Tall Shrub fuel type Page 2

PLOT	STAND	LOCALE	FIRST PLANT ID	DATE	Slope	Area	Conversion	Factor
1	5				0.0%	625.00		

Fixed Plot Area Size = 16.00 (m2)

Prism Basal Area Factor = 0.00 (m2/ha)

----- -- -- INDIVIDUAL PLANT REPORT -----

Case	PLANT ID	L Specie	Parameter(s)			G	S	FUELS	FUELS	FUELS
		F	DBA	LEN	WID	A	S	100 HOUR	10 HOUR	1 HOUR
								(g)	(g)	(g)
1		S HODI	1.1DBA	0.0	0.0	W	M	0.00N	26.99	19.60
2		S HODI	2.7DBA	0.0	0.0	W	M	0.00N	619.03V	186.99V
3		s COCO	5.0DBA	240.0len	230.0wid	W	M	132.141	359.32i	213.75Vi
4		s COCO	1.4DBA	70.0len	90.0wid	W	M	0.00hi	54.34i	16.88i
5		S VAPA	1.4DBA	0.0	0.0	w	M	0.00GL	51.77i	24.69i
6		S VAPA	0.60e+0DBA	0.0	0.0	W	M	0.00GL	0.00im	3.21i
7		s COCO	6.1 DBA	200.0len	220.0wid	W	M	190.971	452.50i	317.77Vi
8		S HODI	2.4DBA	0.0	0.0	w	M	0.00N	410.44v	139.10V
9		S HODI	1.1DBA	0.0	0.0	W	M	0.00N	26.99	19.60

Error messages:

G NO EST: Reass match. Spp/LF/Comp not satisfied in EQN file.
 L NO EST: Reass match. Maximum ESP (Equation Selection Penalty) exceeded.
 N NO EST: No match for Request to Lib in .EQN since Spp/LF/Comp not found at any ESP
 V WARNING: Over extrapolation occurred.
 h WARNING: Under extrapolation occurred.
 i INFORM: No LF in data, LF came from Reassign: Taxonomic LF of Substit section.
 m INFORM: A plant component value <= 0.0 was calculated and set to zero.

----- PLOT SUMMARY REPORT, PLOT =1 -----

L Specie	Number	Parameter(s)			Number	Tree	FUELS	FUELS	FUELS
F	Plants	DBA	LEN	WID	of	BA	100 HOUR	10 HOUR	1 HOUR
	in	average			plants	(m2)	(kg)	(kg)	(kg)
	PLOT					per	hectare		
S COCO	3	4.2	170.0	180.0	1875	0.0	201.95h	541.35i	342.75V
S HODI	4	1.8	0.0	0.0	2500	0.0	0.00N	677.15V	228.30V
S VAPA	2	1.0	0.0	0.0	1250	0.0	0.00G	32.36i	17.44i
S All	9	2.4	170.	180.0	562	0.0	201.95	1250.86	588.49
Grand Tot	9	2.4	170.0	180.0	5625	0.0	201.95	1250.86	588.49

Error messages:

See individual plant report above

Step 10: Using methods described by Burgan (1987) Jeff combined their estimates of live fuel loading with other data they collected to produce the new fuel model they wanted for the tall shrub vegetation type.

Appendix C-Forms

We provide a field form for plant measurements on the next two pages. Items in bold *italics* are required in order for BIOPAK to give valid estimates. Most fields *in the* heading are optional and are included for use as appropriate. Locale code and date code are examples and can be used as identifiers of a record or group of records; in particular, they do not have to stand for locale and date. Slope is needed for BIOPAK to provide correct areal estimates. Only the first eight characters of codes (six for species) will be read by BIOPAK.

The first plant measurement column is given the heading "Cover," a common plot-level plant measurement. It can be changed and used for any other measurement.

For many plants and species, one line of data is needed for each plant. When cover is recorded for a species, however, usually only one line is recorded for each plot.

Be sure to specify the units for plot area, slope, elevation, and all plant measurements. Allowable plant measurements (that is, parameters) are given in BIOPAK users guide (Means and others 1994), *Reference: input Data File: Parameters*. Units can be either English or metric, provided they are from the list allowed by BIOPAK as given in *Appendix: Units: Parameter Units: Input Data File-*.

Field Sheet for Plant Measurements for BIOPAK [ver. 10/30/95]

Locale: Big Summit Prairie, West				Date: 950815			Page 1 of 2			
Locale code: BigSumW				Personnel: M. Lewis and A.C. Clarke						
For/Dist: Ochoco, Big Summit				Plot area: 200 sqft			1 Aspect: 90		Elev: 2000 ft	
Veg type: bitterbrush-sage/fescue					Veg code: PutrArtr			Topo: sideslop		
Notes: From jct of 25 and 63 roads, go 2.4 mi. E. to culvert. Walk 250 yards due north to white PVC pipe at center of circular plot. Width is mean crown diameter. Ht is mean crown height. DBA is diam at base of stem.										
Identifiers					Plant Measurements (Equation Parameters)					
Stand	Plot	Slope %,	Species	Life- form	Cover %	Ht in	Width in	CrnRat %	DBA in	
4	20	15	PUTR			50	35	100		
4	20		ARTR			90	80	50		
4	20		FESTU		21					
4	20		PUTR			70	43	60		
4	20		PUTR			60	70	80		
4	21	10	ARTR			84	75	40		
4	21		ARTR			20	20	20		
4	21		FESTU		40					
4	21		PUTR			100	84	30		
4	21		CELE						0.5	
4	21		CELE						1.7	
4	21		CELE						3.7	

This page is an example of a filled-out field sheet with plant measurements. Page 21 contains a blank field sheet to copy for field use.

THIS PAGE LEFT BLANK INTENTIONALLY

Means, Joseph E.; Krankina, Olga N.; Jiang, Hao; Li, Hongyan. 1996. Estimating live fuels for shrubs and herbs with BIOPAK. Gen. Tech. Rep. PNW-GTR-372. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 21 p.

This paper describes use of BIOPAK to calculate size classes of live fuels for shrubs and herbs. A library of equations to estimate such fuels in the Pacific Northwest and northern Rocky Mountains is presented and used in an example. These methods can be used in other regions if the user first enters fuel size-class equations for a given region into a new library by using the library editor supplied with BIOPAK. Fuel size classes can be estimated in three ways: (1) When appropriate plant measurements are available, fuel classes can be estimated directly for species that have equations in the library or species with similar growth forms. (2) When appropriate plant measurements are not available, fuel classes can be estimated in two steps, first by estimating total aboveground biomass for individual plants and then by estimating biomass in fuel classes from total aboveground biomass. (3) The equations provided can be used to develop new equations that estimate fuels from plot-level estimates of species cover (and possibly other measures).

Keywords: Live fuels, fuel size classes, software, plant biomass, Pacific Northwest, northern Rocky Mountains.

The Forest Service of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.

The United States Department of Agriculture (USDA) prohibits discrimination in its programs on the basis of race, color, national origin, sex, religion, age, disability, political beliefs, and marital or familial status. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means of communication of program information (Braille, large print, audiotape, etc.) should contact the USDA Office of Communications at (202) 720-2791.

To file a complaint, write the Secretary of Agriculture, U.S. Department of Agriculture, Washington, DC 20250, or call (800) 245-6340 (voice), or (202) 720-1127 (TDD). USDA is an equal employment opportunity employer.

Pacific Northwest Research Station
333 S.W. First Avenue
P.O. Box 3890
Portland, Oregon 97208-3890

U.S. Department of Agriculture
Pacific Northwest Research Station
333 S.W. First Avenue
P.O. Box 3890
Portland, OR 97208-3890

Official Business
Penalty for Private Use, \$300

do NOT detach label