Consume 3.0 User's Guide

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Abstract

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Consume is a user-friendly computer program designed for resource managers with some working knowledge of Microsoft Windows® applications. The software predicts the amount of fuel consumption, emissions, and heat release from the burning of logged units, piled slash, and natural fuels based on weather data, the amount and fuel moisture of fuels, and a number of other factors. Using these predictions, the resource manager can accurately determine when and where to conduct a prescribed burn or plan for a wildland fire for use to achieve desired objectives while reducing impacts on other resources. Consume can be used for most forest, shrub and grasslands in North America and may be applicable to other areas of the world.

Keywords: Prescribed burning, woody fuel consumption, duff consumption, fuel moisture, smoke emissions, piled fuels.

Cooperative Acknowledgment

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About This User's Guide

Welcome to Consume 3.0. Consume is a user-friendly computer program that calculates fuel consumption, emission of pollutants, and heat release for resource managers who manage fires and smoke emissions in forest and rangelands. This User's Guide is divided into ten parts:

Overview. Describes general features of Consume and a review of updates in Consume 3.0.

Quick Reference. Summarizes key information to help you begin using Consume.

Basics. Presents basic information you will need to know to use Consume, such as installation basic navigation and getting help.

Recording and Managing Data. Provides information on data files.

Creating Reports and Graphs. Describes how to create reports and graphs.

Interpreting Reports and Graphs. Describes the different kinds of reports and graphs generated by Consume and how to interpret them.

Using Consume in Batch Mode. Details how you can run Consume in a command-line environment.

References. Lists literature cited in this manual.

Appendix A: Tips and Cautions. Points out helpful tips and cautions that may save you time.

Appendix B: Troubleshooting. Describes error messages and helps diagnose problems.

Appendix C: Scientific Background. Provides scientific background for Consume, including documentation of major equations.

Glossary: Defines key words used in this manual and Consume.

Conventions

This manual uses the following conventions:

Menu selections, buttons, and dialog box names are shown in bold text. For example, “Select the **File** menu.”

Commands you type from the keyboard are shown in *italics*. For example, “Enter *Test Unit 1* as the name of the trial burn unit”

Key names are shown in SMALL CAPS. For example, “Press the ESC key to exit Consume.”

Key combinations are shown separated by a hyphen (-). For example, “press SHIFT-F1” means hold down the SHIFT key and press F1.

“Click” refers to pressing the primary mouse button (Usually the left mouse button).

“Double click” refers to pressing the primary mouse button twice.

“Right click” refers to pressing the secondary mouse button.

Contents

Overview

Land managers use prescribed fire and wildland fire for use to maintain and restore ecosystems, reduce fuel loadings, expose mineral soil, improve wildlife habitat, and reduce the hazard of wildfire. In the past, a fire that consumed most of the organic material on a site was thought to have met management objectives. As understanding of forest ecosystems has increased, forest managers have become more discriminating in their use of prescribed fire and managing wildland fire. Fires are now applied to satisfy forestry management objectives and benefit forest ecosystems as a whole.

Consume is a decision-making tool designed to assist you in planning for prescribed fire, wildland fire for use, and wildfire. Consume can help you achieve your burn objectives and assess impacts on air quality, water, and other resources.

How Can Consume Help Me?

Consume predicts fuel consumption, pollutant emissions, and heat release based on a number of factors including fuel characteristics and environmental conditions. Using these predictions, you can determine when and where to conduct a prescribed burn or plan for a wildland fire to achieve desired objectives, while reducing the impact on other resources.

To obtain the most reliable results, you should consider calculating the actual acres burned rather than the total project area. With the exception of canopy and shrub fuels, in which you may specify the percentage of canopy loading consumed and the percentage of acres blackened respectively, Consume assumes burn coverage of 100%.

For example, if a management objective for a harvested unit with logging slash was to retain an average duff depth of two inches on the unit, the manager could use Consume to determine the 1000-hour fuel moisture at which a burn could take place and meet the objective.

Another management objective might be to produce less than 100 tons of particulate matter not exceeding 2.5 micrometers in diameter (PM2.5) from a prescribed burn. By adjusting fuel and weather input variables, the manager could determine whether the prescribed burn will meet the 100-ton objective.

What Updates Have Been Added to Consume v 3.0?

Natural Fuel Consumption Algorithms

FERA recently completed a series of fuel consumption trials in the boreal, southern, and western regions of the United States. Empirical models were developed using the consumption trial data and are now incorporated in the natural fuels consumption algorithms of Consume 3.0. There are now four equation sets in Consume 3.0:

- Activity fuels (mostly unchanged from Consume 2.1),
- Natural fuels - Boreal,
- Natural fuels – Southern, and
- Natural fuels – Western.

Users specify an equation set in Consume by specifying the fuelbed type (activity or natural) and the ecoregion of their specific fuelbed. Equations for estimating consumption from piles are unchanged from Consume 2.1.

Organization

To better reflect actual management strategies, Consume 3.0 is organized hierarchically into projects. Projects are saved into four user-specified categories: planned, active, completed and archived. These categories are for informational purposes only. Each project contains one more burn units. Burn units are further divided into multiple fuelbeds (Figure 1). The majority of specific fuelbed information is managed at the fuelbed level.

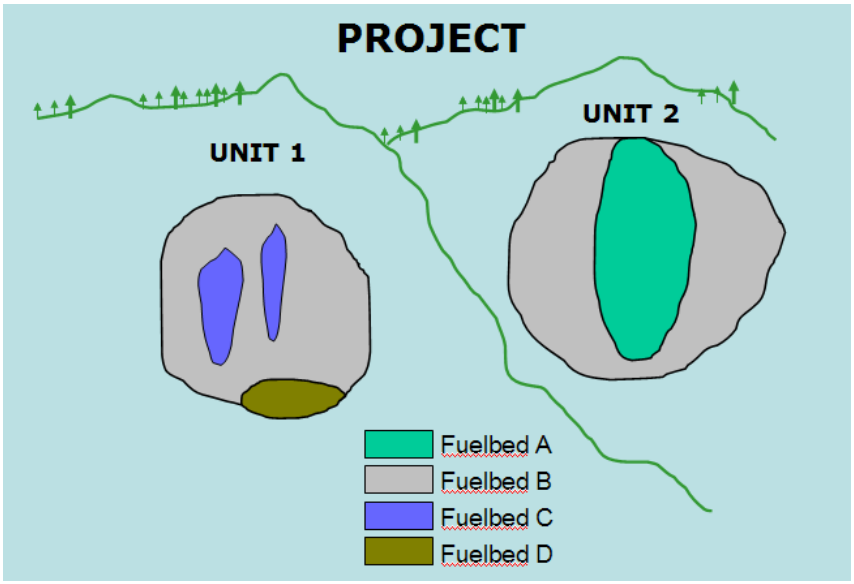

Figure 1: Conceptual diagram of the hierarchical organization of projects, units, and fuelbeds.

FCCS Fuelbeds

The **Fuel Characteristic Classification System** (FCCS), released by the FERA team in August 2005 (www.fs.fed.us/pnw/fera/fccs), was developed in coordination with Consume 3.0 and exports fuel loadings files to Consume**.** The **FCCS** contains a fuelbed reference library and calculates a wide range of fuel characteristics. Fuelbed loading values can be either imported from the **FCCS** or custom-made by Consume users. In both software applications, fuelbeds are organized into six strata from canopy fuels to ground fuels (Figure 2). Many fuelbeds do not contain every stratum and category. For example, a grassland fuelbed would be comprised of nonwoody vegetation but may not contain canopy and shrub information.

Fuelbed Stratum		**Fuelbed Category**
CANOPY		**Trees, Snags, Ladder Fuels**
SHRUBS		**Shrubs**
NONWOODY		**Grasses & Herbs**
WOODY		**Sound & Rotten Wood, Stumps, Woody Fuel Accumulations (Jackpots, Piles & Windrows)**
LITTER-LICHEN-MOSS		**Litter, Ground Lichen & Moss**
GROUND FUELS		**Duff, Basal Accumulations, Squirrel Middens**

Figure 2: Fuelbed strata and categories in a vertical arrangement from canopy to ground fuels.

How Do I Use Consume?

Follow these basic steps to use Consume:

1. Establish a project: Identify a project area with associated burn units and fuelbeds. Designate the project as planned, active, or completed and assign start and end dates to the project.

2. Enter unit and fuelbed data: Gather and enter data about each burn unit and the fuelbeds within each unit. For more information about specific unit and fuelbed data to gather, see "Recording and Managing Data".

3. Enter weather zone data (activity fuels only): For activity (logged or thinned forestland) fuelbeds, Consume predicts consumption and emissions based on measured or calculated 1000-hour fuel moisture. Consume can calculate an adjusted 1000-hr fuel moisture based on input weather zone and daily weather information. Weather zones should cover the entire area where the fuelbeds are located. For information about the specific weather zone data to gather, see "Recording Weather Zone Data." For more information about the specific data to gather, see "Recording Data."

4. Calculate consumption and emissions: Create reports to find optimal dates for conducting prescribed burns, allowing wildland fires to burn, or to determine the quantity of fuels that will be consumed and emissions produced on given dates or at given fuel moistures. For more information about the reports you can create, see "Creating Reports and Graphs" and "Interpreting Reports and Graphs."

5. Update and make changes to existing data as necessary: For more information about making changes see "Recording and Managing Data."

What Data Do I Enter?

Consume calculates consumption and emissions for activity and natural fuels. Different algorithms and assumptions are available to add flexibility in data requirements (e.g., activity fuel consumption may be based on either a measured, or predicted initial 1000-hour fuel moisture, and natural fuel consumption may be predicted from three regions of North America). Appendix C contains complete technical information about Consume. Basic data to complete Consume calculations are entered into the following data entry screens:

- The **Project screen** records general information about your project, including start and end dates, your organization, project status (Active, Completed or Planned) and the calculated size of the project area.

- The **Unit** screen records information about the specific units you will be burning, including the permit number, burn date, treatment type, treatment completion confirmation, tabulated unit size and number of fuelbeds.

- The **Fuelbed** screen is divided into a fuelbed environment screen and a multi-tabbed fuelbed stratum screen containing fuel loadings and/or dimensions by stratum (including canopy, shrub, nonwoody, woody, litter-lichen-moss layers, and ground fuels).

- The **Weather zone data** screens record information about areas that have similar weather characteristics. Weather zone data are *only* required for activity fuelbeds for which 1000-hour fuel moisture content is not known and needs to be predicted. Weather Zones include initial fuel moisture, relative humidity, latitude, temperature, and other factors.

How Does Consume Analyze Data?

Once you have entered project, unit, fuelbed, and weather data, Consume can predict the quantity of fuels that would be consumed and the resulting pollutants generated from a prescribed burn or wildland fire. The consumption algorithms Consume uses depend on whether fuelbeds are defined as activity or natural; natural fuels are further divided into three regional equation sets including the western, southern, and boreal regions of North America.

Activity Fuel Algorithms

Activity Fuel Consumption

Consume uses individual algorithms to predict consumption of each stratum within activity fuelbeds (Ottmar *et al.* 1993). The Canopy, Shrub, and nonwoody strata equations are the same in both activity and natural fuelbed calculations. For small woody fuels less than 3 inches in diameter (1-, 10- and 100-hour fuels), fuel loading, slope, wind speed, and 10-hour fuel moisture are used to predict consumption.

The most important factor in determining consumption of large woody fuels greater 3 inches in diameter is 1000-hour fuel moisture (1000-Th). There are three ways to enter 1000-hr FM in Consume. You may enter a measured value directly, use the NFDRS-1000-hour (NFDRS-Th) value (Deeming *et al.* 1977), or predict the adjusted 1000-hour (ADJ-Th) value based on daily weather information. Measured 1000-hour fuel moisture is the best predictor of fuel consumption. Adjusted 1000-hour fuel moisture is nearly as good a predictor as the measured value and superior to the NFDRS 1000-hour value (Sandberg and Ottmar 1983).

Consume treats piled and non-piled woody fuels separately. Please see the “Pile Algorithms” section for a description of pile calculations.

Major variables that control duff consumption include woody fuel consumption, diameter reduction, preburn duff depth, and duff moisture content. Because actual duff moisture content is difficult to measure, Consume classifies duff as wet, moist, or dry based on days since significant rainfall. The duff consumption algorithm is divided into separate regimes for wet, moist, and dry duff.

During a burn, the rate of smoke production changes throughout the three phases of combustion. Less smoke is produced per ton of fuel consumed during the efficient flaming stage than during the smoldering and residual smoldering phases of combustion. Consume uses 100-hour (i.e., 1 to 3 inch) fuel consumption and large (i.e., > 3 inches) woody fuel flaming diameter reduction to estimate consumption during the flaming phase of the woody fuels and duff. The smoldering consumption is estimated by subtracting the flaming consumption from the total consumption. Residual smoldering consumption is assumed to equal to smoldering consumption.

Activity Fuel Emissions

Emissions by pollutant (PM, PM_{10}, $PM_{2.5}$, CO, CO_2, CH_4, and NMHC) are calculated by multiplying fuel consumption by the appropriate emission factor. Emissions for flaming, smoldering, and residual phases of combustion are calculated individually then summed to calculate total emissions.

Appendix C provides information about Consume algorithms and associated equations.

Pile Algorithms

The term “Pile” is used generically in Consume to represent any woody fuel accumulation, created from timber harvesting or other management activities or though natural processes. Consume pile algorithms apply to all woody fuel accumulations created in activity or natural fuelbeds. Piles are organized into pile groups in the Woody stratum of each fuelbed. Each pile group has one or many piles of the same dimensions, packing ratio, and soil content.

Pile Consumption

Consume calculates pile consumption for each designated pile group and sums pile group consumption for total pile consumption. Consume uses a model developed by Hardy (1996) to calculate consumption of fuels from pile fires. Unlike non-piled fuels, pile consumption is not directly dependent upon fuel diameter. The major factors in determining consumption are:

- Gross pile volume.
- Net woody biomass volume.
- Wood density, measured or weighted average.
- Consumable oven-dry mass.
- Percentage of wood mass consumed.

Pile Emissions

Pile emissions calculations are limited to total particulate matter due to a lack of data on other pollutants and emissions by combustion phase. The mass of emissions produced by a burning pile is calculated by multiplying the mass of fuel consumed by an emission factor for $PM_{2.5}$, PM_{10}, and PM. Emission factors for these particle sizes depend on the pile quality rating; cleaner piles burn more efficiently than dirty piles.

Appendix C provides more detailed information about Consume pile algorithms and the equations that are used.

Natural Fuels Algorithms

Natural Fuel Consumption

Consume uses three different sets of algorithms, based on empirical data from the boreal, southern, and western regions of North America to predict consumption of natural fuels. Fuel consumption is calculated for the six strata in each fuelbed. Equations vary by stratum.

Default equations are used for the canopy, shrub, and nonwoody strata and calculate consumption by combustion phase for each stratum.

Woody fuel algorithms are divided into Southern and Western regional equation sets. Due to a lack of data on woody fuel consumption in boreal forests, boreal fuelbeds are treated as Western forests in woody fuel calculations. Total woody fuel consumption is predicted from pre-burn fuel loadings and/or fuel moistures, including 10-hr, 1000-hr and duff fuel moisture. Total woody fuel consumption is then partitioned into flaming, smoldering, and residual phases of combustion. Consume treats piled and non-piled woody fuels separately. Please see the "Pile Algorithms" section for a description of pile calculations.

To calculate litter, lichen, moss and duff consumption, Consume calculates an overall forest floor reduction based on the three regional datasets: boreal, southern, and western. Overall forest floor reduction is then partitioned into litter, lichen, moss and duff reduction and then converted into total consumption and consumption by combustion phase. Consumption of other ground fuels, including squirrel middens and basal accumulation, is estimated from equations adapted from the forest floor reduction models.

Natural Fuel Emissions

Emissions by pollutant (PM, PM_{10}, $PM_{2.5}$, CO, CO_2, CH_4 and NMHC) are calculated by multiplying fuel consumption by the appropriate emission factor. Emissions for flaming, smoldering, and residual phases of combustion are calculated individually then summed to calculate total emissions.

Appendix C contains more detailed information about Consume natural fuel algorithms and the equations that are used.

What Results Do I Get?

Consume results are presented in several printable reports:

- The **Consumption and Emissions Screen** summarizes consumption, emissions, and heat release for a selected project, unit, or fuelbed.
- The **Consumption by 1000-hour Fuel Moisture Report** displays the quantity of fuels that would be consumed in burns at different values of 1000-hour fuel moisture (only applicable to activity fuelbeds).
- The **Consumption by Combustion Phase Report** displays the quantity of fuels that would be consumed in the flaming, smoldering, and residual phases of a burn and total fuel consumption. The report details consumption data by fuelbed stratum and category.
- The **Emissions by 1000-hour Fuel Moisture Report** displays the quantity of emissions from a burn at different values of 1000-hour fuel moisture (only applicable to activity fuelbeds).

- The **Emissions by Stratum Report** summarizes pollutant emissions from a burn for each fuelbed stratum in selected projects, units, and fuelbeds.

- The **Emissions by Combustion Phase Report** displays the quantity of emissions of a selected pollutant that would be released in the flaming, smoldering, and residual phases of a burn and total pollutant emissions. The report details emissions data by fuelbed stratum and category.

- The **Heat Release by Combustion Phase Report** displays the quantity of heat that would be released from a burn in the flaming, smoldering, and residual phases of a burn. The report details heat release data by fuelbed stratum and category.

Consume provides graphical options for viewing consumption and emissions over a range of 1000-hr fuel moistures. Graphs can be viewed in Microsoft Excel or exported as a comma delimited file to be used in a different graphics program.

- The **Consumption by 1000-hr Fuel Moisture Graph - by Stratum** allows users to view how consumption of selected fuelbed strata varies over a specified range of 1000-hr fuel moistures. Users may select total fuel consumption in addition to the six fuelbed strata to be viewed in each graph.

- The **Consumption by 1000-hr Fuel Moisture Graph – by Project / Unit / Fuelbed** allows users to view how consumption varies over an input range of 1000-hr fuel moisture and differs between a project, units and fuelbeds. Users may select total consumption or one or all of the six fuelbed strata to be viewed as separate graphs.

- The **Emissions by 1000-hr Fuel Moisture Graph – by Pollutant** allows users to view how emissions of selected pollutants vary over a specified range of 1000-hr fuel moistures.

- The **Emissions by 1000-hr Fuel Moisture Graph – by Project / Unit / Fuelbed** allows users to view how emissions of a selected pollutant vary between a project, units and fuelbeds.

Consume can also provide reports that summarize the data you entered:

- The **Input Data Report** displays user input data for selected projects, units, and fuelbeds.

- The **Weather Zone Report** summarizes weather zone and daily weather observation inputs.

You will find detailed information about viewing, saving, printing and exporting reports in "Creating Reports” and “Interpreting Reports."

Quick Reference Guide

CONSUME QUICK REFERENCE

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Mode of Operation	Consume operates in one of two modes: Consume is in browse mode unless you choose to enter edit mode. Browse mode allows you to view information and move from one selection to another. When you change any information on a screen, Consume automatically switches to edit mode. Edit mode is indicated by the presence of the **Cancel Changes** or **Save** buttons in place of the **Calculate Consumption and Emissions** and **Reports** buttons at the bottom right of the screen. When you are in edit mode, you cannot leave the screen you are editing or use the navigation tree until you save or cancel any changes.
Using the navigation tree	All entry screens can be opened from the navigation on the left side of the Consume main screen. To select an item in the navigation tree, simply click on the item. The corresponding screen will appear in the main window. The navigation tree is visible at all times but cannot be accessed if you are editing a project, unit, fuelbed or weather data screen. Items in the navigation tree can be moved by dragging and dropping them into new locations or by using copy, cut, and paste commands. Items may be deleted by clicking on individual items and selecting **Delete** from the **File** menu.
Copying items in the navigation tree	To make a copy of an existing project, unit and/or fuelbed: 1) Click on the item in the navigation tree. Select **Copy** from the **Edit** menu or press CTRL-S. 2) Click on a parent item in the navigation tree. For example, if you are copying a project, click on a Project Category or if you are copying a unit, click on a project. Copying an item to the same location will create a copy of that item. 3) Select **Paste** from the **Edit** menu or press CTRL-V.
Moving items in the navigation tree	To move an item in the navigation tree you may either drag and drop the item to a new location or: 1) Click on the item in the navigation tree. Select **Cut** from the **Edit** menu or press **CTRL-X**. 2) Click on a parent item in the navigation tree. For example, if you are moving a project, click on a project category or if you are moving a unit, click on a project. 3) Select **Paste** from the **Edit** menu or press **CTRL-V**.

CONSUME QUICK REFERENCE

	Quick Reference Guide, page 2 of 3
Project organization	Projects are organized into four categories: Planned, Active, Completed, or Archived. Each project may contain multiple units that in turn can contain multiple fuelbeds.
Projects	A project consists of one ore more units that are organized and managed as a single endeavor by an organization. To create a new project, click on a project category in the navigation tree, select **New Project** from the **File** menu, and enter a project name.
Units	A unit encompasses the area where a prescribed fire or wildland fire has occurred or will occur. Each unit contains one or more fuelbeds to be burned together. To create a new unit in a project, click on the project, select **New Unit** from the **File** menu and enter a unit name.
Fuelbeds	A fuelbed is an area of similar fuel characteristics within a unit. Each fuelbed is described by environmental variables and six fuel layers called strata. To create a new fuelbed in a unit, click on the unit, select **New Fuelbed** from the **File** menu and enter a fuelbed name.
Weather zones	Weather zone data are rarely required in Consume; users who wish to calculate adjusted 1000-hr fuel moistures of activity fuels must enter data in weather zones. To create a new weather zone, click on Weather zone in the navigation tree, select **New Weatherzone…** from the **File** menu and enter a weather zone name.
Reports and Consumption and Emissions buttons	You may access the Reports screen by clicking the **Reports** button in the bottom right of the main screen. The **Consumption and Emissions** button is active only if you have selected a valid project, unit, or fuelbed in the navigation tree, and are in browse mode.
Editing data	To edit data, click on the white input variable box and change the value. The program will switch to edit mode and display the **Cancel changes** and **Save** buttons to remind you that you are in edit mode. You must cancel changes or save your work to leave the screen.

CONSUME QUICK REFERENCE

	Quick Reference Guide, page 3 of 3
Saving / Canceling Changes	To save changes to a new or edited input screen, click on the **Save** button or select **Save** from the **File** menu. Consume will notify you of any errors. If you have errors, you may save your work or continue editing. However, consumption and emissions can not be calculated for invalid projects, units, or fuelbeds that contain errors.
Consumption and Emissions	To calculate consumption for a valid project, click the **Consumption and Emissions** button or the **Reports** button. The Consumption and Emissions screen provides a summary of consumption and emissions for the item selected in the navigation tree. The screen will automatically change to whatever item you select in the navigation tree. For example, you may wish to view summary information for an entire project and then view individual unit and/or fuelbed information.
Selecting and viewing reports	Click on the **Reports** button to open the Reports screen. 1) Select a report from the Select Report/Graph list. 2) Select a valid project from the project list and any combination of units and fuelbeds within that project. 3) Most reports require that you specify units. Under Report Units, click on English or Metric units and specify the units and whether or not to divide the results by unit area.
Selecting and viewing graphs	Graphs are selected in the same manner as reports. Click on the Reports button to open the Reports screen. 1) Select one of the four 1000-hr fuel moisture graphics options from the Report/Graph list. 2) Under Graph Parameters, enter a range and increment of 1000-hr fuel moistures. 3) In the Values to Plot box, select which strata you would like to graph. 4) Under report units, click on English or Metric units and specify the units and whether or not to divide the results by unit area. 5) You may click the Export to Text File button and use a graphics program of your choosing to plot the results or click the Excel button to view the graphs in Microsoft Excel. You must have Excel installed on your computer for this to work.
Printing reports and graphs	To print a report, click on the printer icon at the top of the Reporting screen. To print a graph in Excel, click on the graph and select **Print** from the **File** menu or click on the printer icon in the tool bar.

Basics

This chapter introduces you to the basic information you need in order to use Consume, including:

- Installing and upgrading Consume and using the Consume sample dataset.
- Starting and exiting Consume.
- Overview of the Consume screens and how to use them.
- Backing up and restoring data

System Requirements

You can install Consume on a personal computer with the following system:

- 30 MB of available disk space.
- Microsoft Windows® 2000 or XP operating systems or other operating systems if using Consume in batch mode.
- Optional requirement: Consume links to Microsoft Excel for viewing 1000-hour fuel moisture graphs. If you do not have Excel on your computer, Consume will run but will not support this graphics feature.

Administrative Privileges

If you do not already have administrative privileges on your computer, you must obtain them before installing Consume 3.0. To check if you have administrative privileges, click on the clock at the bottom right of your desktop. If you are allowed to change the date and time on your computer, you already have administrative privileges. If you do not, please contact your system administrator for assistance.

Downloading and Installing Consume 3.0

Consume 3.0 has a flexible design and can be run in Microsoft® Windows or in a simple batch mode for use in other operating systems. The Consume calculator engine was written in Java to allow it to be used in batch mode. The Java implementation for the Windows interface was done using Microsoft® J#.Net. J# requires an extra run-time environment, called the Visual J#.NET Redistributable 1.1. In order to run Consume in Microsoft Windows®, it is necessary to have both Microsoft Framework .NET v 1.1 and Visual J#.NET installed on your computer. Most computers will already have the Microsoft Framework .Net v1.1, but Visual J#.NET will need to be installed on most computers.

The best way to check if you have the necessary Microsoft Windows updates is to try installing Consume 3.0. You will receive detailed error messages if you need to install Microsoft Framework.NET version 1.1 and/or Visual J# .NET. To download and install the necessary updates, you may either follow the on-screen instructions provided by Microsoft® or the instructions provided later in this installation guide.

To Download and Install Consume 3.0:

1) Go to the Consume website: http://www.fs.fed.us/pnw/fera/research/smoke/consume/index.shtml .
2) Under the Consume 3.0 software download, double-click **Setup.msi**.
3) From the File Download dialog box, click **Save to Disk**. Depending on your internet connection speed, the file download may take a few minutes.
4) Once the download is complete, double-click on the file **Setup.msi** to launch the installation process.
5) Follow the on-screen instructions to install Consume 3.0.

   You will receive detailed error messages if you need to install Microsoft Framework.NET v. 1.1 and/or Visual J# .NET v 1.1. To download and install the necessary updates, you may either follow the on-screen instructions provided by Microsoft® or the following sections of this user's guide.

Installing Microsoft® Framework .NET version 1.1 Redistributable Package:

Most Microsoft® Windows 2000 and XP operating systems should have a working version of Microsoft.NET. If your computer does *not* have Microsoft.NET v.1.1, follow these installation instructions:

1) Connect to the internet (a high speed connection is recommended).
2) Go to: http://www.microsoft.com/downloads .
3) Under "Popular Downloads," click on **.NET Framework Version 1.1 Redistributable Package**. If you cannot locate the link under Popular Downloads, type ".NET Framework Version 1.1" under "Search" and then click on **.NET Framework Version 1.1 Redistributable Package** in the search results.
4) Click **Download**.
5) In the File Download dialog box, click **Save to Disk**.
6) Once the download is complete, double-click on the file **dotnetfx.exe** to launch the installation process.
7) Follow the on-screen instructions to complete the installation.

   If your operating system already has Microsoft Framework .NET v1.1 installed, you will get an error message during this installation process. Cancel this installation and proceed to Installing Microsoft® J#.Net Redistributable Package version 1.1.

Installing Visual J#.NET Redistributable Package version 1.1:

Most Microsoft® Windows 2000 and XP operating systems will *not* have Visual J#.NET v 1.1. If your computer does *not* have Visual J#.Net v 1.1, follow these installation instructions:

1) Connect to the internet (a high speed connection is recommended).
2) Go to: http://msdn.microsoft.com/vjsharp/downloads/howtoget/default.aspx .

3) Click **Download Microsoft® Visual J#.NET Redistributable Package 1.1**.
4) Click the **Download** button.
5) In the File Download dialog box, click **Save to Disk**.
6) Once the download is complete, double-click on the file **vjredist.exe** to launch the installation process.
7) Follow the on-screen instructions to complete the installation.

If your operating system already has Microsoft Visual J#.NET 1.1, you will get an error message during the installation process. Cancel this installation and proceed to the Consume 3.0 download and installation.

Instructions for Beginning Consume Users

When you first use Consume, it will display instructions for beginning Consume users.

- Click the **Continue to Consume** button to use the program
- To hide this message, click on the check box next to "Click here if you do not want to see this message again". You may restore the message at any time by clicking Show Entry Screen under Tools → Options → Administrative Information.

Using Sample Data

Consume includes some sample projects and weather zones. Before you use Consume to create your own projects and weather zones you can use these data to try out Consume and see how it works.

For example, you can use the examples to view and modify existing data and create reports.

When you are ready to start using Consume to enter your own data, you can delete the sample projects and weather zones. For more information about deleting records, see “Recording and Managing Data.”

Upgrading from Previous Versions

Consume does not include the ability to import data from versions 1.0 or 2.1. Because the configuration of the program has changed and updated algorithms require more data, information from the previous version would not be sufficient to create a complete and valid project in the new version.

Daily weather information may be imported electronically from any Weather Information Management System (WIMS) data set. (See "Importing Daily Weather".)

Opening Consume

You may open Consume from the Windows® **Start** menu or by double-clicking on the Consume 3.0 icon on your desktop.

To start Consume:

1. Click on the Windows **Start** button.
2. Select the **Programs** menu.
3. Click on the Consume menu choice to open the Consume entry screen.
4. Click **Next** to proceed to the program.

Exiting Consume

If you have not made any unsaved changes, the application will simply close. If you exit Consume while in the edit mode, the application will prompt you to save or cancel your changes.

To exit Consume:

From any main Consume screen, click on the **File** menu, then **Exit.** You may also click on the upper right X in the Consume screen to exit the application. If you have unsaved changes the application will ask you whether you wish to save the changes.

- Click **Yes** to save the changes and exit;
- Click **No** to a discard the changes and exit; or
- Click **Cancel** to return to Consume.

Getting Help

You can get help from many places in Consume by pressing F1. Consume displays a Help screen with specific information about that part of the application.

More general help can be obtained from the help menu.

To use the help menu:

Select the **Help** menu. There are two options:

About provides technical data about the version of Consume and support contacts.

Index lists specific help topics and access the User's Guide online. To use the index, click on a desired topic to view.

Quick Keys

Type the following keys or key strokes to activate quick keys:

File menu: ALT-F *	**New item: ALT-F N**
	Exit: ALT-F X
	New item: CTRL-N
	Save: CTRL-S
Edit menu: ALT-E	**Cancel changes: CTRL-Z**
	Cut: CTRL-X
	Copy: CTRL-C
	Paste: CTRL-V
Tools menu: ALT-T	
Help menu: ALT-H	**Context-sensitive help: F1**
Loading calculators	**F2 (**cursor must be on cell associated with a loading calculator)

* Note: to view quick key stroke commands in menus, press ALT.

Navigating Consume Screens

Most screens can be directly accessed using the navigation tree to the left of the main screen. The navigation tree works similarly to Microsoft Windows Explorer. You may drag and drop items within the tree and use cut, copy and paste commands. Clicking on items in the tree will open screens for viewing. To view a particular project, unit, or fuelbed, for example, simply click on that item in the navigation tree.

When you first begin to use Consume, follow these steps to create a new Project.

1) Click on a Project Category in the navigation tree (Planned, Active, Completed, Archived).

2) Select **New Project…** from the **File** menu to create a new project.

3) Enter a Project Name.

4) Click on your project in the navigation tree and select **New Unit…** from the **File** menu to create a new unit.

5) Click on the unit in the navigation tree and select **New Fuelbed…** from the **File** menu to create a new fuelbed.

You may create as many units and fuelbeds as you need within a particular project.

Please see "Recording and Managing Data" for screen-by-screen instructions. The Fuelbed screen contains detailed environmental and fuels information that are necessary to calculate consumption and emissions. Referring to this Users Guide or Consume's online help will be particularly useful as you navigate the Fuelbed screen for the first time.

The following Quick Start Guide provides some basic information for navigating and using Consume.

Overview of Consume Screens

The following overview will help you navigate Consume. Please see Recording and Managing Data for detailed screen-by-screen instructions for entering data, calculating results and interpreting reports.

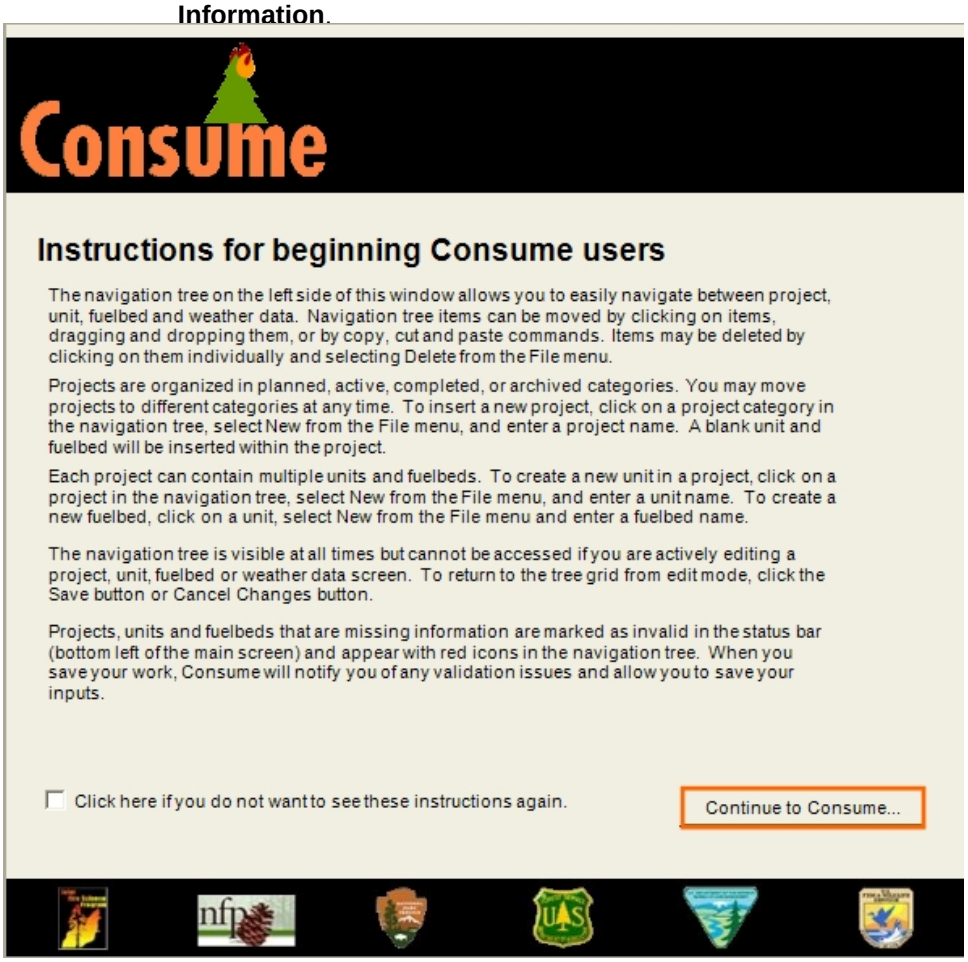
Welcome to Consume

When you open Consume, the first screen you will see is the Consume Welcome Screen. Photos of prescribed burns throughout North America area displayed on this screen along with contact information for FERA and logos of our main sponsors and collaborators. Click **Next** to enter the program. Click the **Help** button to open the online help system

Instructions for Beginning Consume Users

When you first open Consume, it will display instructions for beginning Consume users. Click the **Continue to Consume** button to use the program. To hide this message in the future, click on the check box next to "Click here if you do not want to see this message again".

You may restore the message at any time by clicking Show Entry Screen under **Tools → Options → Administrative Information**.

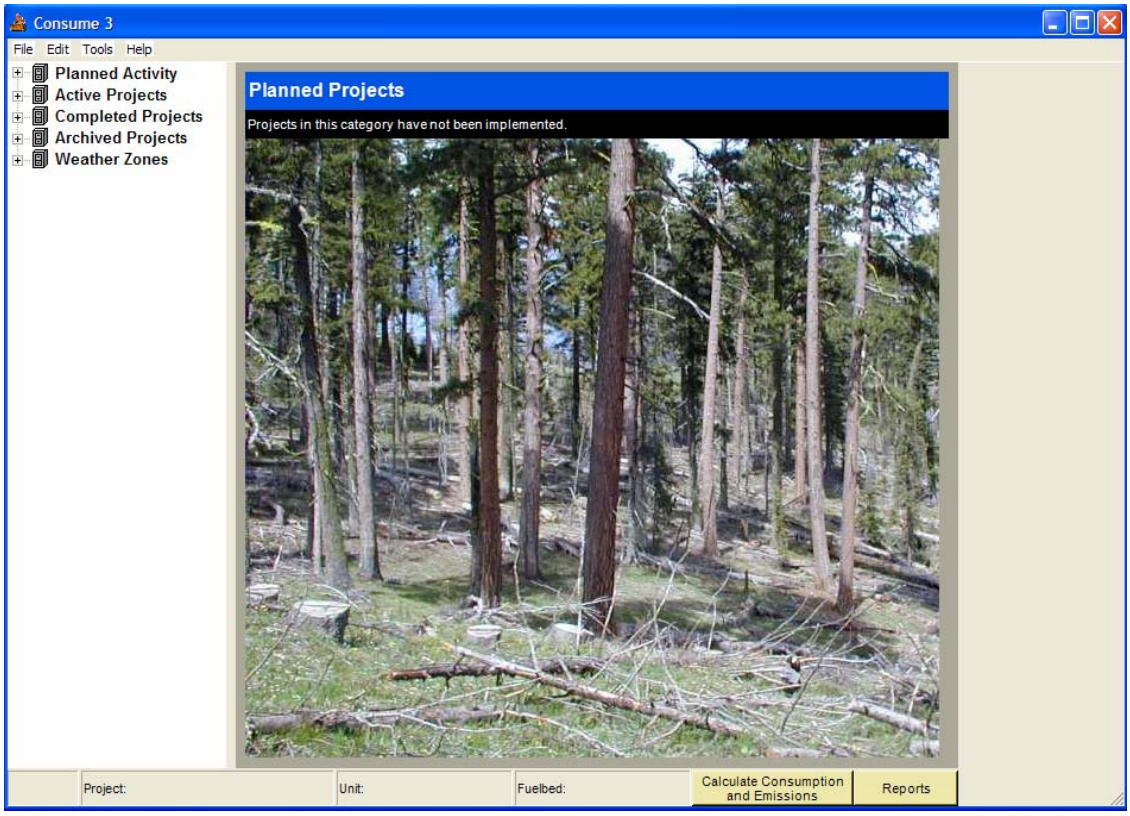


Main Window

The main window is the entry point for all Consume activities. To enter into Project, Unit and Fuelbed screens, use the navigation tree at the left side of the main window. Projects are organized into four categories:

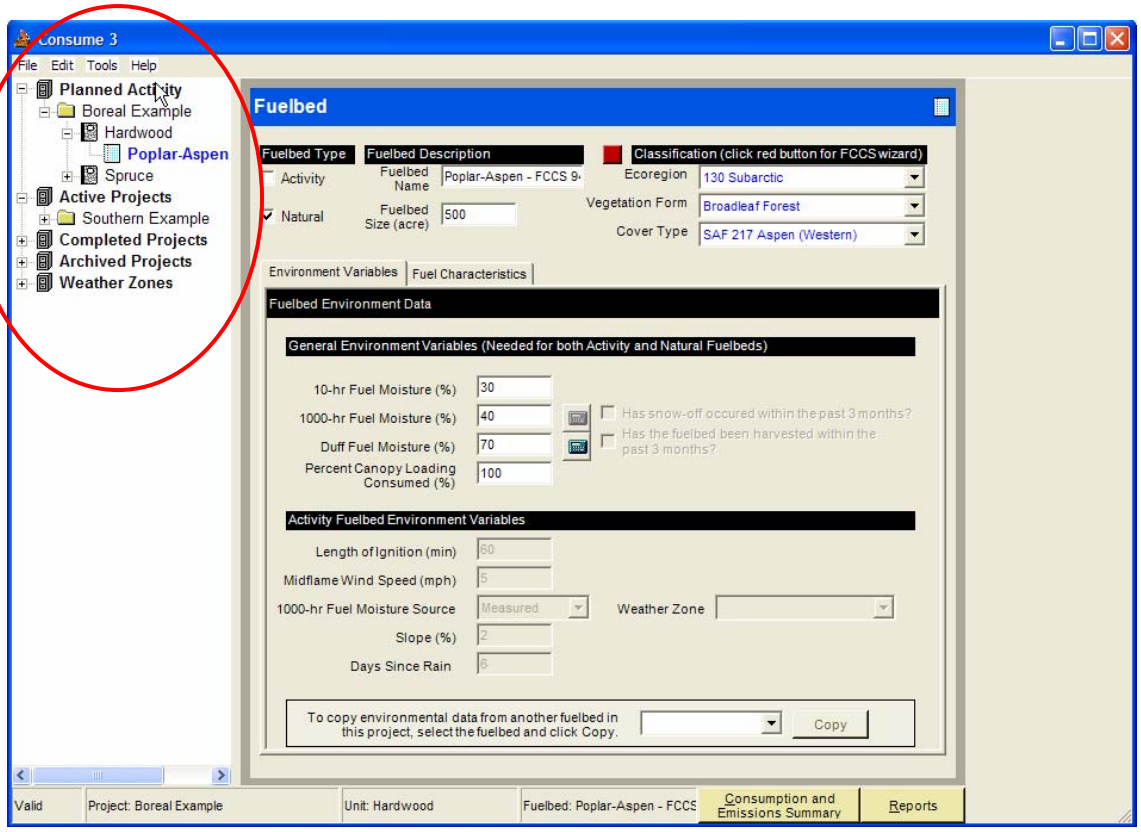
- Planned activity: projects that have not been implemented.
- Active projects: projects that are currently undergoing burn treatments
- Completed projects: projects that have recently completed all burn treatments.
- Archived projects: projects that have completed all burn treatments and are now part of a project archive.

Click on a project category to view existing projects or create a new project.



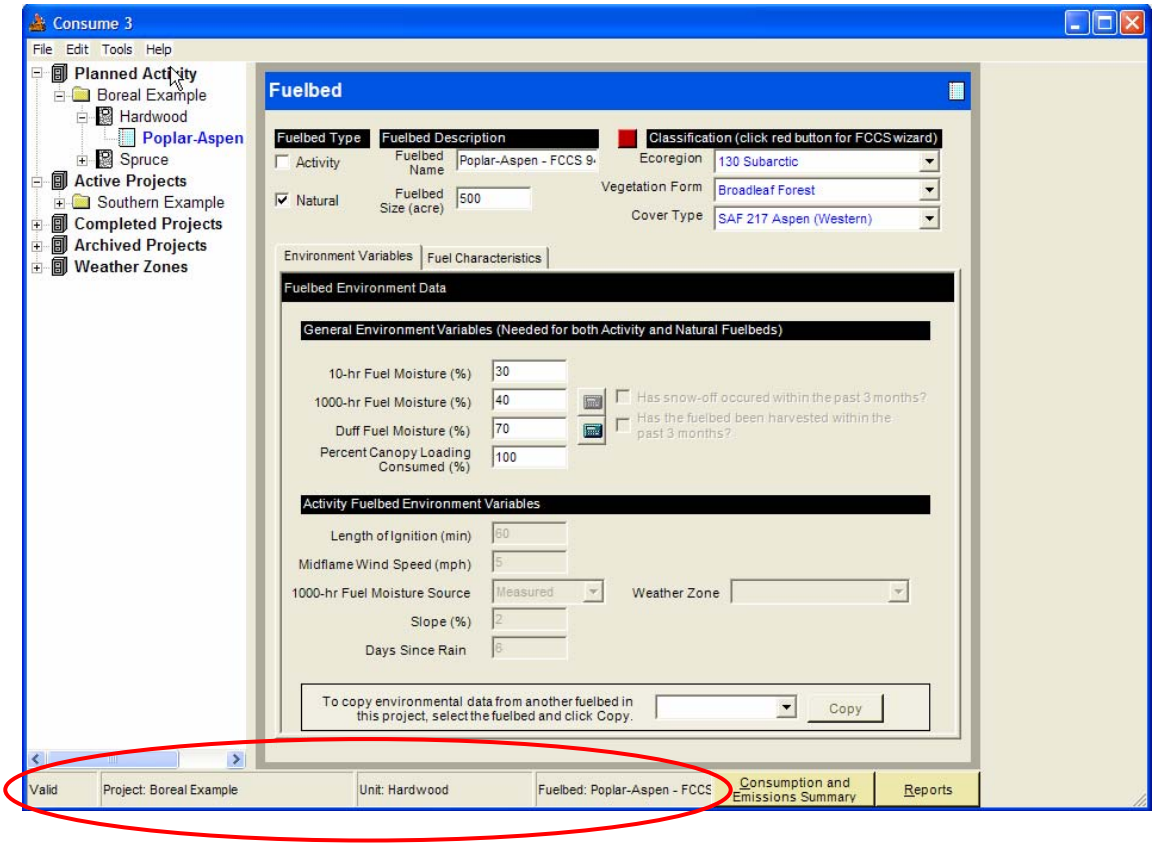
Navigation Tree

All entry screens can be opened from the navigation tree on the left side of the main screen (circled below). To select an item in the navigation tree, simply click on the item. The corresponding screen will appear in the main window. The navigation tree is visible at all times but cannot be accessed if you are editing a project, unit, fuelbed or weather data screen. To return to the navigation tree, save or cancel your changes.



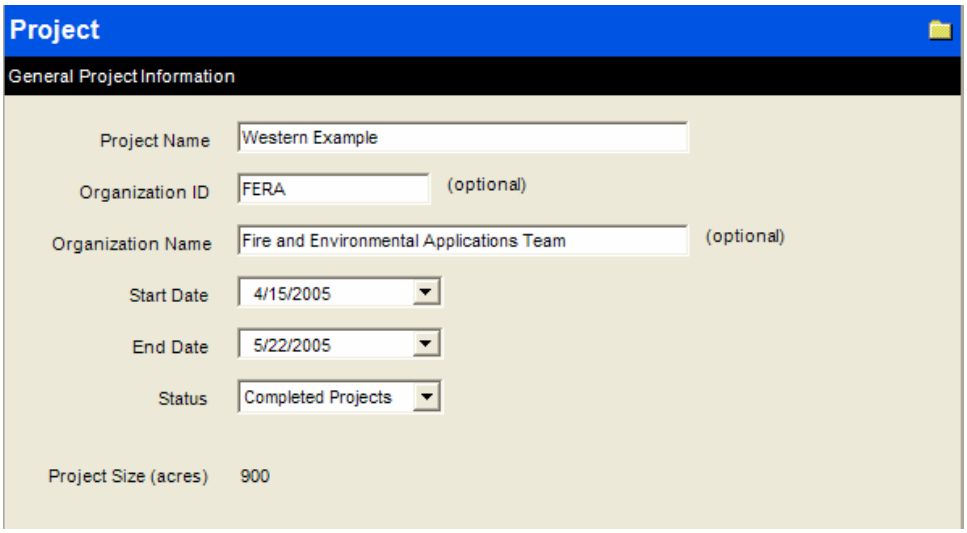
Status Bar

The status bar is located at the bottom of the main window (circled below) and tells you what you are viewing from the navigation tree. If you have selected a fuelbed, the status bar will list if it is valid or invalid, the project name, unit name and fuelbed name.



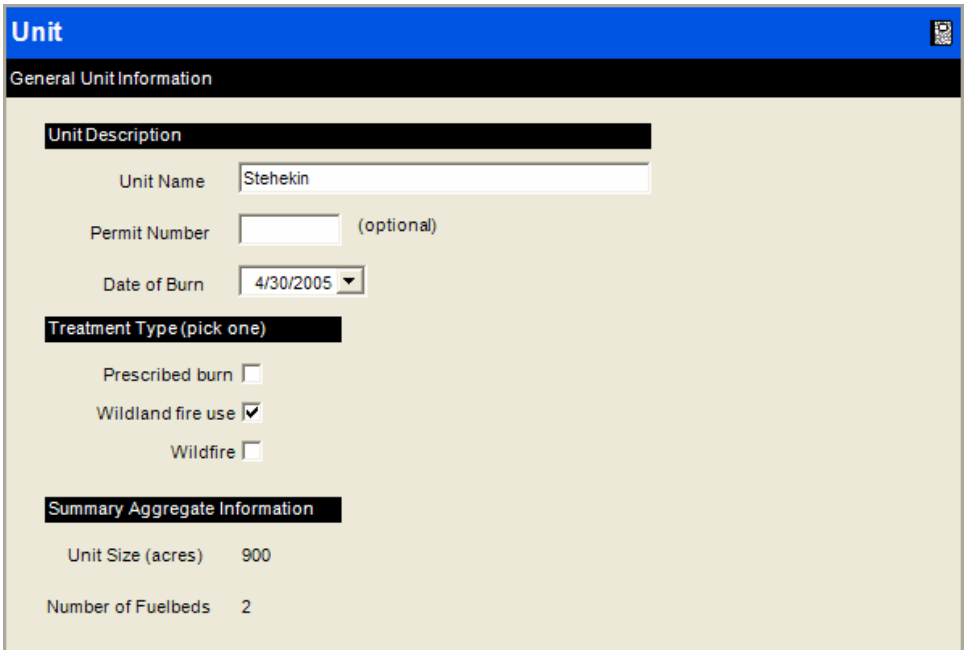
Project Screen

The project screen records basic information about your project including the project name, organization ID, organization name, start date, end date, project status (planned, active, completed or archived) and total project size (acres).



Unit Screen

The unit screen records basic information about your burn unit including the unit name, permit number, burn date, treatment type (prescribed burn, wildland fire use or wildfire), total unit size (acres) and number of fuelbeds in the unit.

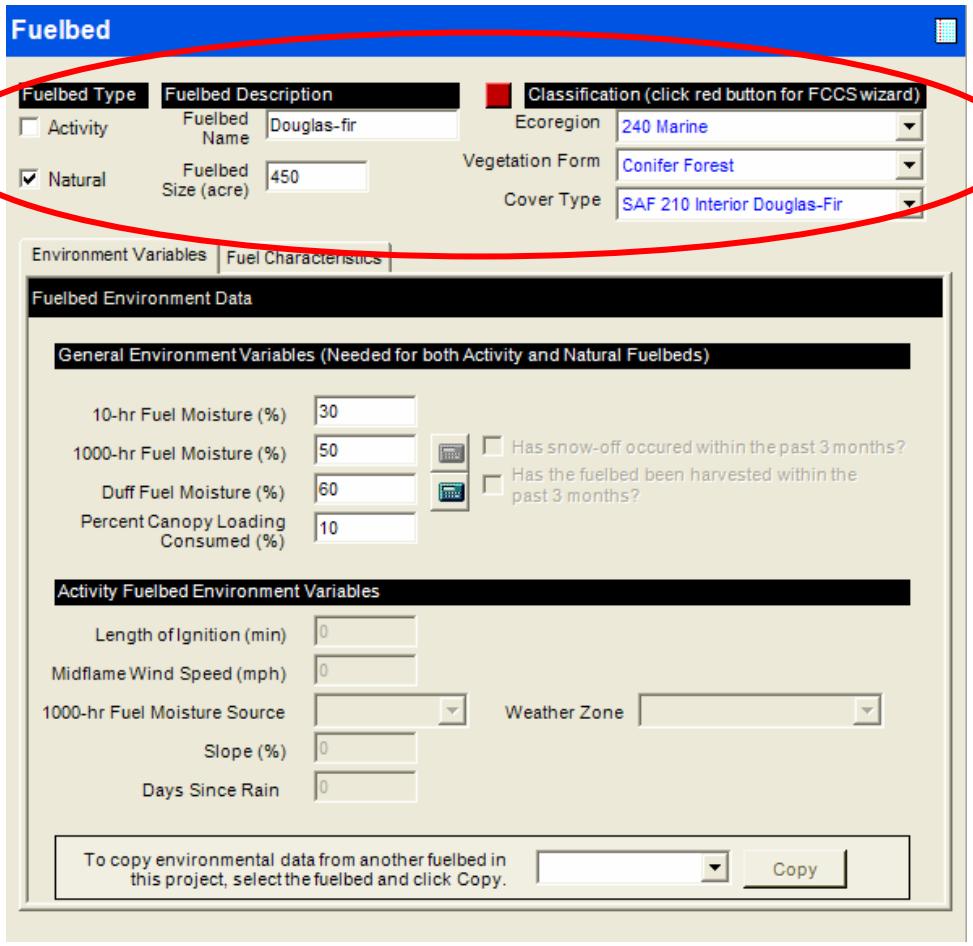


Fuelbed Screen

The fuelbed screen is divided into three main sections:

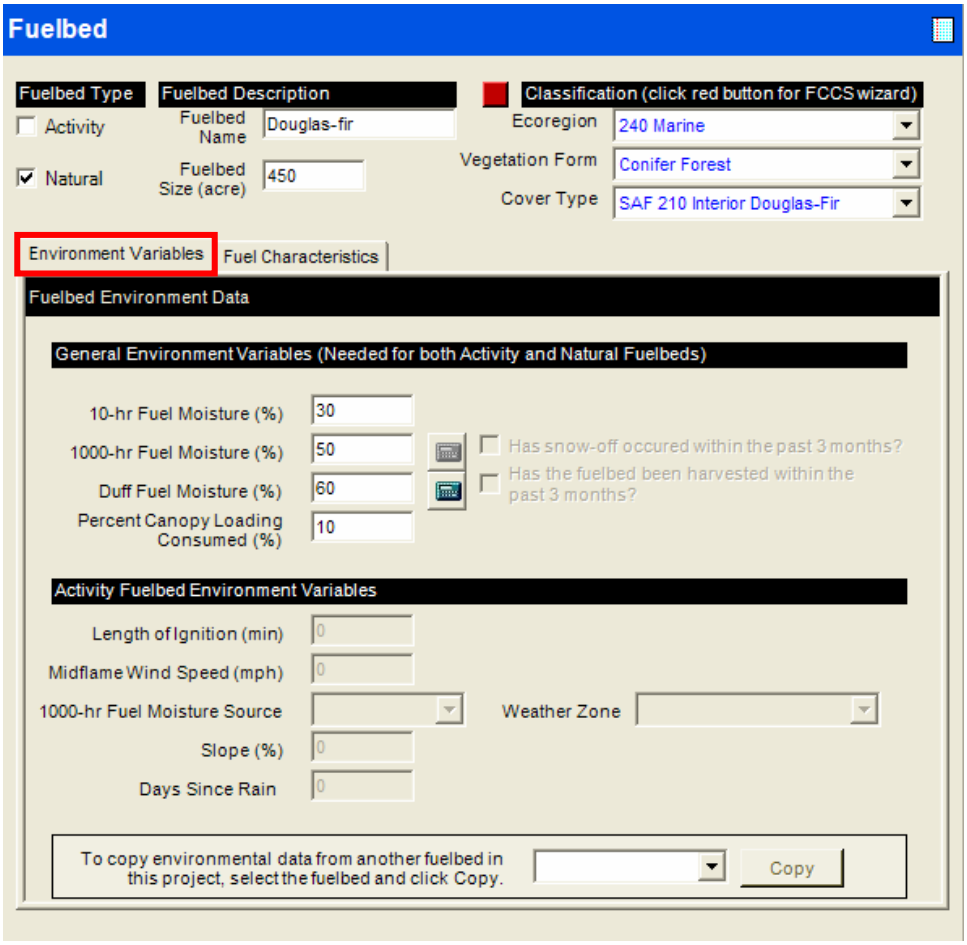
General fuelbed information

The upper third of the fuelbed screen is visible at all times and contains general fuelbed information including fuelbed type, fuelbed description and fuelbed location data using Bailey's ecoregion division (Bailey 1998), vegetation form and cover type. The FCCS wizard (described below) is accessible by clicking the red button to the left of FCCS Information.



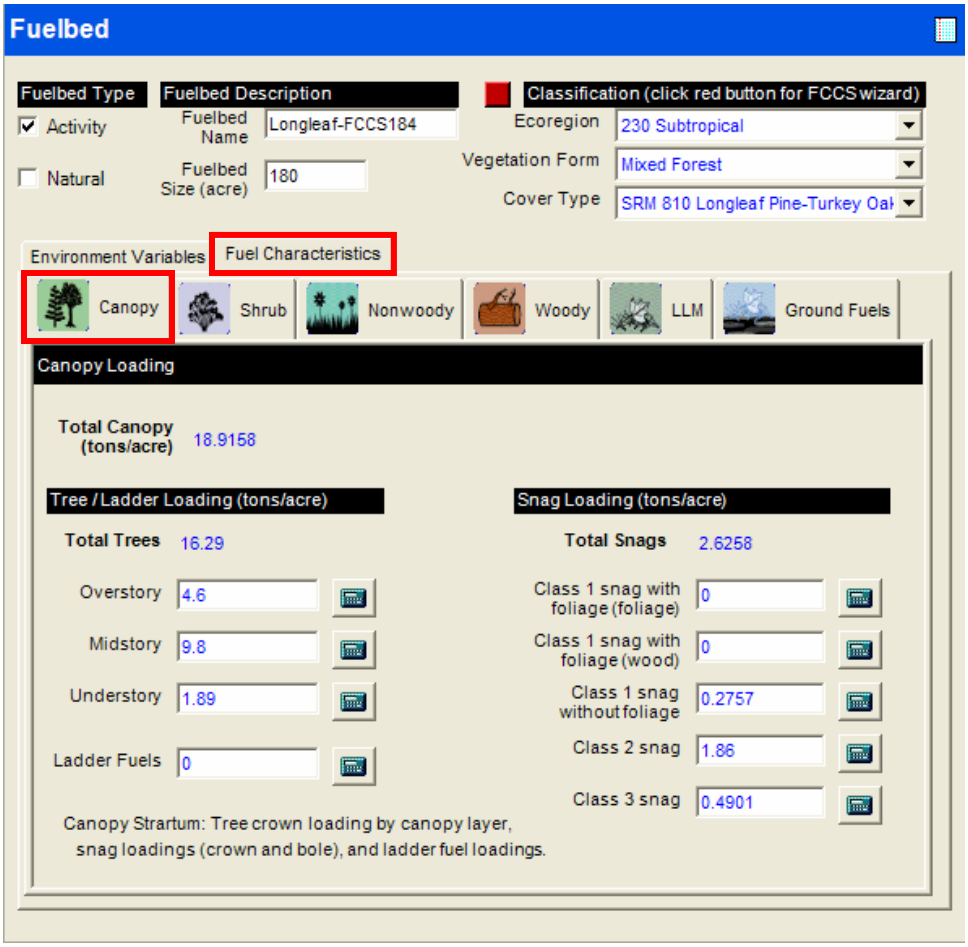
Environmental variables page

The environmental variables page records environmental data necessary to perform consumption and emissions calculations. The General Environmental Variables section records inputs required for all calculations. The Activity Fuelbed Environmental Variables section records input required only for activity fuel calculations.



Fuel characteristics page

The fuel characteristics page records fuel loadings and dimensional data in separate tabs for the canopy, shrub, nonwoody vegetation, woody fuels, litter-lichen-moss and ground fuels strata. See “Recording and Managing Data” for more detailed data entry instructions.



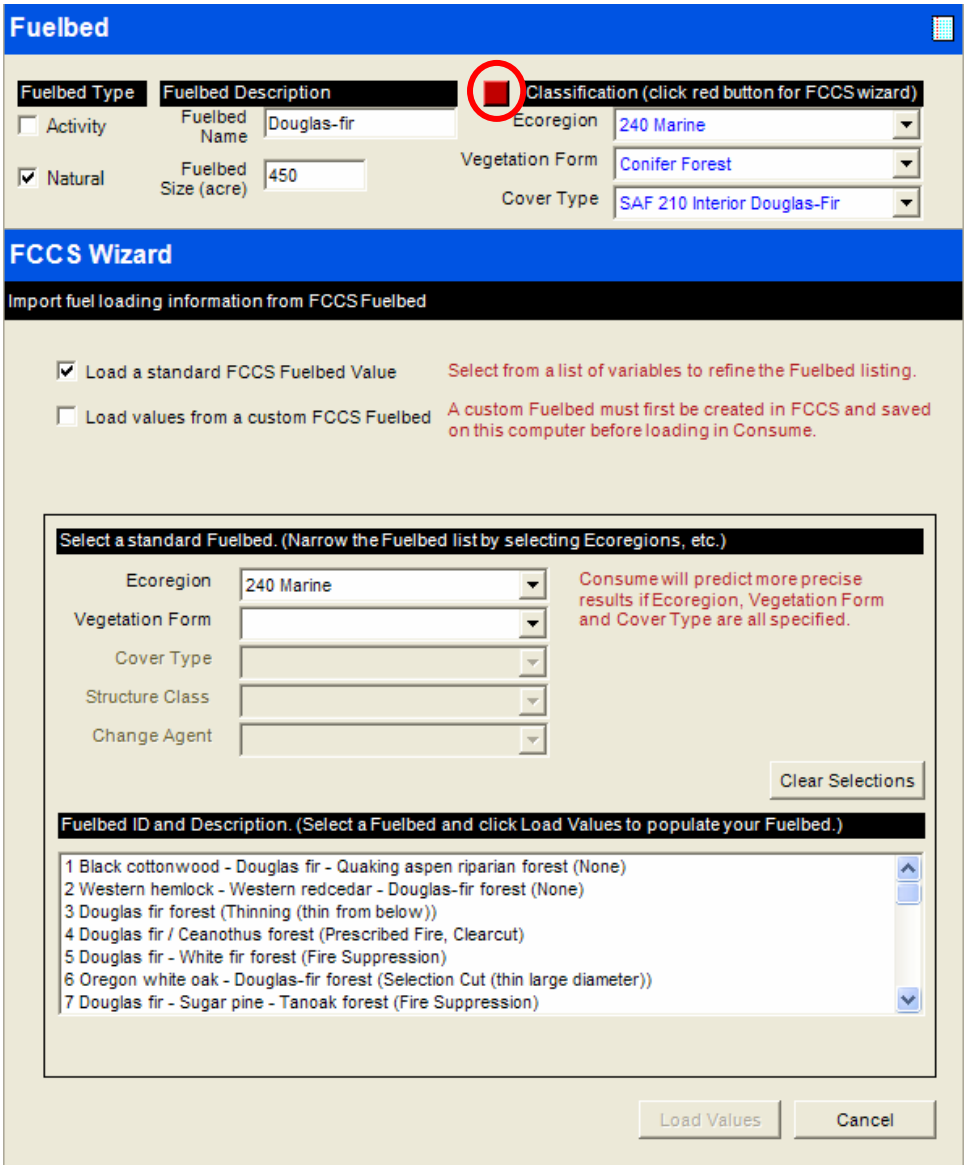
FCCS Wizard

You can use the **FCCS wizard** to import fuel characteristics data from the Fuel Characteristics Classification System (FCCS).

To enter the FCCS Wizard:

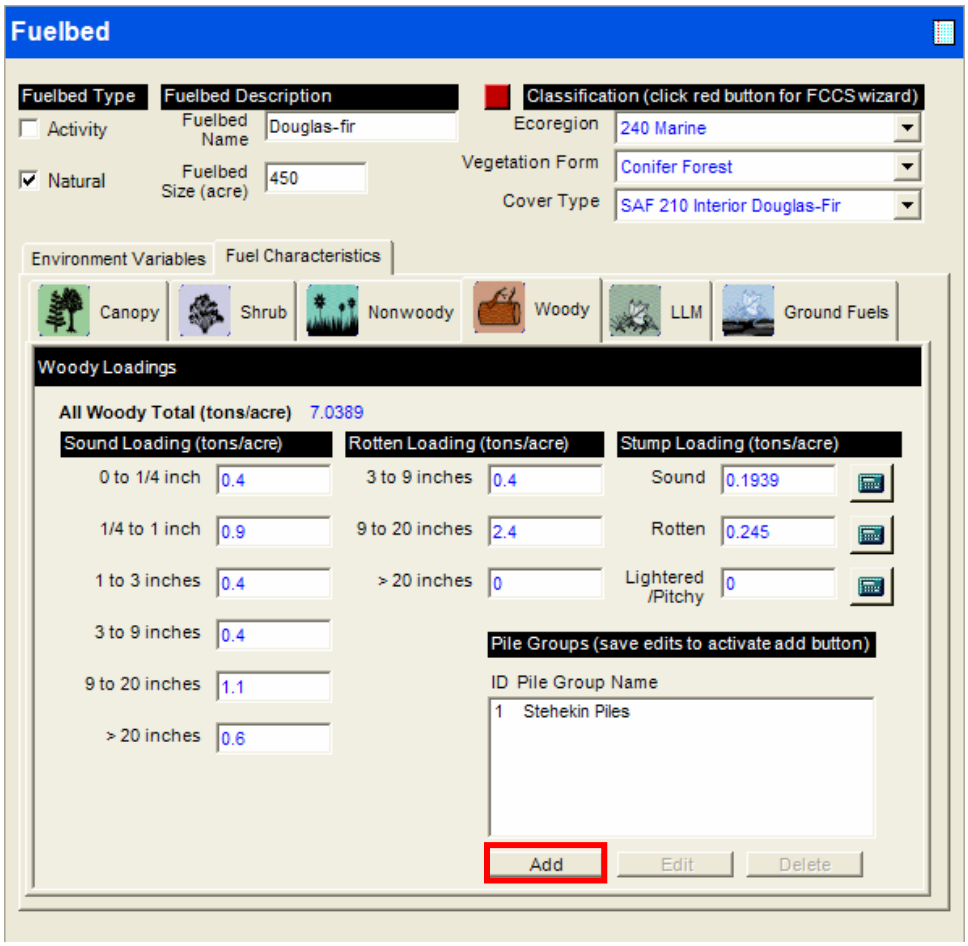
1. Click on the red **FCCS wizard** button in the top section of the Fuelbed screen. This is an unlabelled red button to the left of "FCCS Info" (circled below).

2. You may also select **FCCS wizard** from the **Tools** menu. This option is available only when the fuelbed screen is open.



Pile Group Wizard

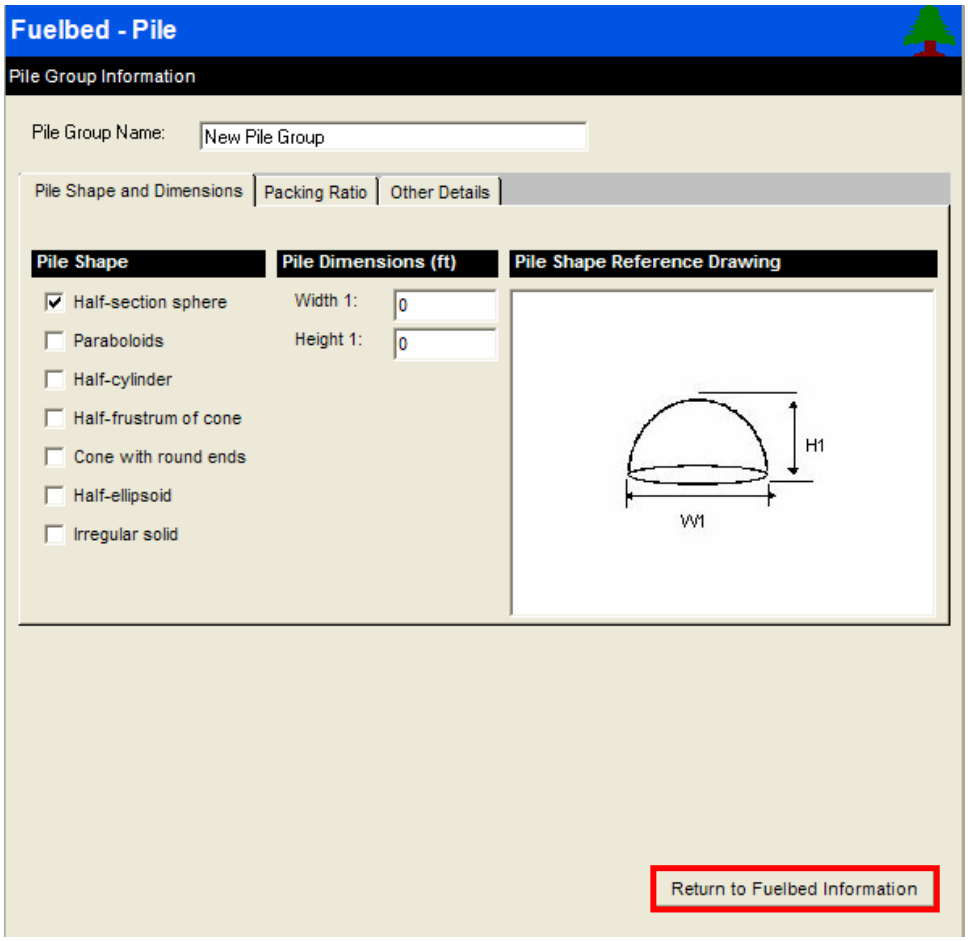
The term “Pile” is used generically in Consume to represent any woody fuel accumulation, created from timber harvesting, other management activities, or though natural processes. Pile groups are entered with other woody fuels information in the Fuel Characteristics page of the Fuelbed screen. Click the **Add** button to launch the Pile Group Wizard.



Pile group information is contained on the following three pages:

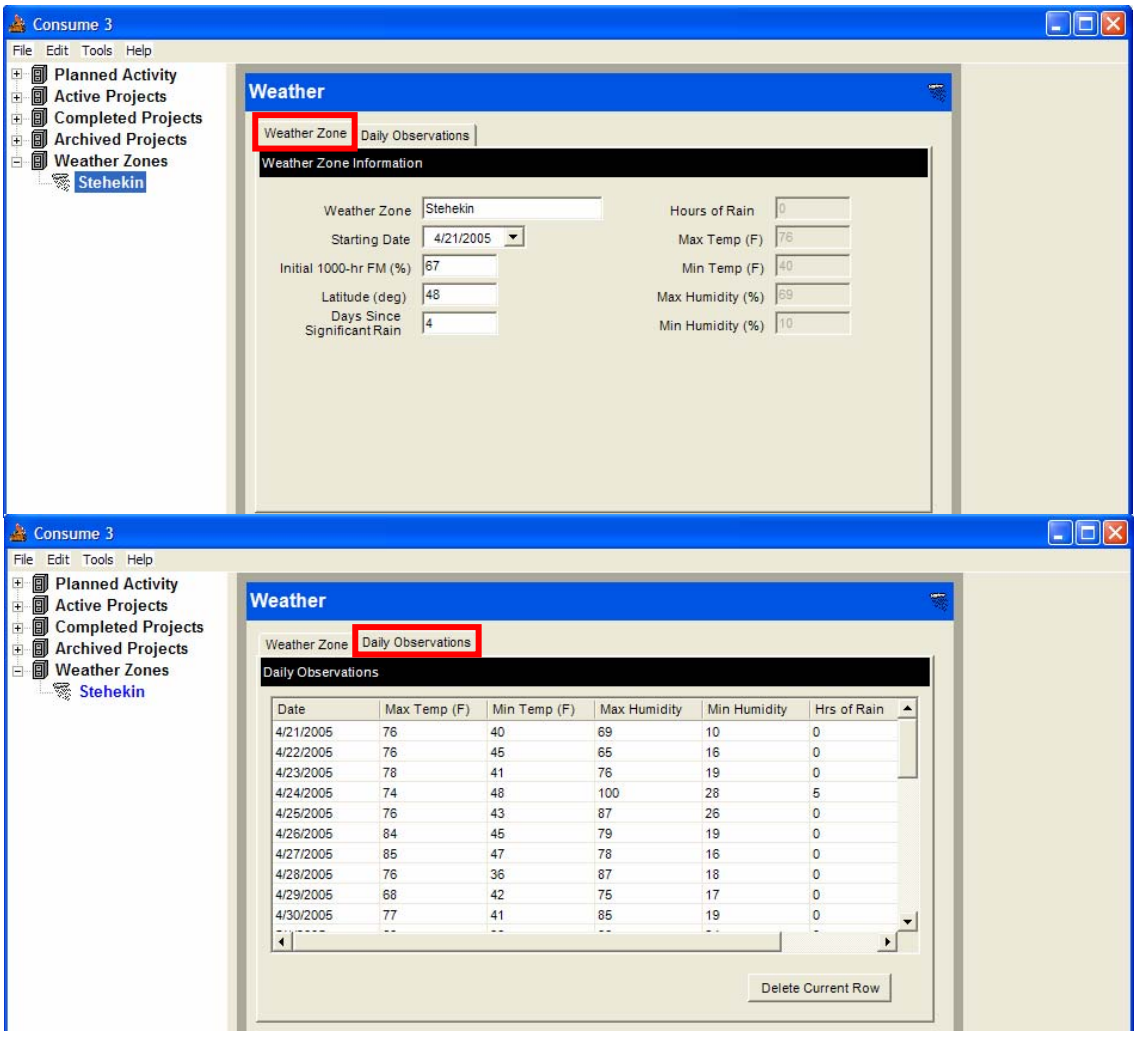
- Pile shape and dimensions
- Packing ratio
- Other details.

To exit the Pile Group Wizard, click the **Return to Fuelbed Information** button.



Weather Zone Entry Screens

Weather zone data are *only* required if you wish to predict the adjusted 1000-hr (Adj-Th) fuel moisture content for activity fuels. The Weather Zone page contains initial weather zone data. The Daily Observations page contains daily observations for each day following the initial information. Daily weather records must run consecutively from the start date of the weather zone until the given burn date. To be used in calculating consumption, the Unit's "Date of Burn" must fall within the dates of listed for a given zone.



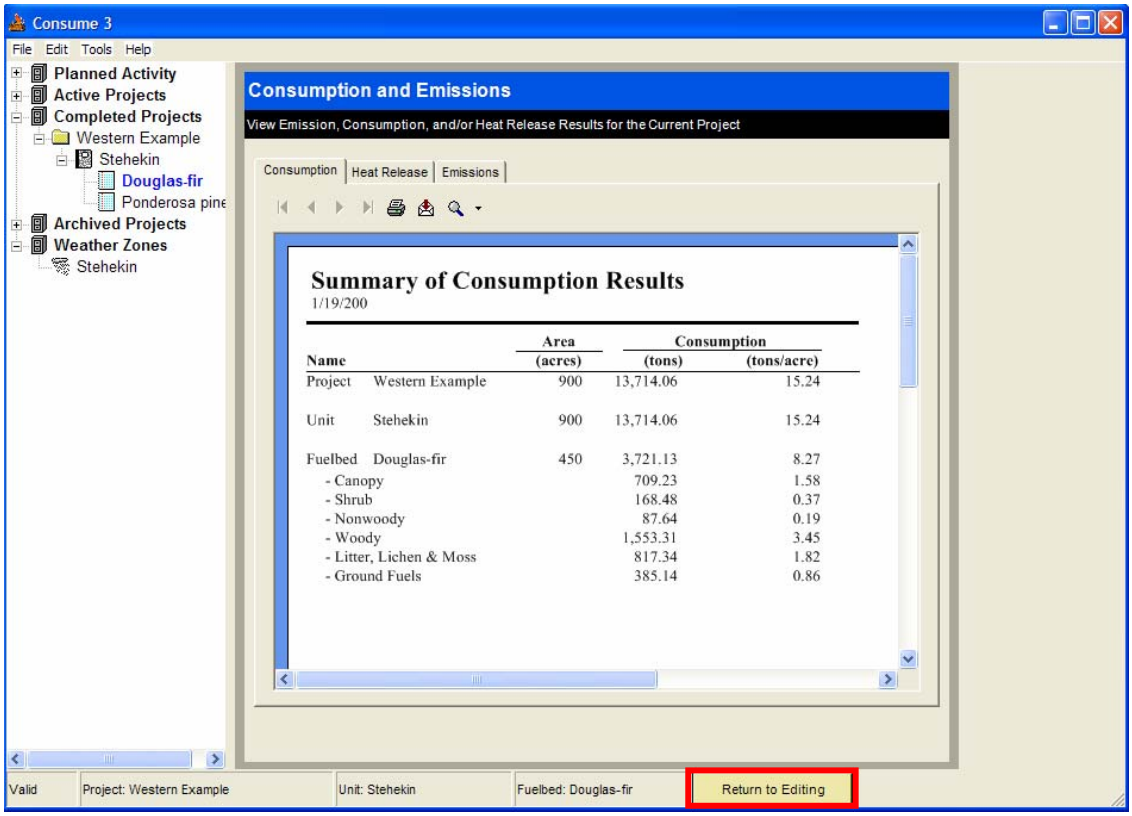
Consumption and Emissions Summary Screen

The Consumption and Emissions screen provides a summary of consumption and emissions for the valid project, unit, or fuelbed selected in the navigation tree.

To view summaries of Consumption, Heat Release and Emissions:

1. Click on a valid project, unit, or fuelbed.
2. Click the **Consumption and Emissions Summary** button at the bottom of the main screen. You also can select **Consumption and Emissions Summary** from the **Tools** menu.
3. The screen will automatically display the item selected in the navigation tree. For example, you may wish to view summary information for an entire project and then view individual unit and/or fuelbed information.
4. To exit the Consumption and Emissions Summary screen, click the **Return to Editing** button at the bottom of main screen.

Note: The **Consumption and Emissions Summary** button becomes inactive when invalid items in the navigation tree are also included in the selection. It is also not available in edit mode.



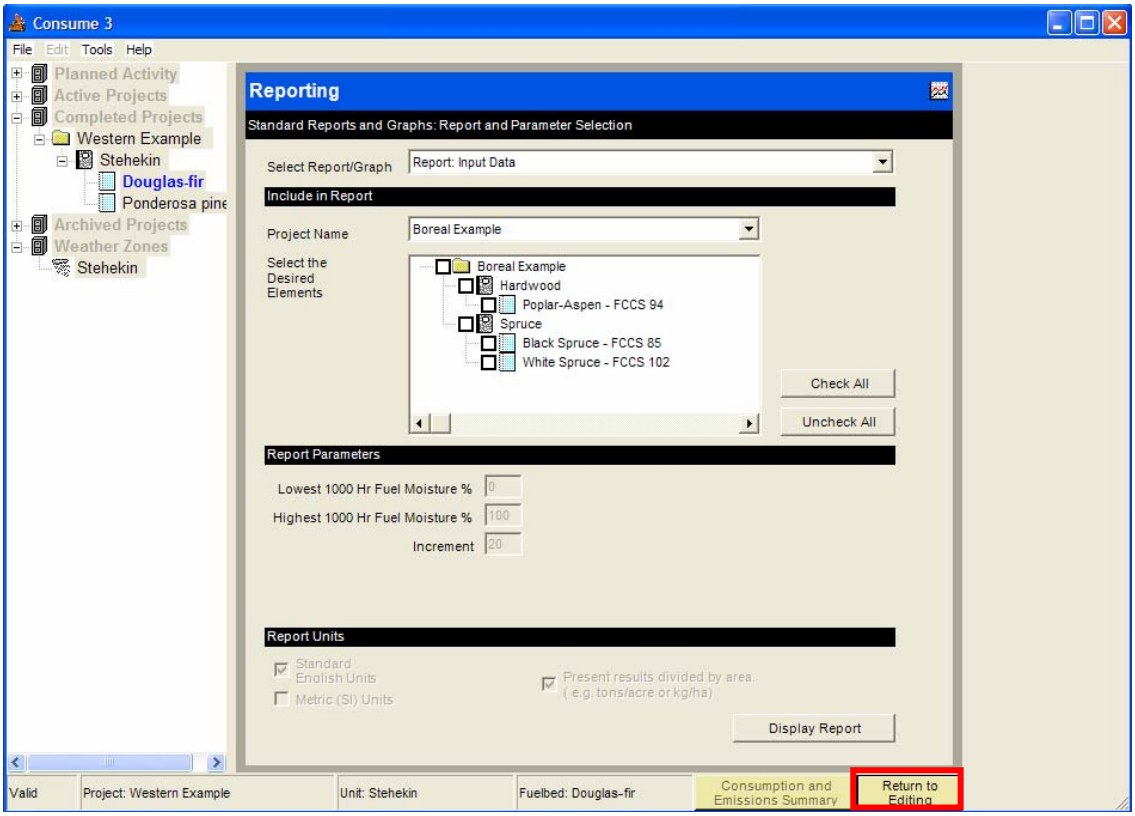
Reports Screen

The Reporting screen is accessible whenever you are in browse mode. To get there, you may either click on the **Reports** button at the bottom right of the main screen or select **Reports** in the **Tools** menu. From the Reports screen, you can select one of several reports and graphs types.

To generate a report or graph:

1. Select a report or graph from the **Select Report/Graph** pull-down list.
1. Select the elements to be included in your report or graph by clicking on the check box next to the unit and/or fuelbed name.
2. Enter any report parameters that apply. (Parameters are grayed out if they are not required.)
3. Enter report measurement units if required. (Measurement units are grayed out if they are not required.)
5. To exit the Reports screen, click the **Return to Editing** button at the bottom of main screen.

Note: You will find detailed information about each graph and report option in "Creating Reports" and "Interpreting Reports."



Viewing, Saving and Printing Reports

Use the toolbar at the top of the Consumption and Emissions Summary screen or Reports screen to view, save and print reports.

The following tools are available in the toolbar:

	Moves to first page of the report		Goes to specified page number.
	Moves one page back		Opens print dialog box
	Moves one page forward		Refreshes report screen
	Moves to end of report		Export to file (.pdf, .xls, .doc, .rtf)
			Changes report size on screen.

Importing and Exporting Projects

Consume allows users to export projects to a file that may be stored as a backup or transferred to other computers.

To export a Project:

1. Click on a project (or an associated unit or fuelbed) to export in the navigation tree.

2. Select **Export** from the **File** menu.

   Consume opens a save dialog box and prompts you for a file location.

3. Select a file location to save the exported project and then click OK.

4. Consume writes the project files to the specified folder and opens the following message:

   The export was successful. Project files have been created at: pathname\EXP_projectname

5. The exported project resides in a folder that contains multiple files. The Consume Export File (.cef) depends on the multiple .xml source files in the shared folder. To avoid corrupting the exported project, do not move or delete individual files from this folder.

To import a Project:

1. Select **Import** from the **File** menu.
2. Select **Import Projects**.
3. Browse to the project location and double-click on the project folder
4. Select the Consume Export File with the extension .cef.
5. Click **OK**.

Backing Up and Restoring Data

You can use the export and import functions in Consume to back up or share your project data with other users.

To back up and restore data in Consume:

1. Click on a Project to export in the navigation tree.
2. Select **Export** from the **File** menu.
3. Select a file destination and click OK.
4. To restore data in Consume, click on a project category in the navigation tree and select **Import** from the **File** menu.
5. Select **Import Projects**.

6. Browse the project directories that you have exported and select a Consume Export File (.cef) to import.

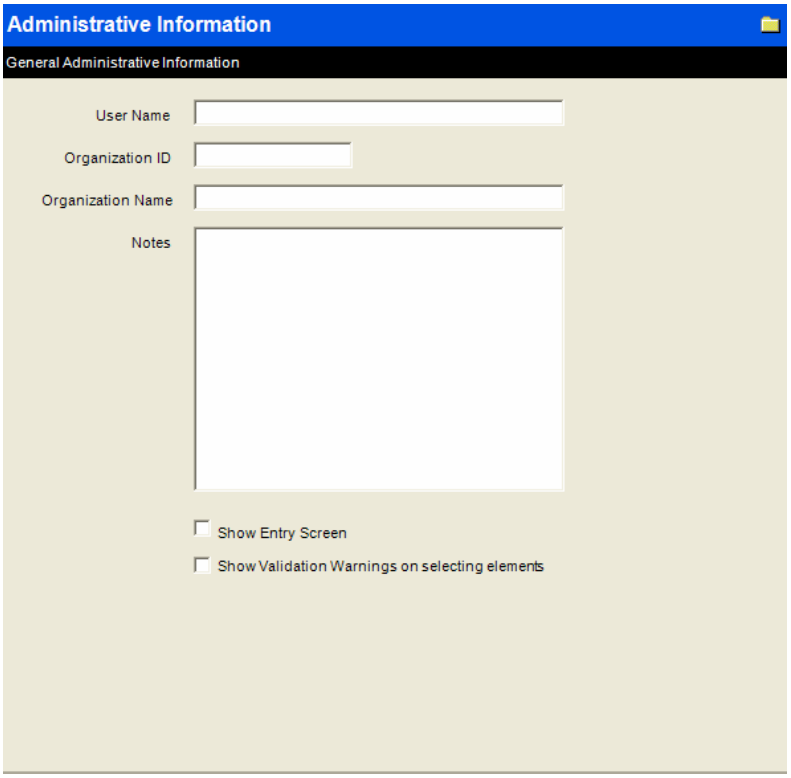
7. Click OK.

If you share exported projects to other Consume users or wish to move exported projects to another location, copy the entire project folder. The Consume Export File (.cef) depends on the multiple .xml source files in the shared folder. To avoid corrupting the exported project, do not move or delete individual files from this folder.

Administrative Information

You can input user information in the administrative information screen including user name, organization ID, organization name, and notes. You can also turn on or off the entry screen (Instructions for beginning Consume users) and validation warning messages by clicking on the corresponding check boxes.

To access the screen, select Tools menu → Options → Administrative Information.



Recording and Managing Data

To create reports that will assist in fire management decisions**,** Consume requires data inputs to be completely valid before it calculates results. Invalid projects and weather zones can be saved, but most reports will not be available for a project until it is fully defined and validated. To identify and correct validation problems, see “creating valid projects.”

Overview of Data Entry Screens

There are four main data entry screens to complete before Consume can calculate results:

Project screen – records general project information.

Unit screen – records general unit information. Note that there may be multiple units in each project.

Fuelbed screen – records environmental variables and fuel characteristics including loading and dimensional data. Note that there may be multiple fuelbeds in each project.

You can directly enter fuel characteristics in Consume or load values from the Fuel Characteristics Classification System (**FCCS**) using the FCCS wizard.

Weather screen – records weather characteristics of an area and Daily weather observations for that weather zone.

Weather zone data are *only* necessary if users wish to estimate the Adj-Th fuel moisture content for activity fuels.

For more information, see "Creating New Projects"

Viewing Data Entry Screens

Consume can display the information on any project, unit, fuelbed or weather zone screen by clicking on that item in the navigation tree.

General instructions:

1. Make sure you are in browse mode. If you are editing a fuelbed screen, save or cancel changes to exit edit mode.

2. To view the information on a project, unit, fuelbed or weather zone, click on that item in the navigation tree.

   The corresponding screen will appear in the main window.

To view projects*:*

Double click on a project category (Planned, Activity, Completed or Archived) in the navigation tree to view existing projects within each category. To view project information, single click on a project in the navigation tree.

To view units:

Double click on a project in the navigation tree to view existing units within that project. To view unit information, single click on a unit in the navigation tree.

To view fuelbeds:

Double click on a unit in the navigation tree to view existing fuelbeds with that unit. To view fuelbed information, single click on a fuelbed in the navigation tree.

To view weather zones:

Double click on the Weather Zones category in the navigation tree to view weather zones. To view weather zone information, single click on a weather zone in the navigation tree.

Entering Input Data

To enter data on any input data screen:

1. Click on an item to edit in the navigation tree or create a new item by selecting **New *item*** from the **File** menu.

   Note: The **New** command in the **File** menu depends on your current focus in the navigation tree.

   To create a new project, click on a project category in the navigation tree and then select **New Project** from the File menu.

   To create a new unit, click on a project in the navigation tree and then select **New Unit** from the File menu.

   To create a new fuelbed, click on a unit in the navigation tree and then select **New Fuelbed** from the File menu.

   To create a new weather zone, click the Weather Zones category in the navigation tree and select **New Weather Zone …**from the File menu.

2. Enter input data in the white entry cells. Input cells that are not applicable to your particular project will be grayed out.

   Note: To switch between cells, you may use your mouse to click on a different cell or press the Enter or Tab key. Shift-Tab will jump to the previous cell.

3. The fuelbed and weather zone screens have multiple input pages.

   Note: To switch between pages, click on the labeled tabs at the top of the page or press Page Down or Page Up on your keyboard.

4. Click the **Save** button or select **Save** from the **File** menu.

   Consume will validate data entry and display any problems. If no problems were identified, Consume will save the information. Otherwise, Consume will list the problems and will prompt you to save the information as is, cancel your work, or continue editing.

Printing Input Data

To print input data for an entire project or individual items within that project, you can create an Input Data Report. See "Creating Reports" for more information.

Consume 3.0 does not support a print option of actual data entry screens. If you wish to print individual data entry screens, you can create a screen capture by using the Print Screen command on your keyboard and pasting the screen capture into Microsoft Word, Microsoft PowerPoint or another application for printing.

Modifying Existing Data

You can use existing items in the navigation tree as the basis for new projects, units, fuelbeds and weather zones. This allows you to create an item for a similar area without creating it from scratch. Once you have created the new item, you can modify its data as needed. Be aware that if you copy an entire project, all units and fuelbeds within that project will be copied as well.

To base a new item on an existing one:

1. Click on an item to copy in the navigation tree.

2. Select **Copy** from the **Edit** menu or type CTRL-C.

   You must be in browse mode to use the navigation tree. If the navigation tree is disabled, you must first save or cancel your changes to exit edit mode.

3. Click on a destination for the item. For a new project, click on a project category. For a new unit, click on a project. For a new fuelbed, click on a unit. For new weather zones, click on the Weather Zones category.

4. Select **Paste** from the **Edit** menu or type CTRL-V.

If an item in the tree grid contains incorrect, incomplete, or out-of-date information, you can make changes to it. For example, you may have entered data from a prescribed burn plan when you first created the fuelbed. As the planned burn date approaches, you may want to verify the accuracy of this data and modify it if needed.

To modify data:

1. Click on an item to modify in the navigation tree.

   The corresponding screen will appear in the main window.

2. Click on the desired input variable box and change the value. Repeat this step until all changes are completed.

   After you make your first change, Consume will switch to edit mode. In edit mode, the **Consumption and Emissions** and **Reports** buttons change to a **Cancel Changes** and **Save** buttons.

3. Click the **Save** button or select **Save** from the **File** menu.

   Consume will validate data entry and display any problems. If no problems were identified, Consume will save the information. Otherwise, Consume will prompt you to save the information as is, cancel your work, or continue editing.

Deleting Items in the Navigation Tree

After conducting a burn, you may want to delete a project or individual items from Consume.

To delete an item from the navigation tree:

1. Click on the item in the navigation tree.

2. Press DELETE on your keyboard or select **Delete** from the **File** menu.

   Consume will prompt you to verify that you wish to delete the record. There is no way to recover a record once it has been deleted, so use delete with care.

Creating Valid Projects

A project is considered valid when all of its units and fuelbeds are valid. Invalid items are marked as red in the navigation tree. The status bar also indicates they are invalid. To view a listing of validation problems for the invalid item:

1. Select the invalid item in the navigation tree. You must be in browse mode to access items in the navigation tree; if you are currently in edit mode, save or cancel your changes to exit edit mode.
2. Select **Save** from the **File** menu or type CTRL-S.
3. Consume will list any validation errors associated with the selected item and ask you if you still wish to save it.
4. Correct the validation problems and resave your work on each screen that had validation errors.
5. Consume will revalidate each item upon saving. If no problems were identified, Consume will save the information. If problems remain, Consume will list them as validation errors.
6. Once your entire project is valid, the project and all units and fuelbeds within it will be valid, and icons will be restored to default colors.

Entering Project Information

To create a new project, click on a project category in the navigation tree, select **New Project** from the **File** menu, and enter a project name. You may also copy an existing project and then edit its project, unit and fuelbed information.

Project name	Name of the project. This name will appear in reports. Project names must be unique..
Organization name	Name of the organization responsible for the project (optional).
Organization code	Code name for the organization (optional).
Start date	Date the project started or is planned to begin.
End date	Date the project ended or is planned to end. Note: project end and start dates must span the burn dates entered for all units within the project. Consume will notify you if you enter a unit burn date outside of your project start and end dates and automatically extend the project end date to accommodate the burn date.
Status	Projects are organized into four categories: planned, active, completed or archived. When you enter the project status, Consume saves your project into a category. If you move projects into different categories in the navigation tree, the project status will update automatically to reflect the change in category. If you change the status and save that change, the project will be relocated into that part of the navigation tree.
Project size (acres)	Consume calculates total fuelbed area in acres for each project. This value is updated whenever fuelbed areas are modified within the project.

Entering Unit Information

To create a new unit, click on a project in the navigation tree, select **New Unit** from the **File** menu, and enter a unit name. You may also copy an existing unit and then edit its unit and fuelbed information.

Unit name	Name of the burn unit. This name will appear in reports. Unit names must be unique within a single project.
Permit Number	Burn permit number of a unit (optional).
Date of burn	The date the unit was burned or is planned to be burned. The burn date must fall on or after the project start date.
Treatment completed	Users can specify one of three burn treatment options including prescribed burn, wildland fire for use, and wildfire.
Unit Size (acres)	Total number of acres in the unit based on acres entered for each fuelbed.
Number of fuelbeds	Total number of fuelbeds in each unit.

Entering Fuelbed Information

To create a new fuelbed, click on a unit in the navigation tree, select **New Fuelbed** from the **File** menu, and enter a fuelbed name. You may also copy an existing fuelbed into a unit and edit its existing information.

There are three main sections of the fuelbed screen:

1. **General Fuelbed Information** is listed at the top of the fuelbed screen and is always visible.
2. The **environmental variables** page records data on the fuelbed environment that influence fuel consumption and emissions.
3. The **fuel characteristics** page records fuel loading and dimensional data by fuelbed stratum (canopy, shrub, nonwoody vegetation, woody fuels, liter-lichen-moss, and ground fuels).

General Fuelbed Information

Fuelbed type Fuelbeds are designated as either activity or natural. Consume uses different algorithms depending on fuelbed type and location.

Fuelbed name When you first create a new fuelbed, Consume prompts you for a fuelbed name. You may change this name when you are editing in the Fuelbed screen. This name is *not* updated when you import a FCCS fuelbed.

Fuelbed size The area of your fuelbed in acres.

Ecoregion Fuelbeds are organized geographically into Bailey's ecoregion divisions including: tundra, subarctic, warm continental, hot continental, subtropical, prairie, marine, Mediterranean, tropical/subtropical steppe desert, tropical/subtropical desert, temperate steppe, temperate desert, savanna, and rainforest. A map of the ecoregions of the United States is provided in the Consume online help and included as Figure 3.

If you use the FCCS wizard to load default loadings, you may specify an ecoregion to narrow the selection list. Consume will then automatically enter this value in the Ecoregion input box in the Fuelbed screen. You may change the ecoregion at any time.

Consume requires an ecoregion division to determine which of three regional equation sets (boreal, southern or western) to use for natural fuel consumption calculations.

Vegetation form

There are seven vegetation forms to select from in Consume: broadleaf forest, conifer forest, mixed forest, grassland, savanna, shrubland and slash.

If you use the FCCS wizard to load default loadings, you may specify a vegetation form to narrow the selection list. Consume then will automatically enter this value in the Vegetation Form input box in the Fuelbed screen. You may change the vegetation form at any time.

Cover type

Consume uses Society of American Foresters (SAF) and Society of Rangeland Management (SRM) cover types in the FCCS wizard to refine fuelbed searches (Eyre 1980, Shiflet *et al.* 1994).

Consume requires a cover type to help select appropriate emissions factors to calculate emissions for your specific fuelbed. If you use the FCCS wizard to refine fuelbed searches and specify a cover type, Consume will automatically enter this value in the Cover Type input box in the Fuelbed screen.

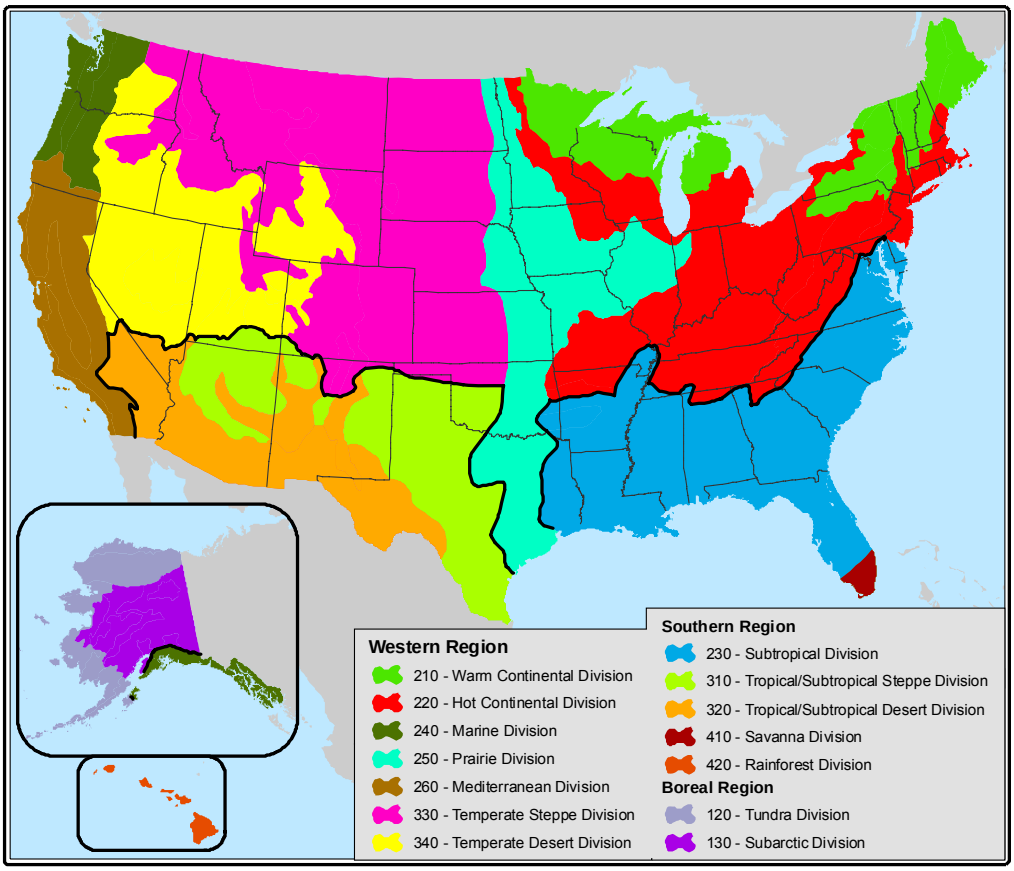


Figure 3: Map of the United States with the Bailey's Ecoregion Divisions (Bailey 1998). The three Consume regions (Boreal, Southern, and Western) used to define the natural fuels consumption datasets, are outlined in black.

Environmental Variables

The environmental variables page records environmental data necessary to perform consumption and emissions calculations.

- The General Environmental Variables section records inputs required for all calculations.
- The Activity Fuelbed Environmental Variables section records input required only for activity fuel calculations.

General Environmental Variables

The following variables are required for all fuelbed types (activity and natural).

10-hour fuel moisture (%) The moisture content of 10-hour fuels (0.26- to 1-inch-diameter woody fuels). 10-hour fuel moisture is expressed as a percentage of the oven-dry weight of the fuel.

When you first enter unit data, you may want to use an estimated 10-hour fuel moisture (e.g., listed in a prescribed burn plan). However, to obtain accurate consumption values as the unit's ignition date approaches, you must check this initial entry and make modifications if necessary.

You can determine 10-hour fuel moisture from moisture samples, moisture meters, or fuel sticks. It is recommended that 15 moisture samples or 15 moisture meter measurements be collected vertically across the fuel bed to represent a unit-average 10-hour fuel moisture. If you use fuel sticks, place the sticks in the fuel bed and multiply the measurement by 1.4 to better represent a unit-average 10-hour fuel moisture.

Consume uses 10-hour fuel moisture as a factor in predicting 100-hour (1- to 3-inch diameter) fuel consumption.

1000-hour Fuel Moisture (%) Measured or estimated 1000-hour fuel moisture for the unit. 1000-hour fuel moisture is the moisture content of sound, woody material 3-8 inches in diameter and can be directly measured or estimated using the ADJ-Th or NFDRS-Th fuel moisture models.

Fuel moisture is expressed as a percentage of the oven-dry weight of the fuel.

Has snow off occurred in Check this box if snow off has occurred on your fuelbed within the

the past 3 months?

past 3 months.

Consume uses the snow off date threshold to determine whether large woody fuels (> 3 inches in diameter) are cured. If you check this box, the calculator button next to 1000-hr FM will be activated and is available to help estimate 1000-hr fuel moisture for your fuelbed.

Has the fuelbed been harvested in the past 3 months?

Check this box if your fuelbed has been harvested in the past 3 months.

Consume uses the harvest date threshold to determine whether large woody fuels (> 3 inches in diameter) are cured. If you check this box, the calculator button next to 1000-hr FM will be activated and is available to help estimate 1000-hr fuel moisture for your fuelbed based on the number of months since the fuelbed was harvested.

Duff Fuel Moisture (%)

The duff fuel moisture of the area of the unit that will be treated.

Consume uses duff fuel moisture in many of its natural fuel equations of rotten wood consumption and forest floor reduction equations.

Percent canopy loading consumed (%)

Percentage of canopy loading consumed by the fire. If you do not know the value and choose not to enter this variable, Consume will assume the following defaults:

Prescribed burn = 0%

Wildland fire for use = 40%

Wildfire = 60%

Consume uses the percentage of canopy consumption in its estimate of canopy consumption and emissions.

Activity Fuelbed Environmental Variables

The following variables are required for activity fuelbeds only. If you select a natural fuelbed type, these variables will be grayed out and cannot be modified.

Length of Ignition (minutes)

The amount of time, in minutes, that it will take to ignite the area to be burned. For example, if it will take three hours to complete ignition of the area, enter *180*.

When you enter initial fuelbed data, you may want to use the

	ignition time listed in your burn plan. However, to obtain accurate consumption values as the unit's ignition date approaches, you must check this initial entry and make modifications if necessary. Consume uses ignition time to determine if the fire will be of high intensity. The intensity of a fire affects the diameter reduction of large woody fuels.
Mid-flame wind speed (miles/hr)	The mid-flame wind speed, in miles per hour, during the burn. The maximum wind speed is 35 miles per hour. When you enter initial fuelbed data, you may want to use the wind speed value specified in the prescribed burn plan. However, to obtain accurate consumption values as the unit's ignition date approaches, you must check this initial entry and make modifications if necessary. Consume uses wind speed as a factor in predicting 100-hour (1- to 3-inch-diameter) fuel consumption.
1000-hour Fuel Moisture Source	The source of the 1000-hour fuel moisture data for the unit. Measured – The directly-measured fuel moisture that represents the average unit fuel moisture of large woody fuels. Input this value directly. ADJ-Th – Adjusted 1000-hour fuel moisture is estimated and represents the average unit fuel moisture of large woody fuels. Selecting this option requires a weather zone with daily weather information. NFDRS-Th – National Fire Danger Rating System's 1000-hour fuel moisture content (http://www.wrh.noaa.gov/sew/fire/olm/nfdrs.html)
Weather zone	If you select ADJ-Th as the 1000-hr fuel moisture source, Consume requires you enter a valid weather zone. Weather zones and daily weather information are used to calculate an adjusted 1000-hour fuel moisture.
Slope (%)	The average vertical change (rise) in the unit's ground surface over a given horizontal distance (run). Slope is expressed as a percentage (%). Consume uses slope to predict consumption of 100-hour fuels.
Days Since Rain	The number of days since significant rainfall. Significant rainfall is one-quarter inch in a 48-hour period. Consume uses days since rain to predict duff consumption in activity fuelbeds.

Copying environmental variables from another fuelbed

Consume allows you to copy environmental variables data from one fuelbed to another. To save time entering data, you may wish to use this feature when fuelbeds share similar environments.

To copy environmental variable data from another fuelbed:

1) Select a fuelbed name from the toggle list next to "To copy environmental data form another fuelbed in this project, select the fuelbed and click Copy" at the bottom of the Environmental Variables page.

2) Click the **Copy** button.

3) Consume will update the input screen with environmental variables from your selected fuelbed. Any previous inputs will be overwritten.

4) If you wish to cancel changes, click the **Cancel Changes** button or select **Cancel Changes** from the **Edit** menu.

5) Click the **Save** button or select **Save** from the **File** menu.

   Consume will validate data entry and display any problems. If no problems were identified, Consume will save the information. Otherwise, Consume will prompt you to save the information as is, cancel your work, or continue editing.

Fuel Characteristics

Fuel characteristics include fuel loadings and dimensional data by fuelbed stratum. You may enter these values for each stratum from your own data or use the **FCCS wizard** to import fuel characteristics data from the **Fuel Characteristics Classification System**.

Consume tracks and displays three types of entered data:

Black = data entered directly by users.

Blue = data loaded from the FCCS wizard.

Red = data originally loaded from FCCS and later modified in Consume.

If you choose to enter fuel characteristics directly, you will need to fill out the six stratum input pages and provide an entry for every input variable. You can either enter values directly into Consume or allow Consume to calculate values with inputs using loading calculator buttons where available. Any variables you do not enter either will cause a validation error or will be saved as zero. Input variables that are not required are grayed out. Many fuelbeds will lack one or several fuelbed strata and categories. For example, your fuelbed may not contain a canopy or shrub stratum. In these cases, Consume will automatically fill these inputs as zero.

FCCS Wizard

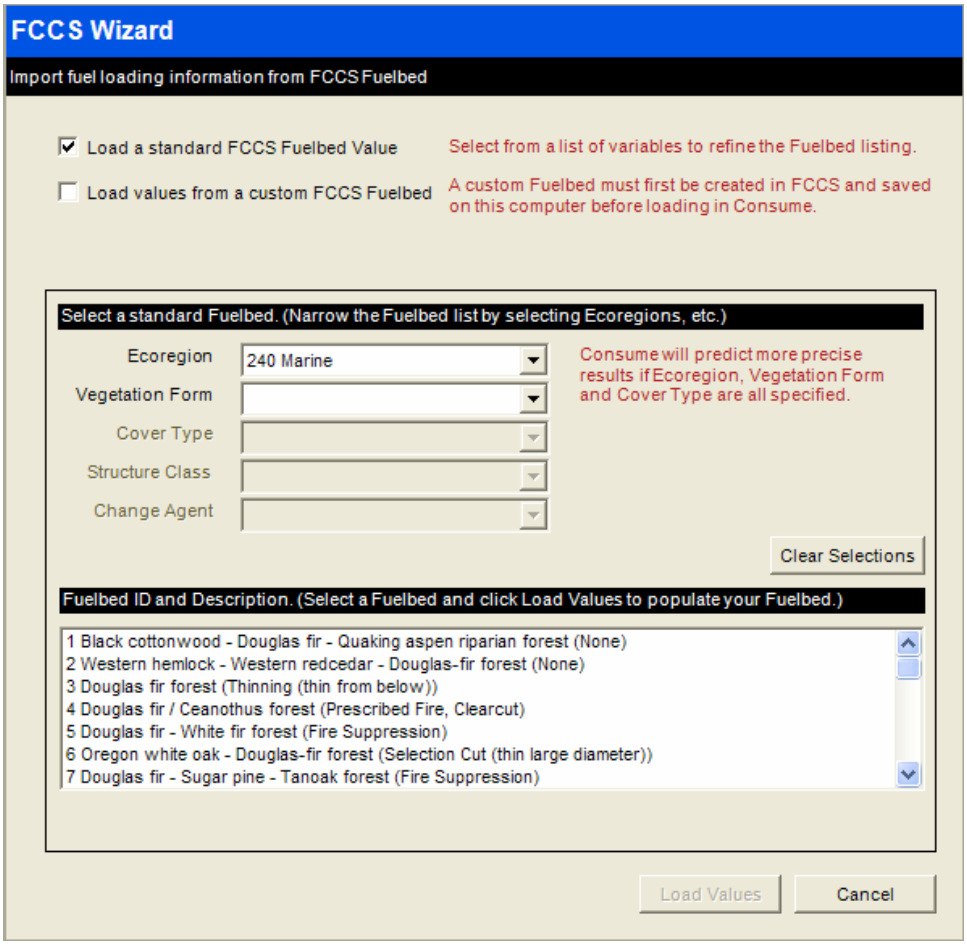
You can use the **FCCS wizard** to import fuel characteristics data from the Fuel Characteristics Classification System (FCCS). The FCCS wizard will automatically fill in most fuel characteristics required in the fuel characteristics page of the Fuelbed screen.

You will still need to fill in general fuelbed information, fuelbed environment information, pile group data, if applicable, and percent black in the Shrub Stratum of the fuelbed characteristics page.

To enter the **FCCS wizard**:

1. Click on the red **FCCS wizard** button in the general information section of the Fuelbed screen. This is the unlabelled, solid red button to the left of “Classification”.

2. If you are currently viewing a fuelbed, you may also select **FCCS wizard** from the **Tools** menu. This option is available only when the fuelbed screen is open.



Loading a standard fuelbed

If you are loading a standard FCCS fuelbed, you can select a fuelbed from the entire list of FCCS fuelbeds or query the fuelbeds using five selection variables. Standard fuelbeds contain fuel loadings and dimension data that were created for each of the FCCS national fuelbeds and preloaded into Consume.

Note: Consume does *not* import any pile group data from the FCCS fuelbeds. It also calculates total shrub loading from imported shrub foliage loading values in the FCCS.

To select a fuelbed by name:

1. When you first launch the FCCS wizard, all available FCCS fuelbeds are listed in the results window under "Fuelbed ID and Description. If you do not see the full list, click the **Clear Selections** button.

2. Select a fuelbed from the "Fuelbed ID and Description" window.

3. Click the **Load Values** button at the bottom right of the FCCS wizard screen.

To query the FCCS fuelbeds:

1. Select an ecoregion and/or vegetation form from the drop-down lists.

2. You may then consecutively select a cover type, forest structure class and change agent. Each selection narrows the selection list. Not every selection variable may be necessary to narrow the list to a single fuelbed.

3. Select a fuelbed from the results window under "Fuelbed ID and Description"

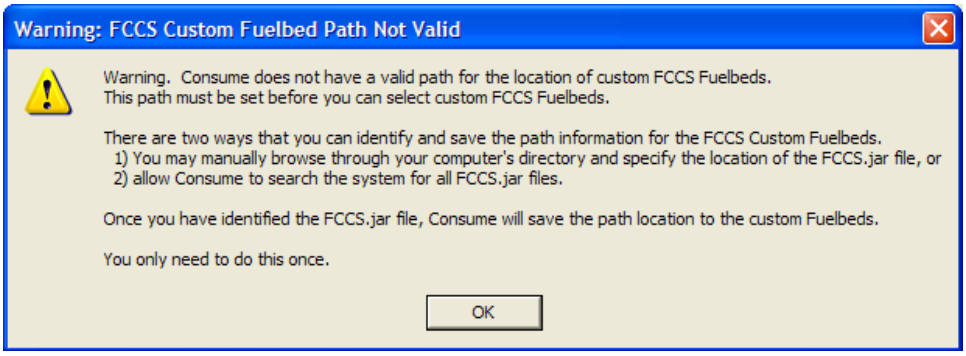
4. Click the **Load Values** button at the bottom right of the FCCS wizard screen.

Note: if you selected an Ecoregion, Vegetation Form and Cover type to query the FCCS national fuelbeds, Consume will automatically fill these variables under General Fuelbed Information.

Loading a custom fuelbed

If you are loading a custom FCCS fuelbed, click on the checkbox next to "Load values from a custom FCCS fuelbed".

If this is your first time using this feature, Consume will prompt you to either **browse** to the location where the FCCS executable file (fccs.jar) is stored on your computer or ask Consume to **search** for it.



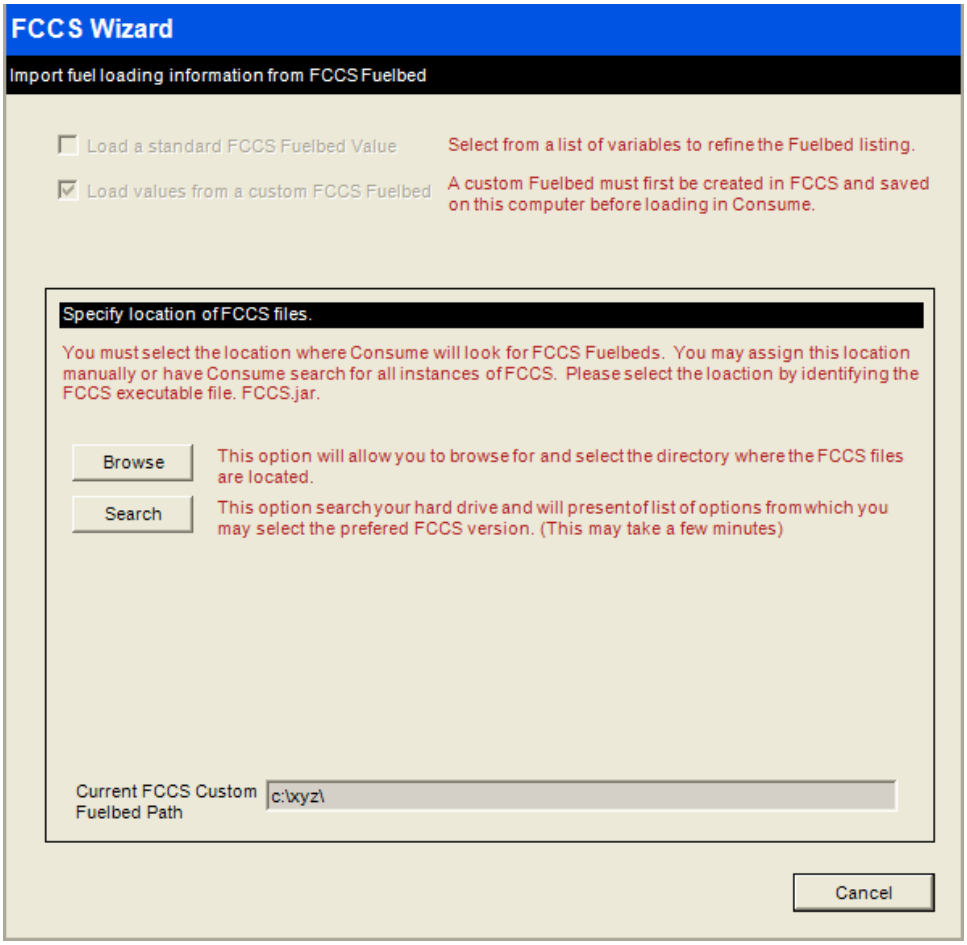
To locate Consume export files in the FCCS:

- Click the **Browse** button to locate the fccs.jar yourself or click **Search** to prompt Consume to search for the file.

  During automated searches, Consume will search your computer for fccs.jar. This may take several minutes, depending on your processor speed. If you have multiple copies of fccs on your computer, you will need to select the correct path (i.e., the fccs folder that contains your Consume export files).

- Once you have specified where fccs.jar is located, click the **FCCS location** button. Consume will set a default folder for opening Consume export files (fccs/results/consume). If you ever change the location of FCCS on your computer, Consume will again prompt you to find where fccs.jar is located.

- Once you have set the default location of Consume export files in the FCCS, you can click on the Get Custom FCCS Fuelbed to import custom FCCS fuelbeds into Consume.

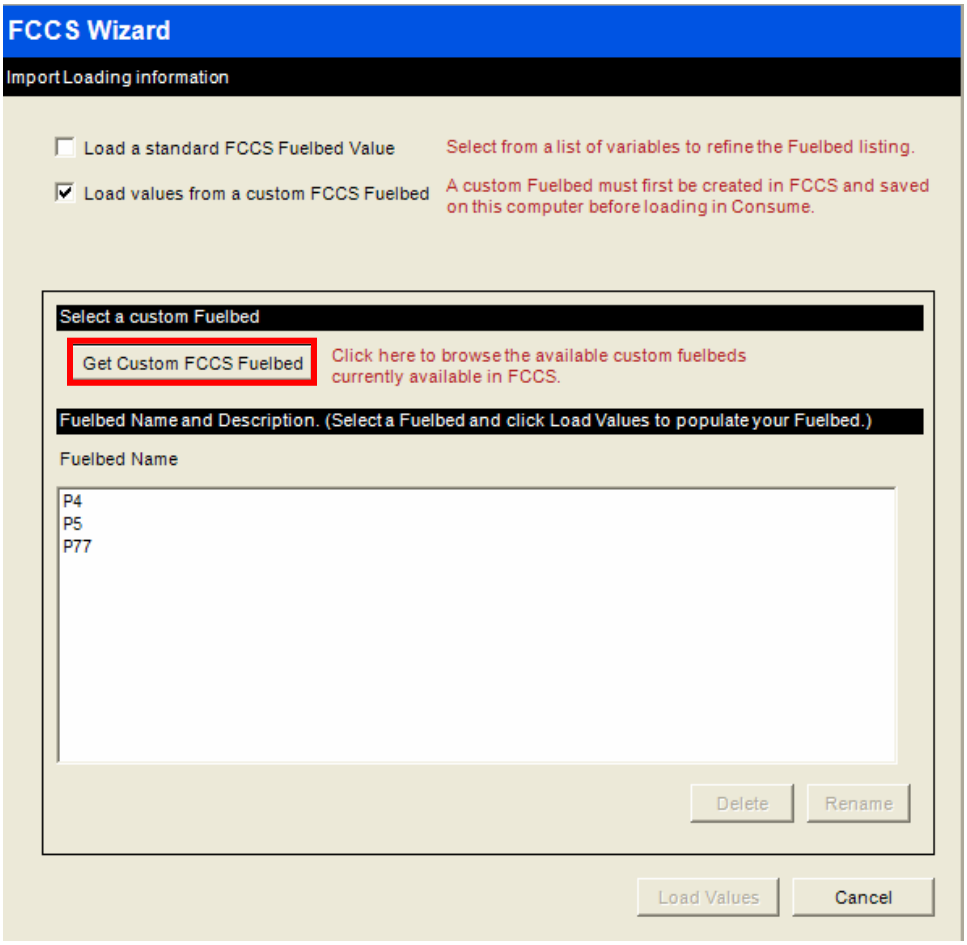


To import a custom FCCS fuelbed into the library:

- From the fccs/results/consume folder, select *either* an input or intermediate file:
  …/fccs/results/consume/projectname_intermediate.xml OR
  …fccs/results/consume/projectname_input.xml.

  Note: although Consume requires both files, you only need to specify one of them for import.

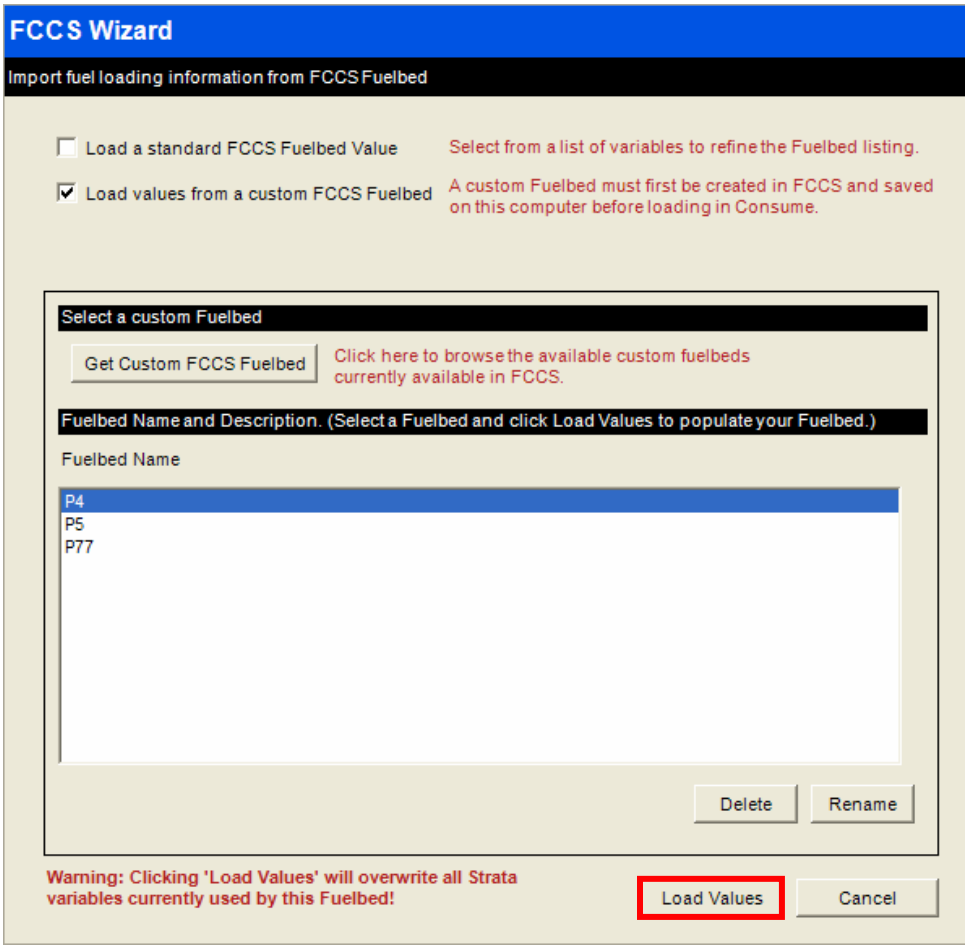
- Click the **Open** button to import the custom FCCS fuelbed file.



To load a fuelbed from the custom fuelbed library:

- If you have already compiled a library of custom FCCS fuelbeds, you can select a custom fuelbed under Fuelbed ID and Description.

- Click the **Load Values** button to populate the fuel characteristics pages of the fuelbed screen.



Loading Calculators

Consume offers loading calculators for users who already have some data but do not have fuel loadings for all strata and categories. Loading calculators are available for trees, snags, ladder fuels, shrubs and stumps.

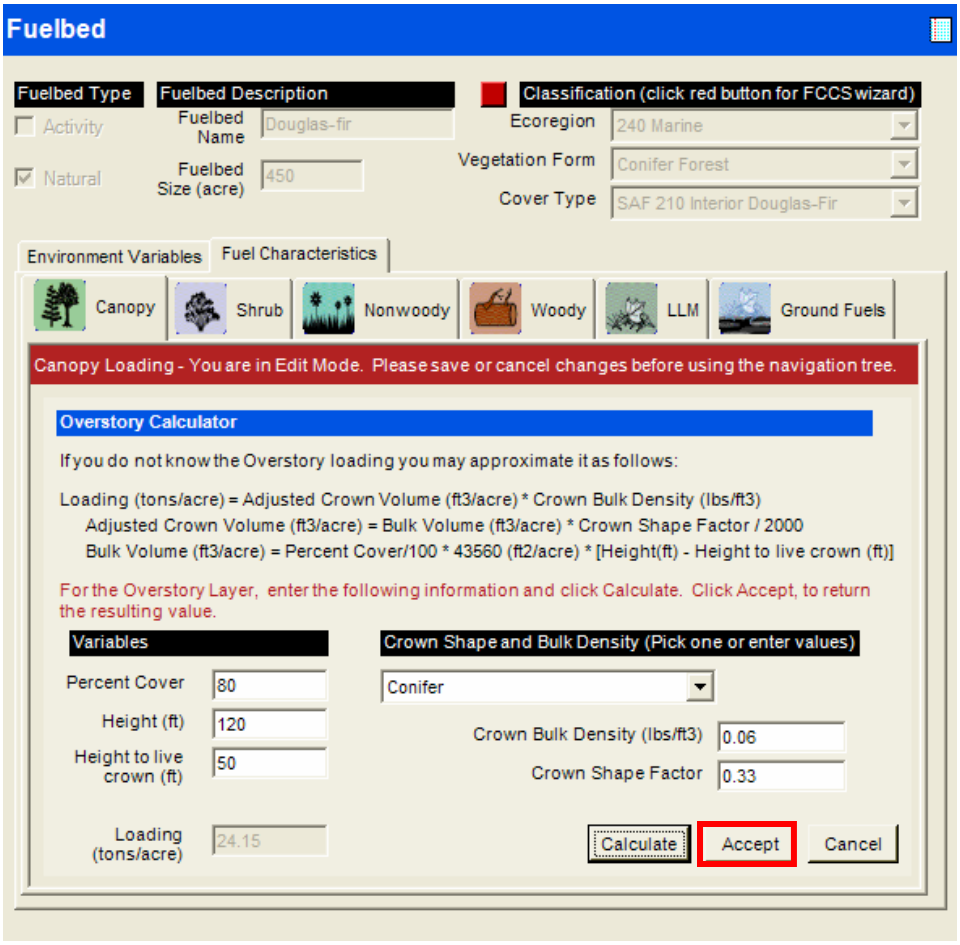
The calculators use the same equations as in FCCS but with defaults in place of species-specific variables such as crown bulk density and wood particle densities. Because default values are used, results can vary substantially from the species-specific loading calculations in FCCS.

To use the **Loading Calculators**:

1. Click on the calculator icon to the right of the input loading variable (overstory trees shown below) or click on the entry cell and press F2 on your keyboard.

2. Enter input values and Click the **Calculate** button.

3. Click the **Accept** button to accept the loading calculation or the **Cancel** button to cancel changes and return to the fuelbed screen.


Fuelbed
Fuelbed Type
Activity
Natural
Fuelbed Description
Fuelbed Name
Douglas-fir
Fuelbed Size (acre)
450
Classification (click red button for FCCS wizard)
Ecoregion
240 Marine
Vegetation Form
Conifer Forest
Cover Type
SAF 210 Interior Douglas-Fir
Environment Variables
Fuel Characteristics
Canopy
Shrub
Nonwoody
Woody
LLM
Ground Fuels
Canopy Loading - You are in Edit Mode. Please save or cancel changes before using the navigation tree.
Overstory Calculator
If you do not know the Overstory loading you may approximate it as follows:
Loading (tons/acre) = Adjusted Crown Volume (ft3/acre) * Crown Bulk Density (lbs/ft3)
Adjusted Crown Volume (ft3/acre) = Bulk Volume (ft3/acre) * Crown Shape Factor / 2000
Bulk Volume (ft3/acre) = Percent Cover/100 * 43560 (ft2/acre) * [Height(ft) - Height to live crown (ft)]
For the Overstory Layer, enter the following information and click Calculate. Click Accept, to return the resulting value.
Variables
Percent Cover
80
Height (ft)
120
Height to live crown (ft)
50
Loading (tons/acre)
24.15
Crown Shape and Bulk Density (Pick one or enter values)
Conifer
Crown Bulk Density (lbs/ft3)
0.06
Crown Shape Factor
0.33
Calculate
Accept
Cancel

About Fuel Characteristics Data

If you choose to enter fuel characteristics on your own, you will need to fill out the six stratum input pages and provide an entry for each input variable. You can either enter the value directly into Consume or allow Consume to calculate values with inputs using calculator buttons where available. Input variables are described below. Any variables you do not enter either will cause a validation error or will be saved as zero. Input variables that are not required are grayed out.

Canopy

Total canopy Consume automatically calculates total canopy loading (including all trees, snags and ladder fuels) in tons per acre when you save your changes.

Total trees Consume automatically calculates total tree loading (including overstory, midstory and understory layer crown loading) in tons per acre when you save your changes.

Total snags Consume automatically calculates total snag loading (including class 1 snags, class 2 snags and class 3 snags) in tons per acre when you save your changes.

Overstory Input loading (tons/acre) of overstory crowns. Overstory trees include dominant and emergent trees in the forest canopy.

Overstory loadings can be imported from FCCS using the FCCS wizard. Alternatively, users can input their own loading value or use the overstory calculator button.

Midstory Input loading (tons/acre) of midstory crowns. Midstory trees include co dominant and intermediate trees in the forest canopy.

Understory Input loading (tons/acre) of understory crowns. The understory layer is composed of tree seedlings and saplings separated from the overstory and midstory by a gap in the canopy.

Canopy

Ladder fuels	Input loading (tons/acre) of ladder fuels.
Class 1 snag with foliage (foliage)	Input loading (tons/acre) of the foliage portion of recently dead snags that have not yet dropped their needles or leaves.
Class 1 snag with foliage (wood)	Input loading (tons/acre) of the wood portion of recently dead snags that have not yet dropped their needles or leaves.
Class 1 snag without foliage	Input loading (tons/acre) of the wood portion of recently dead snags without foliage.
Class 2 snag	Input loading (tons/acre) of standing dead trees greater than 4.5 feet tall with coarse branches and bark intact.
Class 3 snag	Input loading (tons/acre) of standing dead trees greater than 4.5 feet tall that are predominately rotten with no bark intact.

Shrubs

Total shrub loading	Consume automatically calculates total shrub loading (including primary and secondary layers) in tons/acre when you save your changes.
Total percent live	Consume automatically calculates the sum of percent live in primary and secondary layers (maximum is 100%).
Primary layer	Input loading (tons/acre) of the primary shrub layer representing the loading of the entire shrub. If you imported this value from the FCCS, Consume calculates shrub loading as 3 times that of the shrub foliage loading recorded in the FCCS.

Shrubs

Secondary layer	Input loading (tons/acre) of the secondary shrub layer representing the loading of the entire shrub. If you imported this value from the FCCS, Consume calculates shrub loading as 3 times that of the shrub foliage loading recorded in the FCCS.
Percent live of primary layer	Input percentage of shrub vegetation in the primary layer that is living.
Percent live of secondary layer	Input percentage of shrub vegetation in the secondary layer that is living.
Percent black	Input percentage of the shrub stratum blackened by the burn. Consume offers a calculator for users who do not know the percentage of blackened acres of the shrubland. This calculator is best suited to shrublands dominated by sagebrush and/or bitterbrush. This value is *not* imported from FCCS fuelbeds. You will need to enter it yourself. The default percent black is 0.

Nonwoody

Nonwoody loading	Consume automatically calculates the total nonwoody vegetation loading (including primary and secondary layers) in tons/acre when you save your changes. Nonwoody vegetation includes grasses, sedges, and other herbaceous fuels.
Total percent live	Consume automatically calculates the sum of percent live in primary and secondary layers (maximum is 100%).
Primary layer	Input loading (tons/acre) of the primary nonwoody layer.
Secondary layer	Input loading (tons/acre) of the secondary nonwoody layer.
Percent live of primary layer	Percentage of nonwoody vegetation in the primary layer that is living.
Percent live of secondary layer	Percentage of nonwoody vegetation in the secondary layer that is living.

Entering Woody Fuels Data

If you are entering woody fuel loadings directly into Consume**,** use the planar intersect method or a photo series to estimate fuel loadings. Woody fuel size classes and their time lag equivalents include:

Diameter (inches)	Time lag (hours)
0.0-0.25	1
0.26-1.0	10
1.1-3	100
3.1-9	1000
9.1-20	10000
20.1+	10000+*

* Fuels 20.1 inches or more in diameter have a time lag greater than 10,000 hours.

Woody Fuels

All woody total Consume automatically calculates total loading of downed woody fuels in tons/acre when you save your changes. Downed woody fuels include sound and rotten continuous woody fuels, stumps, and woody fuel accumulations (piles, jackpots and windrows).

Sound woody loadings Input loadings (tons/acre) of 0-1/4 inch, ¼ to 1 inch, 1 to 3 inch, 3 to 9 inch, 9 to 20 inch, and > 20 inch sound woody size classes.

Rotten woody loadings Input loadings (tons/acre) of 3 to 9 inch, 9 to 20 inch, and > 20 inch sound woody size classes.

Stump loadings Input loadings (tons/acre) of sound, rotten and lightered (i.e., pitch soaked) stumps.

Pile groups Pile groups record data on woody fuel accumulations of the same type, size, and dimensions.

Click the **Add** button in the Woody stratum page of the Fuelbed screen to enter the **Pile Group Wizard**.

Pile Group Wizard

Piles groups are listed in the Woody stratum page of the Fuelbed screen. Each pile group represents a collection of identical piles. If your fuelbed has piles of varying shape, size or composition, it will require multiple pile groups. You can use Consume to create new pile groups, view existing pile group records, modify existing pile group records and delete pile group records.

Note: Because Consume requires several additional variables on pile groups that are not entered in the FCCS, Consume does *not* import any pile group information from standard or custom FCCS fuelbeds. You will need to pile group information yourself.

To add a new pile group, click the **Add** button below the pile group section of the Woody page of the Fuelbed screen.

To view and modify an existing pile group, select a pile group name and click the **Edit** button. Make any edits to the pile group, then save your changes by clicking on the **Save** button or selecting **Save** from the **File** menu. You may also cancel your changes by clicking on the **Cancel Changes** button or selecting **Cancel Changes** from the **Edit** menu.

To delete a pile group, select a pile group name and click the **Delete** button.

About Pile Group Data

Pile group information is divided into three pages:

Page 1 - Pile Group Wizard - Pile Dimensions and Quality

Pile Group Name The pile group name must be unique within a fuelbed. It is possible to have pile groups in different fuelbeds with the same name.

Pile Shape The shape of all piles in this pile group. Each pile shape requires specific dimensions. A graphical representation of each pile shape is displayed. See "Pile Shape Drawing."

Page 1 - Pile Group Wizard - Pile Dimensions and Quality

Pile Dimensions Enter dimensions for all displayed fields. These dimensions represent the information required to adequately characterize a pile.

Pile Shape Drawing A graphical representation of the pile shape. You may select the pile shape by clicking on a shape name or the check box next to it.

Consume uses the shape and dimensions to determine the volume of the pile.

Page 2 - Pile Group Wizard - Packing Ratio

Packing Ratio (1-3) The ratio of wood volume to the total pile volume, called the packing ratio, ranges from 6 to 26 percent. Select the most appropriate packing ratio from the following three options:

1. Piles with species content dominated by ponderosa pine, with mean diameters of the large woody fuel averaging less than 10 inches, have a packing ratio of 10 percent (0.10).

2. Piles dominated by short-needled conifers have packing ratios from 15 to 20 percent (0.15 to 0.20).

3. Highly compacted, clean piles with larger logs (diameters greater than 10 inches), especially those built with a crane or loader, can have packing ratios as high as 25 percent (0.25).

Page 3 Pile Group Wizard - Other Details

Percent soil by pile volume (%) The percentage of the pile by volume that consists of soil (best estimate). Consume uses "Percent soil by pile volume" to determine the mass of combustible material in the pile.

Page 3	**Pile Group Wizard - Other Details**
Primary Species (>= 50%)	The species that represents a majority of the fuel in this pile. If no single species is greater or equal to 50% then sum the most abundant species until the sum equals or exceeds 50%. Select the most abundant species among those summed to represent the group.
Percent of Primary Species (%)	The percentage of the pile that is the primary species (must be greater that or equal to 50%). Consume uses "percent of primary species" to determine the weighted-average density of the piled fuels.
Secondary Species (<50%)	The species that best represents the remainder of the pile.
Percent of Secondary Species (%)	The percentage of the pile that is the secondary species. Consume will set this amount to 100 minus the Percent of Primary Species. Consume uses "percent of secondary species" to determine the weighted-average density of the piled fuels.
Number of Piles of this type	The number of individual piles included in this pile group. Consume uses "number of piles of this type" to determine the total fuel loading on the burn unit.
Pile Quality	Is the pile clean (0), dirty (> 0 to 10%), or really dirty (10-30%)? Consume uses "pile quality" to determine the appropriate emission factor for particulate matter.

Forest Floor Data

Because most users report forest floor variables in depths, Consume requires dimensional data rather than loadings for forest floor variables including litter, lichen, moss, duff, basal accumulations and squirrel middens. Consume then multiplies the depths (inches) by a bulk density (tons/acres/inch) to obtain loading values. The bulk density depends on the type, derivation and arrangement of litter.

Litter Lichen Moss

LLM Depth (inches) Depth (inches) of litter, lichen, and moss layers.

Percent cover (%) Percent cover (%) of litter, lichen, and moss layers. Maximum is 100% for each layer.

Moss type Type of moss. Click on the down arrow to the right of the toggle box to select from two options (sphagnum or other moss).

Litter arrangement Arrangement of litter layer. Click on the down arrow to the right of the toggle box to select from three options (fluffy, normal, or perched).

Litter type Type of litter. You may enter a relative cover for multiple litter types. Relative covers must sum to 100%.

Ground Fuels - Duff

Duff Depth (inches) Depth (inches) of upper and lower duff layers.

Percent cover (%) Percent cover (%) of upper and lower duff layers. Maximum = 100% for each layer.

Ground Fuels - Duff

Derivation

Derivation of upper and lower duff layers. Click on the down arrow to the right of the toggle box to select from two options for each layer.

Note: Most fuelbeds only contain an upper duff layer. Lower duff layers are characterized by dense, highly decomposed organic matter (humus) and are common in productive conifer forests of the western United States, boreal forests, and wetland sites. Because lower duff has such a high bulk density, incorrectly selecting this will result in unrealistically high loading values for your duff layer.

Ground Fuels - Basal Accumulations

BA Depth (inches) Depth (inches) of basal accumulations.

Basal accumulations are needles, twigs, bark pieces, litter, and duff that accumulate and form over time at the base of trees creating a deeper organic layer than the surrounding area.

BA Radius (ft) Radius (feet) of basal accumulations in feet. Radius is measured from the outer edge of the tree to the outer edge of the accumulation.

BA Percent affected (%) Percentage of trees in fuelbed with basal accumulations.

BA Derivation Derivation of basal accumulations. Click on the down arrow to the right of the toggle box to select from two options for each layer.

Ground Fuels - Squirrel Middens

SM Depth (inches) Depth (inches) of squirrel middens.

Squirrel middens are mounds of cone scales and other cone debris accumulated over time from squirrels exacting seeds. The mounds are composed of very pure organic matter that can burn for extended periods of time. Squirrel middens are generally only found in boreal spruce-dominated forests.

SM Radius (ft) Radius (feet) of squirrel middens.

SM Density (# / acre) Density (number per acre) of squirrel middens.

Recording Weather Data

Weather data from a weather zone is *only* needed if you specify an activity fuelbed and ask Consume to predict an Adjusted 1000-hr fuel moisture.

Weather data are comprised of weather zones and daily weather information. A weather zone is a geographic area in which weather data are collected daily. A weather zone should contain representative weather data for units that are to be treated with prescribed fire.

For example, if a project is in a geographic area represented by a single manual weather station or a remote automatic weather station (RAWS), that area would be a suitable weather zone.

You can use Consume to create, modify, view, and delete weather zones.

To create a new weather zone:

1. Click on the Weather Zone category in the navigation tree and select **New Weather Zone** from the **File** menu.

   Note: The navigation tree is disabled in edit mode. Save or discard current changes to exit edit mode.

2. Input data in the weather zone and daily observation pages.

3. Click the **Save** button or select **Save** from the **File** menu.

Consume will validate data entry and display any problems. If no problems were identified, Consume will save the information. Otherwise, Consume will prompt you to save the information as is, cancel your work, or continue editing.

To view and modify an existing weather zone:

1. Double-click on the **Weather Zone** category in the navigation tree to view a listing of weather zones.

2. Click on a weather zone to view and modify existing data.

3. Make any edits to the weather zone and daily observations pages.

4. Click the **Save** button or select **Save** from the **File** menu.

   Consume will validate data entry and display any problems. If no problems were identified, Consume will save the information. Otherwise, Consume will prompt you to save the information as is, cancel your work, or continue editing.

   Note: To be valid, a weather zone must include daily observations that span the input burn date on the Unit screen. Saving a weather zone in an invalid state will invalidate any fuelbeds that use that weather zone. Making changes and saving the weather zone in a valid state will not revalidate invalid fuelbeds; each fuelbed must be revalidated individually.

To delete a weather zone:

1. Select a weather zone in the navigation tree.

2. Press DELETE on your keyboard or select **Delete** from the **File** menu.

   Consume will prompt you to verify that you wish to delete the weather zone. There is no way to recover a record once it has been deleted, so use delete with care.

   Consume will revalidate the units and fuelbeds saved in your library. Any fuelbeds using the deleted weather zone will be marked as invalid.

Weather Zones

Predictions of fuel consumption in activity fuelbeds rely heavily on estimates of large woody fuel moisture. You can increase the accuracy of large woody fuel moisture predictions by creating as many weather zones as needed to ensure that the events occurring in each fuelbed will be represented as precisely as possible. At a minimum, you should create a weather zone for each weather station.

Each weather zone is characterized by an initial 1000-hour fuel moisture. Fuelbeds that share location and initial fuel moisture can use the same weather zone.

You can determine initial 1000-hour fuel moisture in several ways. The methods are, in order of accuracy, measured, adjusted, and assumed standard values.

About Weather Zone Data

A weather zone is only needed if you want to predict the adjusted 1000-hr fuel moisture for activity fuels. If you know the 1000-hr fuel moisture content, a weather zone is not required. Weather zone data are based on a 24-hour observation period. For example, the observation period could be from 1400 hours to 1400 hours the following day. Weather zone data includes the following information:

Weather – Weather Zones page

Weather Zone Name A unique name for the weather zone. Assign a name to the weather zone that is easy for you *et al.* to remember and identify.

Starting Date The date of the initial weather reading for the weather zone. Type dates as three part dates with either a two- or four-digit year. For example, enter dates as mm/dd/yy or mm/dd/yyyy.

Caution: You must have valid, accurate weather data for the starting date, and for **every** day thereafter. Because you cannot change the starting date, be sure you can obtain reliable weather data for that date and for all subsequent dates.

Initial 1000-Hour Fuel Moisture (%) The moisture content of cured, woody 1000-hour (3- to 9-inch-diameter) fuels on the weather zone's starting date. Fuel moisture is expressed as a percentage of the oven-dry weight of the fuel.

The value for initial 1000-hour fuel moisture must be an integer between 1 and 500.

Weather – Weather Zones page

A note on initial 1000-hr fuel moisture

Consume requires initial fuel moisture to determine adjusted 1000-hour fuel moisture. For Consume to calculate an accurate adjusted 1000-hr fuel moisture, the value you enter in the Initial 1000-hour fuel moisture field must accurately reflect the actual fuel moisture of the large woody fuels on the units in the weather zone. Adjusted 1000-hr fuel moisture is essential in predicting large woody fuel consumption in activity fuelbeds. The more accurate you can be in calculating this variable, the more reliable Consume will be in estimating consumption and emissions.

You can determine initial 1000-hour fuel moisture in several ways. The methods are listed below in decreasing order of accuracy:

1. Measure the fuel moisture by weighing and oven-drying 20 cross sections of 1000-hour fuels collected from units in the weather zone. This is the most accurate method.

2. Use the adjusted 1000-hour fuel moisture estimated by an earlier prototype of Consume, or fuel moisture nomograms (Ottmar and Sandberg, 1985). This method will be accurate only if weather data has been continuously maintained.

Assume that fuel moisture will be 45 percent in April and May, 35-40 percent in summer months, and 50 percent or more in winter months. Use this method only if you cannot use the methods above.

Latitude (degrees)

A measurement of the distance of a site from the equator. Each degree of latitude runs in an east-west direction parallel to the equator. There are 180 degrees of latitude from pole to pole. All weather zones in the northern hemisphere will have a latitude between 0 °N and 90 °N, so the *Latitude* field must contain a number between 0 and 90.

Consume uses latitude to determine the length of the drying day, which is one of the factors used to calculate adjusted 1000-hour fuel moisture.

Recording Daily Weather Data

Once you have created a weather zone, you can use the information to calculate fuel consumption estimates for a burn on the starting date in a weather zone. To get fuel consumption estimates for burns on days subsequent to the starting date, you must enter daily weather data. If you have multiple weather zones, you need to enter daily weather data for each zone.

To predict large woody fuel moisture, Consume requires an uninterrupted sequence of daily weather observations. You must create a daily weather record for each day between the starting date for a weather zone and the burn date. Consume does not allow you to enter daily weather data in non-sequential order. For instance, you cannot enter weather data for June 15 before you enter data for June 14. If you miss a weather observation, use the previous day's weather data, or estimate the data to the best of your ability.

You can add, view, modify, and delete daily weather records and import Weather Information Management System (WIMS) data.

Importing Daily Weather Records

Consume allows you to enter daily weather data directly from the Weather Information Management System (WIMS). To access and export daily observations from WIMS, you must have a user account and working knowledge of this online database program.

When importing data, make sure that your data begins with the date specified in the weather zone definition, and that daily weather information is complete and sequential.

To import daily observations from WIMS:

1. In the navigation tree, select the weather zone to which the daily weather observations will be added.

   Note: The navigation tree is disabled in edit mode. Save or discard current changes to exit edit mode.

2. Select **Import Daily Weather** from the **File** menu.

An Open file dialog will appear.

3. Select the folder and file containing the WIMS data.

4. Click **OK**.

Adding Daily Weather Observations

If you do not have access to the Weather Information Management System (WIMS), you may elect to enter daily observations directly into Consume.

When using daily weather observations to predict large woody fuel moisture, you must include daily weather records for every day between the weather zone's start date and the last date you want Consume to analyze.

As a result, Consume allows you to add a new daily record only for the day immediately following the last record in a zone.

To create a set of daily weather observations:

1. If you have not already done so, create a new weather zone and enter the weather zone inputs on the Weather screen.

   Note: The start date on the weather zone must match the beginning date of your daily observations, and your daily observations data must fall within the minimum and maximum limits you specify for the weather zone.

2. Click on a white data entry cell to begin entering data.

   Note: Consume requires that daily weather records be in sequential order from start date to end date.

3. Click on the **Save** button or select **Save** from the **File** menu.

   Consume will validate data entry and display any problems. If no problems were identified, Consume will save the information. Otherwise, Consume will prompt you to save the information as is, cancel your work, or continue editing.

Viewing and Modifying Daily Observations

If daily observations need to be corrected, you can modify any of the daily observations you have added.

You can view or print a listing of all the daily observations from the Reports Menu. For more information, see "Creating Reports" and “Interpreting Reports."

To view and modify daily observations:

1. Select a Weather Zone from the navigation tree.

   Note: The navigation tree is disabled in edit mode. Save or discard current changes to exit edit mode.

2. Click on the Daily Observations tab on the Weather screen to view the daily observations page.

   Consume displays the daily weather records in rows from the start date to end date.

3. Click on the desired box and change the value. Repeat this step until all changes are completed.

   After you make your first change, Consume will switch to edit mode to remind you that you are making changes.

4. Click the **Save** button or select Save from the File menu to save your changes.

   Consume will validate data entry and display any problems. If no problems were identified, Consume will save the unit information. Otherwise, Consume will prompt you to save the information as is, cancel your work, or continue editing.

Deleting Daily Observations

If you need to remove daily weather records from the screen, you can do so from the weather zone screen, daily weather page.

To delete an individual daily weather record:

1. In the navigation tree, select the weather zone from which daily weather records will be deleted.

2. Click the Daily Observations tab.

   Click a cell in a row that you wish to delete.

3. Click the **Delete Current Row** button..

Note: Consume requires that daily weather records be continuous and in sequential order. If you delete a record in the middle of a range of dates and save your changes, you will receive a validation error. To correct this validation error, enter data for any missing days and save your changes.

About Daily Observations

Daily observations are stored on the second page of the Weather screen. If you want to use a weather zone that is not already saved in Consume, you must create a new weather zone before you can create a daily weather record for it.

Each daily weather record includes the following data:

Observations

Date The date on which the daily weather readings were collected. You must create new records in date order. To modify or view existing weather data, simply scroll through the records to find the desired information.

For example, if the last daily weather entry for a weather zone was July 15, 2000, Consume enters 07/16/00 (July 16, 2000) as the date for the next daily weather entry. You should enter weather data for this date before moving on to the next date.

Weather zone data are based on a 24-hour observation period. For example, the observation period could be from 1400 hours to 1400 hours the following day.

Maximum and Minimum Temperature (degrees F) The highest and lowest air temperature, in degrees Fahrenheit (°F), during the 24-hour observation period for the date in the *Date* field. For example, if the temperature on the starting date ranged from 50 to 75 °F, you would enter *50* in the minimum temperature field and *75* in the maximum temperature field.

Consume uses temperature and humidity data to determine adjusted 1000-hour fuel moisture.

Maximum and Minimum Relative Humidity (%) The highest and lowest relative humidity, during the 24-hour observation period. For example, if the reported relative humidity on the starting date ranged from 35 to 85 percent, you would enter *35* in the minimum relative humidity field and *85* in the maximum relative humidity field.

Consume uses temperature and humidity data to determine adjusted 1000-hour fuel moisture.

Hours of Rain The hours of total rainfall in the 24-hour observation period of the

(hours) date in the Date field.

If more than a trace of rain fell, enter *1*. If rain fell for several hours, enter the cumulative total of all occurrences, rounded up to the next whole hour.

If it was raining at the time of the observation, enter the duration of rainfall up to that time. Account for the remainder of the rainfall the next day (if the total duration of the rainfall for both days exceeds one hour).

Consume uses hours of rain to estimate adjusted 1000-hour fuel moisture.

Significant Rain? Indicates whether the specified day received significant rain. A significant amount of rainfall is 0.25 inches. This amount is necessary to saturate the duff layer. Consume uses significant rainfall to predict duff consumption.

Click the box for each day that received significant rainfall. You may need to scroll to the right to see this column.

Creating Reports and Graphs

Once you have entered all necessary input data, you can create several types of reports to summarize your inputs and predict consumption and emissions.

About Reports and Graphs

The following reports and graphs are available in Consume:

- The **Consumption and Emissions Summary Screen** summarizes consumption, emissions and heat release for a selected project, unit, or fuelbed.
- The **Input Data Report** displays input data for selected projects, units, and fuelbeds.
- The **Weather Zone Report** summarizes weather zone and daily weather observation inputs (only applicable to certain activity fuelbeds).
- The **Consumption by 1000-hour Fuel Moisture Report** displays the quantity of fuels that would be consumed in burns at different values of 1000-hour fuel moisture.
- The **Consumption by Combustion Phase Report** displays total fuel consumption and the quantity of fuels consumed in the flaming, smoldering, and residual phases of a burn. This report also details consumption data by fuelbed stratum and category.
- The **Emissions by 1000-hour Fuel Moisture Report** displays the quantity of emissions from a burn at different values of 1000-hour fuel moisture.
- The **Emissions by Stratum Report** summarizes pollutant emissions from a burn for each fuelbed stratum in selected projects, units, and fuelbeds.

- The **Emissions by Combustion Phase Report** displays total pollutant emissions and the quantity of emissions of a selected pollutant released in the flaming, smoldering, and residual phases of a burn. This report also details emissions data by fuelbed stratum and category.

- The **Heat Release by Combustion Phase Report** displays total heat released and the quantity of heat released in the flaming, smoldering, and residual phases of a burn. This report also details heat release data by fuelbed stratum and category.

- The **Consumption by 1000-hr Fuel Moisture Graph - by Stratum** allows users to view how consumption of selected fuelbed strata varies over a specified range of 1000-hr fuel moistures. Users may view total fuel consumption or fuel consumption in each of the six fuelbed strata in a single graph.

- The **Consumption by 1000-hr Fuel Moisture Graph – by Project / Unit / Fuelbed** allows users to view how consumption varies over an input range of 1000-hr fuel moisture and differs between a project, units and fuelbeds. Users may select total consumption or one or all of the six fuelbed strata to be viewed as separate graphs.

- The **Emissions by 1000-hr Fuel Moisture Graph – by Pollutant** allows users to view how emissions of selected pollutants vary over a specified range of 1000-hr fuel moistures.

- The **Emissions by 1000-hr Fuel Moisture Graph – by Project / Unit / Fuelbed** allows users to view how emissions of a selected pollutant vary over a range of 1000-hr fuel moistures.

Consumption and Emissions Summary Screen

The Consumption and Emissions Summary screen provides a summary of consumption and emissions for any valid project, unit, or fuelbed selected in the navigation tree.

To view a summary of Consumption, Heat Release, and/or Emissions:

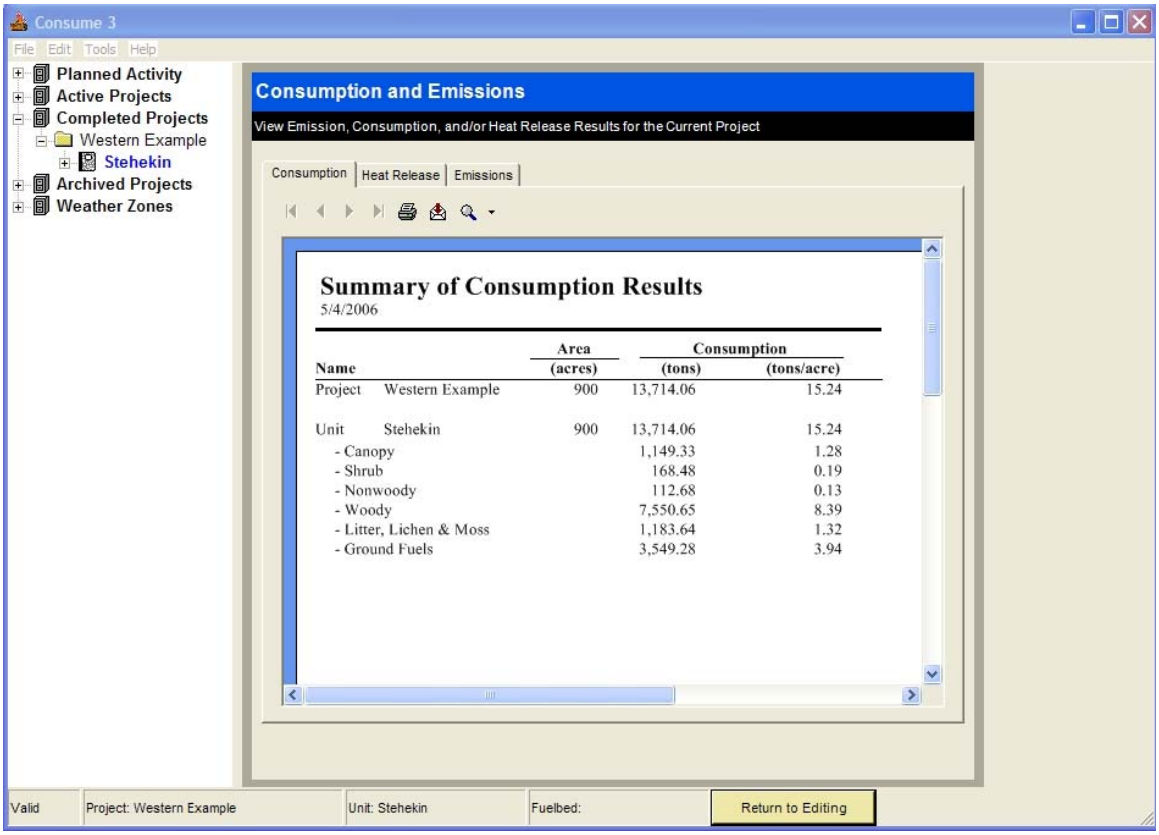
1. Click on a valid project, unit, or fuelbed in the navigation tree.

   Note: Consume cannot calculate results for invalid projects.

2. Click the **Consumption and Emissions Summary** button at the bottom of the main screen or select **Consumption and Emissions Summary** from the **Tools** menu.

3. The Consumption, Heat Release and Emissions summaries are displayed on separate pages. Click on the labeled tabs to switch between pages.

4. Once the Consumption and Emissions Summary Screen is open, you may click on other valid items in the navigation tree to view summary results for each item.



Creating Reports

The Reports screen is accessible whenever you are in browse mode. From the Reports screen, you can select one of several reports and graphs types.

To create a report:

1. Enter the Reports screen by clicking on the **Reports** button at the bottom right of the main screen or select **Reports** in the **Tools** menu.

2. Select a report or from the **Select Report/Graph** pull-down list.

3. Select a project and any project items (i.e., units and fuelbeds) you wish to include in your report.

   Note: All projects, including those that are invalid, are listed in the project menu. Consume can only calculate results for completely validated projects. You may view Input Data and Weather Zone reports for invalid projects, but all other reports require that projects be valid.

4. Enter any report parameters that apply. (Parameters are grayed out if they are not required.)

   Reports involving 1000-hr fuel moisture will require you to input a lowest and highest 1000-hr fuel moisture percentage and a fuel moisture increment.

5. Enter report measurement units if required. (Measurement units are grayed out if they are not required.)

6. Click the **Display Report/Graph** button.

   Note: The **Display Report/Graph** button is inactive until all report parameters have been specified.

   Consume will generate a report and open a viewing screen for it. To return to the reports selection screen, click the Back button at the bottom right of viewing screen.

Viewing, Saving and Printing Reports

Use the toolbar at the top of the Consumption and Emissions Summary screen or Reports viewing screen to view, save and print reports.

The following tools are available in the toolbar:


Moves to first page of the report


Moves one page back


Moves one page forward


Moves to end of report


Goes to specified page number.


Opens print dialog box


Refreshes report screen


Export to file (.pdf, .xls, .doc, .rtf)


Changes report size on screen.

Exiting Reports

Click the **Back** button at the bottom right of the Reports viewing screen to return to the Reports selection screen.

Click the **Return to Editing** at the bottom of the main screen to exit the Reports screens and return to the data entry screens.

Exporting Reports

You can export Consume reports to four file formats including Adobe Acrobat (.pdf), rich text format (.rtf), Microsoft Word (.doc), and Microsoft Excel (.xls).

To export reports:

1. Starting from a Report Output screen, click the envelope icon.

   The Save Dialog screen will appear.

2. Select **Report Format**.

3. Select the destination.

4. Click **OK.**

You might want to use Consume reports in other programs for several reasons:

- *Word processors:* Include report information in a paper, management report, or other document. You can then change fonts, styles, and paragraph formats to make the information more attractive and easier to read.

- *Spreadsheets:* Combine Consume consumption predictions with other data to calculate smoke emission. Create charts that show Consume report information graphically. Present statistical analyses of weather, fuel loadings, consumption, or any other report information.

- *Database management programs:* Retrieve any information in Consume using database querying and reporting tools. Maintain a comprehensive database of all management data by combining Consume report information with information in other databases.

Creating Graphs

Consume supports four graph options to assess how consumption and emissions vary over a range of 1000-hr fuel moistures. If you are planning a prescribed burn, you may wish to use these graphs to determine an optimal fuel moisture range to meet your fuel consumption goals while limiting emissions.

1. **Consumption by 1000-hr FM (by Stratum):** compares consumption among selected fuelbed strata. Consume generates a unique graph for each project, unit and fuelbed specified by the user.

2. **Consumption by 1000-hr FM (by Project/Unit/Fuelbed)**: compares consumption among selected projects, units, and fuelbeds. If multiple fuelbed strata are specified, Consume generates a unique graph for each stratum.

3. **Emissions by 1000-hr FM (by Pollutant):** compares emissions among selected pollutants. Consume generates a unique graph for each Project, Unit and Fuelbed specified by the user.

4. **Emissions by 1000-hr FM (by Project/Unit/Fuelbed):** compares pollutant emissions among selected projects, units, and fuelbeds. If multiple pollutants are specified, Consume generates a unique graph for each pollutant.

To create a graph:

1. Enter the Reports screen by clicking on the **Reports** button at the bottom right of the main screen or selecting **Reports** in the **Tools** menu.

2. Select a graph from the **Select Report/Graph** pull-down list.

3. Select a *valid* project and any project items (i.e., units and fuelbeds) you wish to include in your report.

   All projects, including those that are invalid, are listed in the project menu. However, Consume can only calculate results for completely validated projects.

4. Enter graph parameters including lowest and highest 1000-hr fuel moisture and the increment to plot.

5. Specify which values to include in your graph (fuelbed strata and total).

6. Select either English or Metric system.

7. Specify graph units (lbs or tons if English was selected or kg or Mg if Metric was selected). Click on the corresponding check box if you want results in per unit area.

8. If you have a working copy of Microsoft Excel on your computer, you can view Consume-generated graph results in Excel by clicking on the **Excel** button at the bottom right of the Reports screen.

   If you wish to export the graphics data to be viewed and/or printed in a different program, click the **Export to TextFile** button.

   Note: The **Excel** and **Export to TextFile** buttons are inactive until all necessary parameters have been selected.

9. To return to the Reports screen from viewing graphs in Microsoft Excel, simply exit or minimize Excel.

Saving and Printing Graphs

If you view graph results in Microsoft Excel, you may save the Consume-generated spreadsheets directly in Excel. You may also use print the reports directly in Excel. To return to the Reports screen of Consume, simply exit or minimize Excel.

If you export graph results to file, Consume will save the results as a comma delimited file (.csv). You may import these results in any program that supports comma delimited file formats.

Interpreting Reports and Graphs

This section explains the contents of each type of Consume report. For more information about the calculations Consume uses for reports and graphs see Appendix C.

For information on creating reports, see “Creating Reports.”

Consumption and Emissions Summary Screen

The Consumption and Emissions Summary screen provides a summary of consumption, emissions, and heat release for any valid project, unit, or fuelbed selected in the navigation tree. The following information is included in the three summary reports:

Consumption Summary Report

Area	Area of the selected project, unit, or fuelbed.
Consumption (tons)	Consumption in total tons for the selected project, unit, or fuelbed and by fuelbed stratum.
Consumption (tons/acre)	Consumption in tons per acre for the selected project, unit, or fuelbed and by fuelbed stratum.

Heat Release Summary Report

Area	Area of the selected project, unit, or fuelbed.
Heat release (btu)	Heat release in total btus for the selected project, unit, or fuelbed and by fuelbed stratum.
Heat release (btu/acre)	Heat release per unit area (btu/acre) for the selected project, unit, or fuelbed and by fuelbed stratum.

Emissions Summary Report

Area	Area of the selected project, unit, or fuelbed.
Emissions (tons)	Pollutant emissions in total tons for the selected project, unit, or fuelbed.
Emissions (tons/acre)	Pollutant emissions in tons per acre for the selected project, unit, or fuelbed and by fuelbed stratum.

Interpreting Reports

Input Data Report

The Input Data Report shows all the data you entered in selected Project, Unit and Fuelbeds. You must select a project and at least one unit and fuelbed within that project to include in the input data report.

The first page of the report displays results for the entire project. Units and fuelbeds are listed in hierarchical order on subsequent pages. Click the next arrow in the toolbar to go to the next page of the report.

For more information about each type of data, see "Recording and Managing Data.

Weather Zone Report

The Weather Zone Report displays weather data that have been entered for a selected weather zone. The report lists the initial weather zone data and each daily weather record. The following information is included in a Weather Information report:

Weather Zone Name The unique name of the weather zone.

Date The date of the initial data for the weather zone.

Initial 1000–Hour Fuel Moisture (%) The beginning moisture content of 1000–hour fuels on units represented by this weather zone.

Latitude The latitude (to the nearest degree) of the burn units in this weather zone.

Maximum and Minimum Temperature (degrees F) The highest and lowest air temperature, in degrees Fahrenheit (°F), during the 24-hour observation period for the date in the *Date* field.

Maximum and Minimum Relative Humidity (%) The highest and lowest relative humidity, during the 24-hour observation period.

Rainfall (hours) The hours of total rainfall in the 24-hour observation period of the date in the Date field.

Significant Rain? Indicates whether the specified day received significant rain. A significant amount of rainfall is 0.25 inches.

Consumption by 1000-hr Fuel Moisture Report

The Consumption by 1000-hour Fuel Moisture Report predicts fuel consumption over a range of 1000-hour fuel moistures. You may wish to create a Consumption by 1000-hour Fuel Moisture Report to help determine when a prescribed burn will meet your management objectives.

This report is most useful in assessing the effects of 1000-hr fuel moisture on activity fuel consumption. Natural fuel algorithms place less emphasis on 1000-hr fuel moisture.

The first page of the report displays consumption results for the entire project. If you selected units and fuelbeds, these are listed in hierarchical order on subsequent pages. Click on the forward arrow (►) in the tool bar to go to the next page of the reports.

The following information is included in the Consumption by 1000-hour Fuel Moisture report:

Project The name of the project you are evaluating.

Unit The name(s) of any units within the project. If you selected multiple units within the project, each unit summary is displayed a separate page followed by any fuelbeds within that unit.

Fuelbed The name(s) of any fuelbeds within reported units. If you selected multiple fuelbeds within a unit, each fuelbed will be displayed on a separate page after the unit information page.

Burn Date Date of the burn.

1000–Hour Fuel Moisture (%) The 1000-hr fuel moisture modeled by Consume.

Woody Consumption* Consumption of woody fuels in the project, unit, or fuelbed you are viewing. Woody fuels include sound wood, rotten wood and stumps. Consumption of sound and rotten wood is presented in totals and by size classes.

Other Consumption*	Consumption of other fuels in the project, unit, or fuelbed you are viewing. Consumption is displayed for each of the six fuelbed strata in addition to litter, duff and total fuel consumption for the project, unit, or fuelbed you are viewing.

*Users specify measurement units in the reports selection screen (e.g., tons or tons/acre or Mg or Mg/ha).

Emissions by 1000-hour Fuel Moisture Report

The Emissions by 1000-hour Fuel Moisture Report predicts air pollutant emissions over a range of 1000-hour fuel moistures. You may wish to create an Emissions by 1000-hour Fuel Moisture Report to help determine whether a prescribed burn will meet smoke management objectives.

This report is most useful in assessing the effects of 1000-hr fuel moisture on emission of activity fuels. Natural fuel algorithms place less emphasis on 1000-hr fuel moisture.

The first page of the report displays emission results by pollutant for the entire project. If you selected units and fuelbeds, these are listed in hierarchical order on subsequent pages. Click on the forward arrow (►) in the tool bar to go to the next page of the reports. The following information is included in the Emissions by 1000-hour Fuel Moisture report:

Project The name of the project you are evaluating.

Unit The name(s) of any units within the project. If you selected multiple units within the project, each unit summary is displayed a separate page followed by any fuelbeds within that unit.

Fuelbed The name(s) of any fuelbeds within each reported unit. If you selected multiple fuelbeds within a unit, each fuelbed will be displayed on a separate page after the unit information page.

Burn Date Date of the burn.

1000–Hour Fuel Moisture (%) The 1000-hr fuel moisture modeled by Consume.

Emissions Emissions of each pollutant produced by the prescribed burn in the project, unit, or fuelbed you are viewing. The air pollutants include PM PM_{10} $PM_{2.5}$ CO, CO_2, CH_4, and NMHC.

* Users specify measurement units in the reports selection screen (e.g., tons or tons/acre or Mg or Mg/ha).

Consumption by Combustion Phase Report

The Consumption by Consumption Phase Report predicts total fuel consumption and fuel consumption by the flaming, smoldering, and residual combustion phases of a burn. You may wish to create this report to help determine the amount and type of fuels that will be consumed in a fire.

The first page of the report displays consumption results for the entire project. In addition to total consumption, consumption is calculated by fuelbed stratum and category. If you selected units and fuelbeds, these are listed in hierarchical order on subsequent pages. Click on the forward arrow (►) in the tool bar to go to the next page of the reports. The following information is included in the Consumption by Combustion Phase Report:

Project	The name of the project you are evaluating.
Unit	The name(s) of the units within the project. If you selected multiple units within the project, each unit summary is displayed a separate page followed by any fuelbeds within that unit.
Fuelbed	The name(s) of the fuelbeds within each unit. If you selected multiple fuelbeds within a unit, each fuelbed will be displayed on a separate page after the unit information page.
Burn Date	Date of the burn.
Consumption by Combustion Phase	Consumption by the flaming, smoldering, and residual phases of fire by fuelbed stratum and category. Consumption values are displayed for the project, unit, or fuelbed, depending on which page of the report you are viewing.
Total	Total consumption over all phases of the fire by fuelbed stratum and category. Consumption values are displayed for the project, unit, or fuelbed, depending on which page of the report you are viewing.

* Users specify measurement units in the reports selection screen (e.g., tons or tons/acre or Mg or Mg/ha).

Emissions by Combustion Phase Report

The Emissions by Consumption Phase Report predicts air pollutant emissions for the flaming, smoldering, and residual combustion phases of a burn. You may wish to create an Emissions by Combustion Phase Report to help determine the quantity of emission for each combustion phase of a fire.

If you selected units and fuelbeds, these are listed in hierarchical order below the selected project at various fuel moistures percentages. Click on the forward arrow (►) in the tool bar to go to the next page of the report. The following information is included in the Emissions by Combustion Phase Report:

Project The name of the project you are evaluating.

Unit The name(s) of the units within the project. If you selected multiple units within the project, unit summaries and corresponding fuelbed summaries are listed below the selected project.

Fuelbed The name(s) of the fuelbeds within each unit. If you selected multiple fuelbeds within a unit, each fuelbed is displayed in alphabetic order following the unit summary.

Burn Date Date of the burn.

Emissions by combustion phase Emissions of each air pollutant by the flaming, smoldering, and residual phases of a fire. The air pollutants include PM, PM_{10}, $M_{2.5}$, CO, CO_2, CH_4, and NMHC. Emission values are displayed for the project, unit, or fuelbed, depending on which page of the report you are viewing.

Total Total emissions of each pollutant over all phases of the fire. The air pollutants include PM, PM_{10}, $PM_{2.5}$, CO, CO_2, CH_4, and NMHC. Emissions values are displayed for the project, unit, or fuelbed, depending on which page of the report you are viewing.

* Users specify measurement units in the reports selection screen (e.g., tons or tons/acre or Mg or Mg/ha).

Emissions by Stratum Report

The Emissions by Stratum Report predicts air pollutant emissions by stratum. You may wish to create an Emissions by Stratum Report to assess the contribution of different fuels to air pollutant emissions.

If you selected units and fuelbeds, these are listed in hierarchical order below the selected project. Click on the forward arrow (►) in the tool bar to go to the next page of the report.

The following information is included in the Emissions by Stratum Report:

Project The name of the project you are evaluating.

Unit The name(s) of the units within the project. If you selected multiple units within the project, unit summaries and corresponding fuelbed summaries are listed below the selected project.

Fuelbed The name(s) of the fuelbeds within each unit. If you selected multiple fuelbeds within a unit, each fuelbed is displayed in alphabetic order following the unit summary.

Burn Date Date of the burn

Emissions by Stratum Air pollutant emissions by the six fuelbed strata including canopy, shrub, nonwoody, woody, LLM and ground fuels. The air pollutants include PM, PM_{10}, $PM_{2.5}$, CO, CO_2, CH_4, and NMHC. Emissions values are displayed for the project, unit, or fuelbed, depending on which page of the report you are viewing.

Total Total emissions of each pollutant. The air pollutants include PM, PM_{10}, $PM_{2.5}$, CO, CO_2, CH_4, and NMHC. Emissions values are displayed for the project, unit, or fuelbed, depending on which page of the report you are viewing.

* Users specify measurement units in the reports selection screen (e.g., tons or tons/acre or Mg or Mg/ha).

Heat Release by Combustion Phase Report

The Heat Release by Combustion Phase Report displays total heat released and the quantity of heat that would be released from a burn in the flaming, smoldering, and residual phases of a burn. The report details heat release data by fuelbed stratum and category.

The following information is included in the Heat Release by Combustion Phase Report:

Project The name of the project you are evaluating.

Unit The name(s) of the units within the project. If you selected multiple units within the project, unit summaries and corresponding fuelbed summaries are listed below the selected project.

Fuelbed The name(s) of the fuelbeds within each unit. If you selected multiple fuelbeds within a unit, each fuelbed is displayed in alphabetic order following the unit summary.

Burn Date Date of the burn.

Heat release by combustion phase Heat release (btu/acre) by the flaming, smoldering, and residual phases of fire and by fuelbed stratum and category. Heat release values are displayed for the project, unit, or fuelbed, depending on which page of the report you are viewing.

Total Total heat release (btu/acre) over all phases of the fire by fuelbed stratum and category. Total heat release values are displayed for the project, unit, or fuelbed, depending on which page of the report you are viewing.

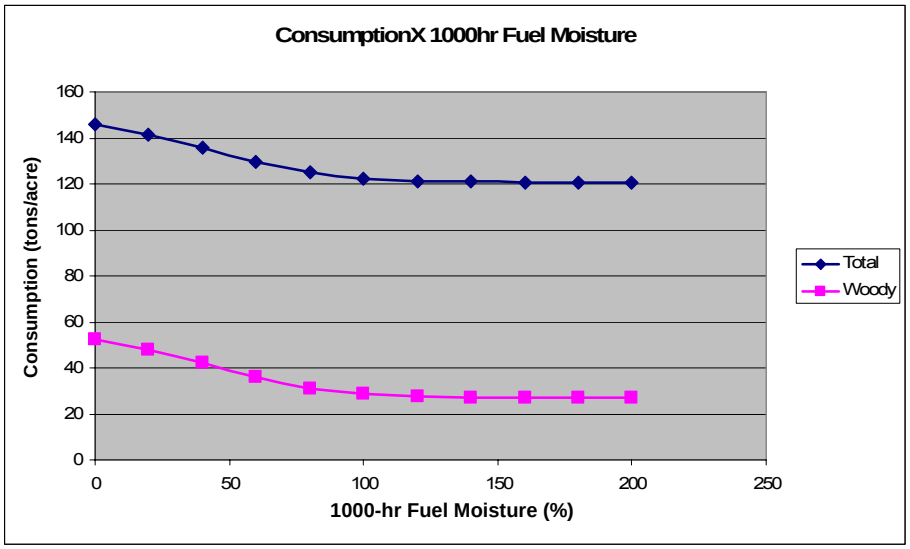
Interpreting Graphs

For information about creating graphs in Consume, see "Creating Graphs" under "Recording and Managing Data."

Consumption by 1000-hr Fuel Moisture Graph (by Stratum)

The Consumption by 1000-hr FM Graph (by Stratum) compares consumption among selected fuelbed strata. At least one of the strata under "Values to Plot" must be selected. Consume generates a unique Microsoft Excel worksheet and graph for each project, unit and fuelbed specified by the user.

The following example presents total project consumption and woody consumption by percentage of 1000-hr fuel moisture



The **Export to TextFile** button creates a comma-delimited file that can be imported into other graphics programs. In this example, the file was parsed into columns:

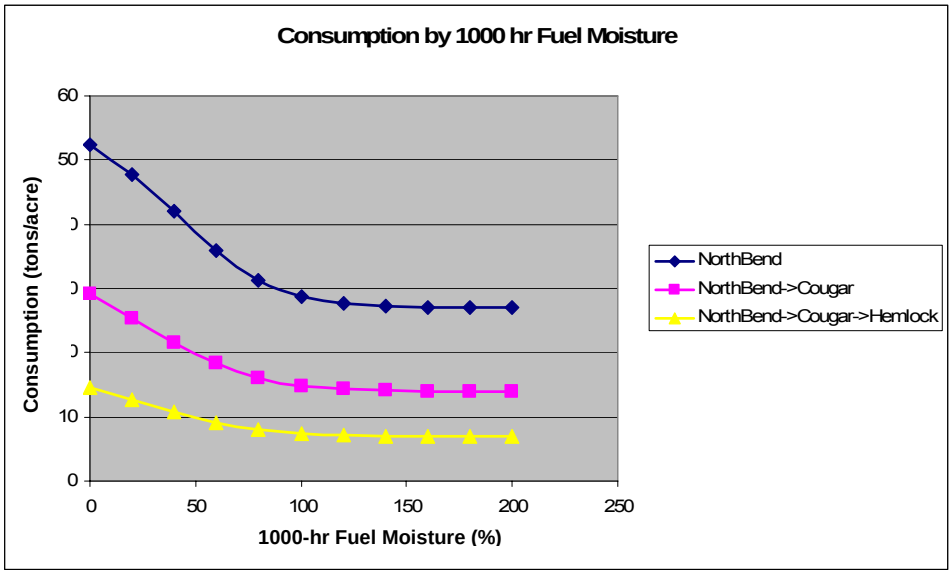
Project NorthBend

FM	Total	Woody
0	145.98	52.29
20	141.43	47.74
40	135.75	42.06
60	129.63	35.94
80	124.89	31.20
100	122.36	28.68
120	121.29	27.61
140	120.88	27.19
160	120.72	27.03
180	120.66	26.97
200	120.63	26.94

Consumption by 1000-hr Fuel Moisture Graph (by Project/Unit/Fuelbed)

The Consumption by 1000-hr FM Graph (by Project / Unit / Fuelbed) compares consumption among selected projects, units, and fuelbeds. At least one of the strata under "Values to Plot" must be selected. If multiple fuelbed strata are specified, Consume generates a unique graph for each stratum.

The following example compares woody fuel consumption in a project, unit and fuelbed combination. The graph was automatically generated in Microsoft Excel by clicking the **Excel** button in Consume.



The **Export to TextFile button** creates a comma-delimited file that can be imported into other graphics programs. In this example, the file was parsed into columns:

North Bend
Woody

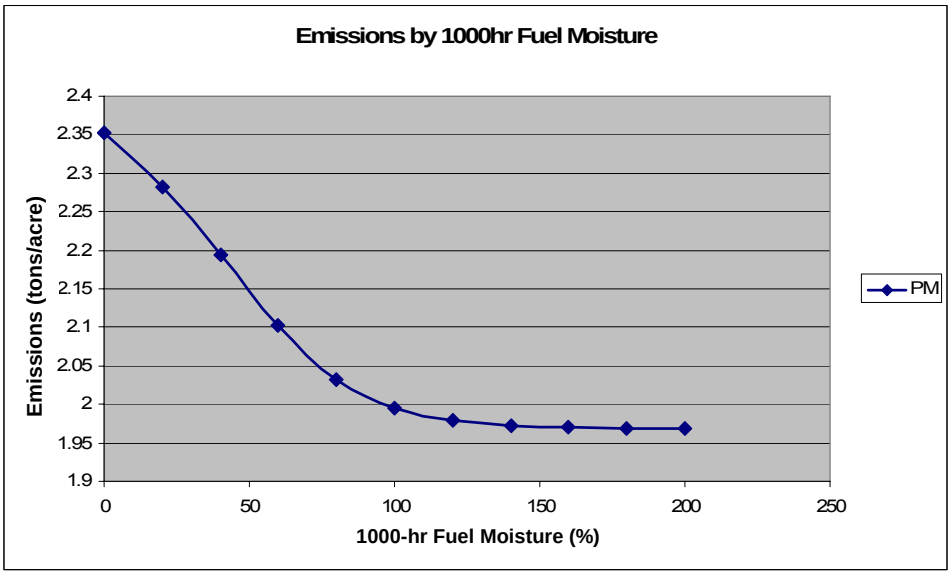
	Project	Unit	Fuelbed
FM	NorthBend	Cougar	Hemlock
0	52.29	29.08	14.54

20	47.74	25.36	12.68
40	42.06	21.54	10.77
60	35.94	18.28	9.14
80	31.20	16.05	8.03
100	28.68	14.88	7.44
120	27.61	14.35	7.18
140	27.19	14.12	7.06
160	27.03	14.03	7.01
180	26.97	13.99	6.99
200	26.95	13.97	6.98

Emissions by 1000-hr Fuel Moisture Graph (by Pollutant)

The Emissions by 1000-hr FM Graph (by Pollutant) compares emissions among selected pollutants. Consume generates a unique graph for each Project, Unit and Fuelbed specified by the user.

The following example compares particulate matter (PM) emissions for an entire project. The graph was automatically generated in Microsoft Excel by clicking the Excel button in Consume.



The **Export to TextFile button** creates a comma-delimited file that can be imported into other graphics programs. In this example, the file was parsed into columns:

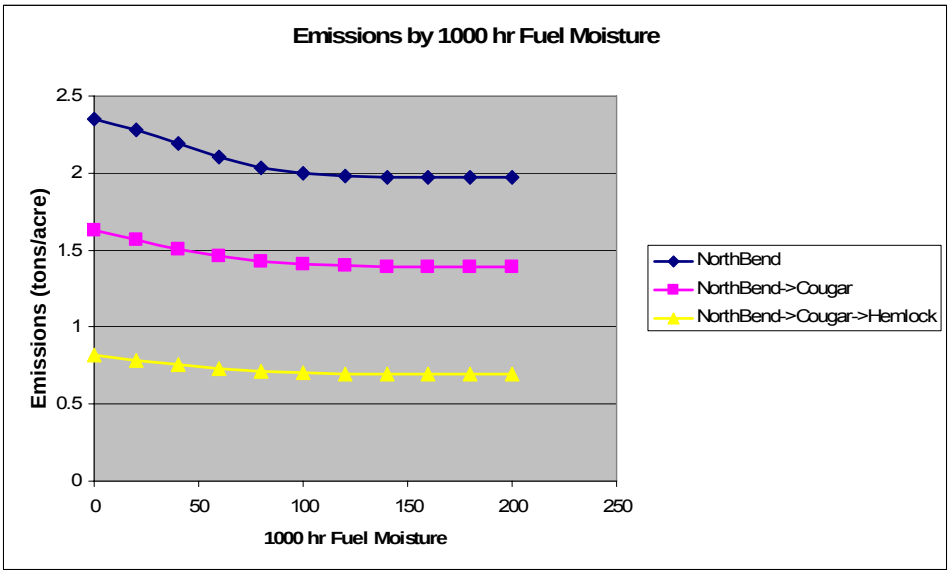
NorthBend
Project NorthBend

FM	PM	
0		2.35
20		2.28
40		2.19
60		2.10
80		2.03
100		1.99
120		1.98
140		1.97
160		1.97
180		1.97
200		1.97

Emissions by 1000-hr Fuel Moisture Graph (by Project/Unit/Fuelbed)

The Emissions by 1000-hr Fuel Moisture Graph (by Project/Unit/Fuelbed) compares pollutant emissions among selected projects, units, and fuelbeds. If multiple pollutants are specified, Consume generates a unique Microsoft Excel worksheet and graph for each pollutant.

The following example compares particulate matter (PM) emissions for a project, unit fuelbed combination. The graph was automatically generated in Microsoft Excel by clicking the **Excel** button in Consume.



The **Export to TextFile** button creates a comma-delimited file that can be imported into other graphics programs. In this example, the file was parsed into columns:

NorthBend
PM

FM	Project NorthBend		Unit Cougar	Fuelbed Hemlock
0		2.35	1.63	0.81
20		2.28	1.57	0.78
40		2.19	1.51	0.75
60		2.10	1.46	0.73
80		2.03	1.42	0.71
10				
0		1.99	1.41	0.70
12				
0		1.98	1.40	0.70
14				
0		1.97	1.39	0.70
16				
0		1.97	1.39	0.70
18				
0		1.97	1.39	0.70
20				
0		1.97	1.39	0.70

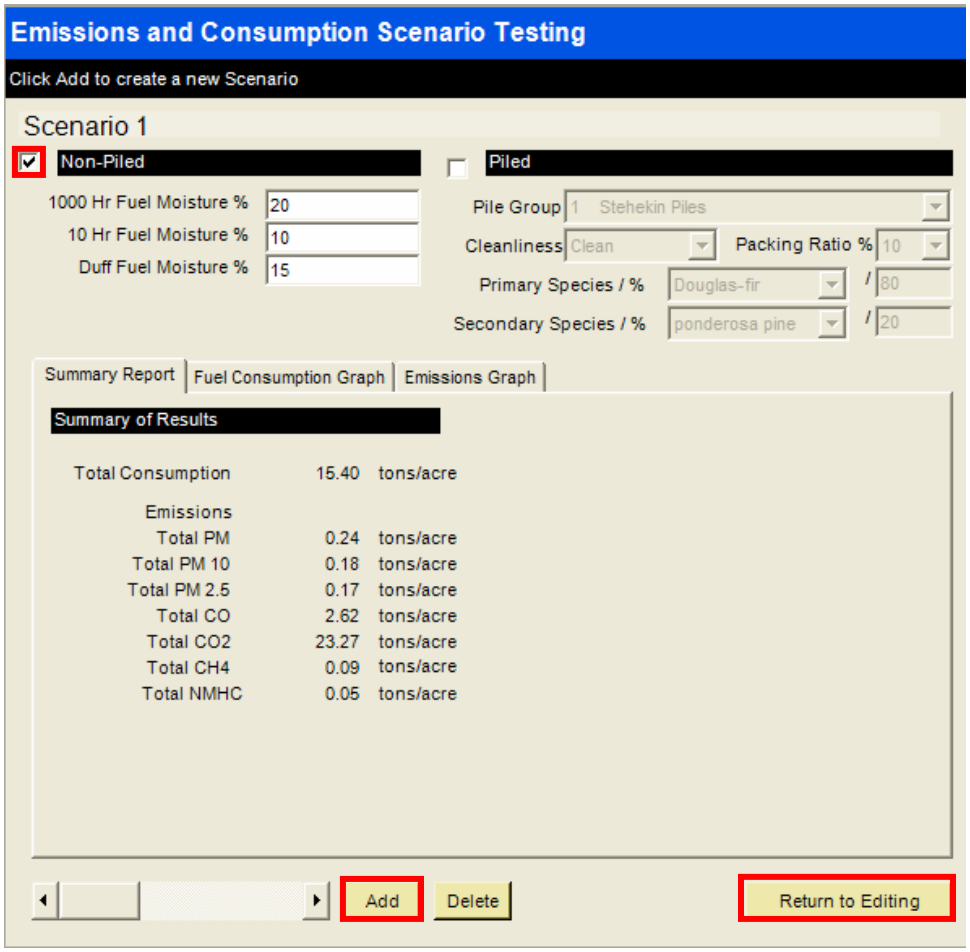
Scenario Testing

You can use the Scenario Testing Tool to examine how environmental variables and pile properties affect estimates of consumption and emissions. The Scenario Testing Tool accommodates up to ten scenarios per fuelbed.

Non-Piled Scenarios

To evaluate how fuel moisture inputs influence non-piled fuel consumption and emissions, check **Non-Piled** and specify fuel moisture inputs for the scenario.

1. Save the scenario by typing CTRL-S, selecting **Save** from the **File** menu or clicking the **Save** button at the bottom of the main screen.
2. Click the **Add** button and repeat the above steps to create up to nine additional scenarios.
3. Once you have created multiple scenarios, you can use the slider bar at the bottom left of the page to scroll between scenarios.
4. To exit the Scenario Testing Tool, click the **Return to Editing** button.

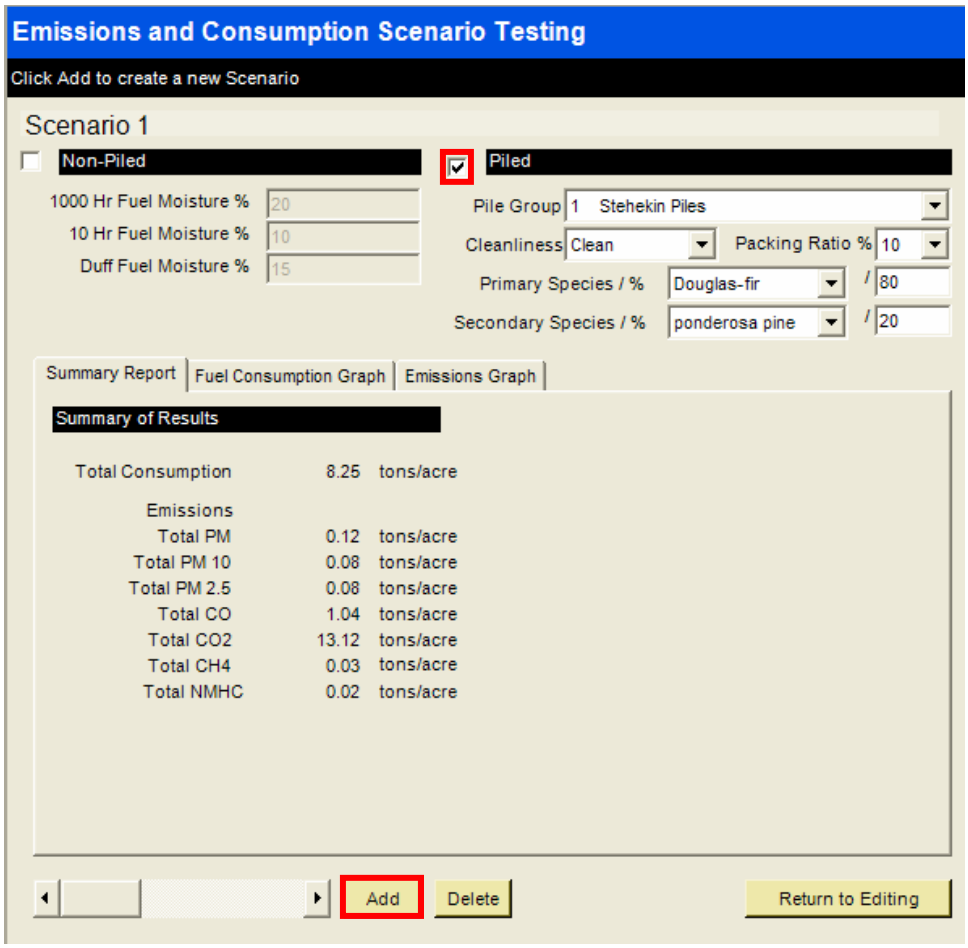

Emissions and Consumption Scenario Testing
Click Add to create a new Scenario
Scenario 1
Non-Piled
1000 Hr Fuel Moisture % 20
10 Hr Fuel Moisture % 10
Duff Fuel Moisture % 15
Piled
Pile Group 1 Stehekin Piles
Cleanliness Clean
Packing Ratio % 10
Primary Species / % Douglas-fir / 80
Secondary Species / % ponderosa pine / 20
Summary Report
Fuel Consumption Graph
Emissions Graph
Summary of Results
Total Consumption 15.40 tons/acre
Emissions
Total PM 0.24 tons/acre
Total PM 10 0.18 tons/acre
Total PM 2.5 0.17 tons/acre
Total CO 2.62 tons/acre
Total CO2 23.27 tons/acre
Total CH4 0.09 tons/acre
Total NMHC 0.05 tons/acre
Add
Delete
Return to Editing

Piled Scenarios

To evaluate how pile properties influence pile consumption and emissions:

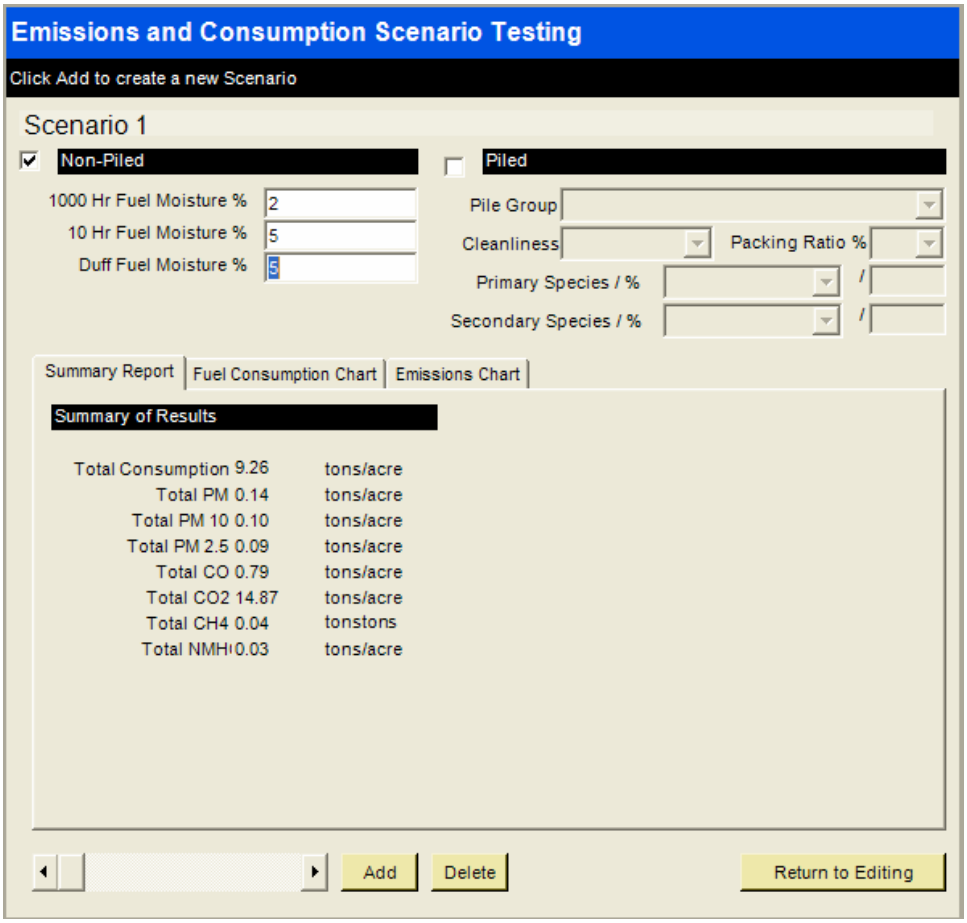
1. Select a valid fuelbed in the navigation tree.
2. Select **Consumption and Emissions Scenario Testing** from the **Tools** menu.
3. Click on the **Add** button at the bottom of the page to add a new scenario.
4. Check **Piled** and specify inputs for the scenario.

   Note: your fuelbed must have piles to use this feature of the scenario testing tool.
5. Save the scenario by typing CTRL-S, selecting **Save** from the **File** menu or clicking the **Save** button at the bottom of the main screen.



Summary Report

To view a summary of consumption and emissions for the current scenario, click on the Summary Report tab. The summary report lists consumption and emissions in tons/acre for your fuelbed under the specified scenario parameters.



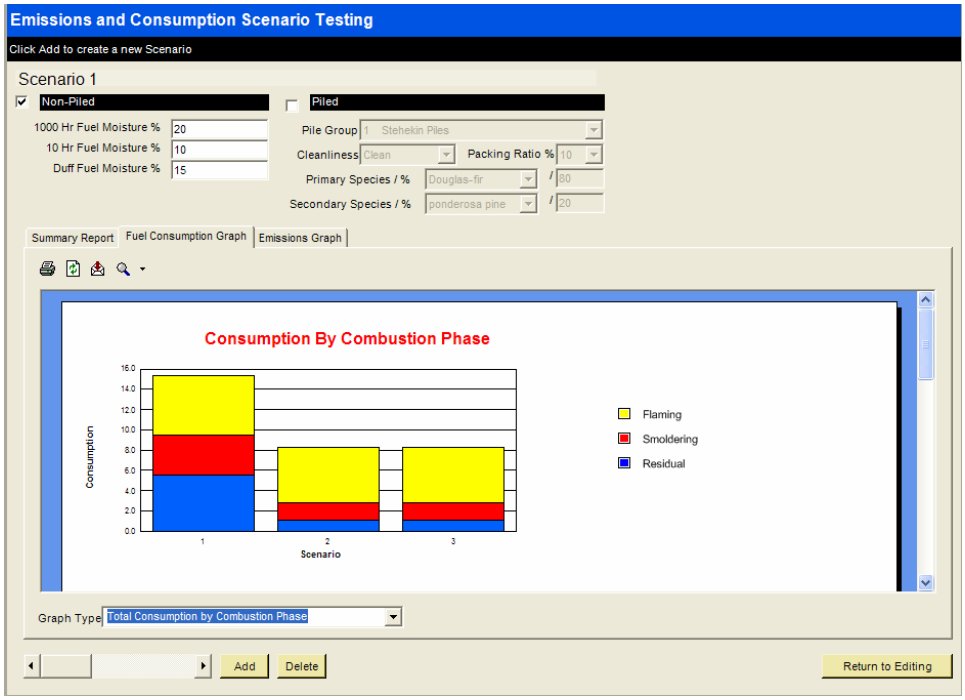
Fuel Consumption Graphs

The scenario testing tool offers a variety of fuel consumption graphs including: Total consumption, Total consumption by combustion phase, Total consumption by stratum, Sound woody fuel consumption by combustion phase, Rotten woody fuel consumption by Combustion Phase, LLM Consumption by combustion phase, Ground fuel consumption by combustion phase and Pile consumption.

To view a fuel consumption graph:

1. Click on the **Fuel Consumption** tab.
2. Select a graph type. Depending on your computer's processing speed, the graph may take a few moments to load. Each graph type compares fuel consumption over all of the scenarios you have created for a particular fuelbed.
3. To print the graph, click on the Printer icon in the tool bar.
4. To export the graph, click on the Export icon in the tool bar.
5. To resize the graph, select a different zoom setting by clicking on the down arrow to the right of the magnifying glass.

***Note**:* the Sound and Rotten woody fuel consumption graphs include continuous downed and dead woody fuels only and do not include piles or stumps.

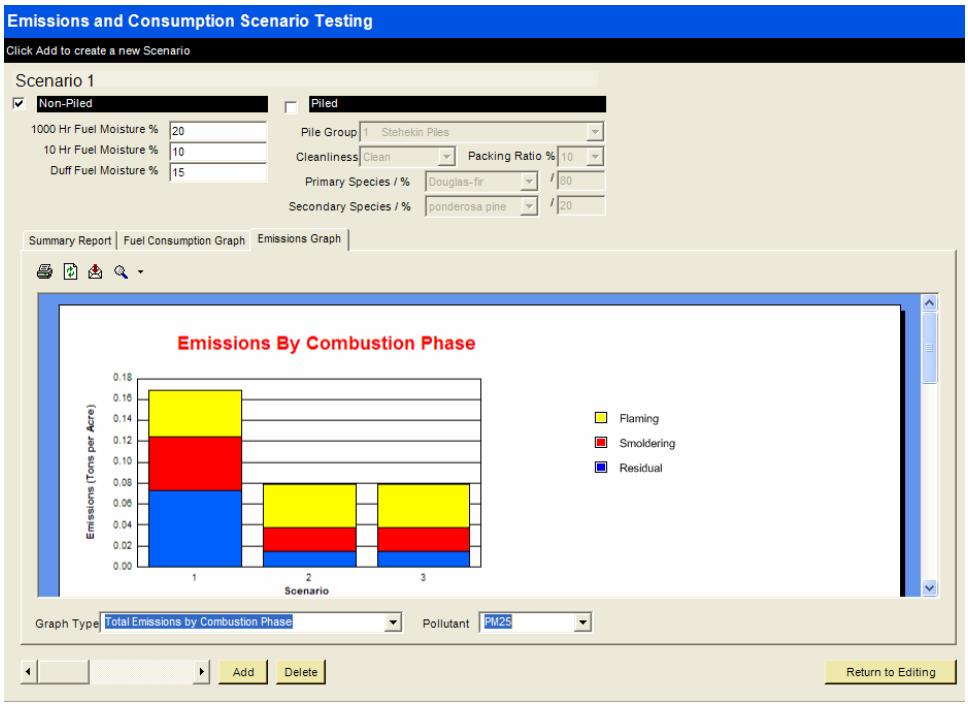


Emissions Graphs

The scenario testing tool offers a variety of emission graphs including: Total emissions, Total emissions by combustion phase, Total emissions by stratum, Woody fuel emissions by combustion phase, LLM emissions by combustion phase, Ground emissions by combustion phase and Pile emissions.

To view an emissions graph:

1. Click on the Emissions tab.
2. Select a graph type. Depending on your computer's processing speed, the graph may take a few moments to load. Each graph type compares emissions over all of the scenarios you have created for a particular fuelbed.
3. To print the graph, click on the Printer icon in the tool bar.
4. To export the graph, click on the Export icon in the tool bar.
5. To resize the graph, select a different zoom setting by clicking on the down arrow to the right of the magnifying glass.



Using Consume in Batch Mode

All Consume 3.0 calculations are handled in a Java-based engine, which can be run in batch mode on a wide variety of operating systems including Macintosh OS, Unix and Linux. Even if you are running Consume on a MS Windows operating system, some applications may be more efficient to run in batch mode. For example, if you wish calculate consumption and emissions from a large number of fuelbeds associated with a GIS mapping project, it may be most efficient to create a single input file and generate a single comma-delimited output report using the Consume batch mode.

Downloading Consume Batch Version

1. Double-click on the **ConsumeBatch.zip** file on the Consume home page:

   http://www.fs.fed.us/pnw/fera/research/smoke/consume/index.shtml

2. Unzip **ConsumeBatch.zip** into a single folder that is readily located from a command line environment. For example: C:\ConsumeBatch\. Four files will be extracted into the folder: ConsumeBatch.jar, Input.xls, ConsumeBatchInput.txt, and SampleOutput.txt.

Editing the Consume Batch Input File

An Excel workbook is included in the Consume Batch files with several supporting worksheets to help you build a batch input file. You may create your own input file by creating a comma delimited file following the specifications listed below.

1. The input file must contain all input variables for each fuelbed in a single, comma-delimited row. There is no limit on the number of fuelbed rows that can be included in your input file.
2. Enter your input data in the Template worksheet or on your own.

3. If you have a complex fuelbed that includes piled and non-piled fuels, the Consume Batch Mode requires that you separate your piled data from non-piled data. Create two separate fuelbeds; one with piled data and the other with non-piled data.
4. If you need help with any input variable, refer to the Input Definitions Worksheet or the "Definition of Batch Input Variables" table provided below.
5. The other Excel worksheets in input.xls provide lookup tables referenced in the Input Definitions Worksheet (Ecoregions, Cover Type, Pile Shape, Wood Density). These tables are also included in Appendix D of this User's Guide.
6. Once you have completed your entries in the input file, delete the header row and save the worksheet in comma delimited format (.csv). There are no restrictions on input filename or extension.

Definition of Batch Input Variables

Full Variable Name	Sample input	Type	Units	Notes (recommended input ranges in parentheses)
Piled or Natural	N	String	n/a	Tells Consume what type of calculation to do per row (P=Piled, N=Non-piled)
Fuelbed Name	FCCS1	String	n/a	
Burn Date	5/5/2005	Date	n/a	(month/day/year)
Treatment Type	1	String	n/a	1=Prescribed burn, 2=Wildland fire for use, 3=Wildfire
FCCS number	27	String	n/a	Imports fuel loadings and other fuels data from FCCS
FCCS custom output file & path		String	n/a	*NOT IMPLEMENTED - In future versions of Consume, this will allow import of a custom fuel loading file from FCCS*
Equation type	1	String	n/a	1=Activity-Boreal, 2=Activity-Southern, 3=Activity-Western, 4=Natural-Boreal, 5=Natural-Southern, 6=Natural-Western. See Ecoregion for a link between Ecoregion division and Consume regional equation types.
CoverTypeID	33	Integer	n/a	See Cover Type for input options. Input Cover type ID (not type number).
Fuelbed Size	100	Double	Acres	0-10,000,000
10 hr Fuel Moisture	60	Double	Percent	0-150

Full Variable Name	Sample input	Type	Units	Notes (recommended input ranges in parentheses)
1000 hr Fuel Moisture	100	Double	Percent	0-200
Duff Fuel Moisture	120	Double	Percent	0-400
Percent of crown consumed	100	Double	Percent	0-100
Shrubland % Blackened	10	Double	Percent	0-100
Ignition duration	20	Long	Minutes	Activity fuels only; 0-72,000 (50 days)
Mid-flame Wind Speed	10	Double	Miles per hour	Activity fuels only; 0-100
Slope	15	Double	Percent	Activity fuels only; 0-100
Days Since Rain	60	Integer	Days	Activity fuels only; 0-365
Source of 1000 hr Fuel Moisture	1	String	n/a	Activity fuels only; 1=MEAS-TH, 2=NFDRS-TH; ADJ-TH not supported in batch mode.
Harvest?	TRUE	Boolean	n/a	Activity fuels only; Has the fuelbed been harvested within the past 3 months? True or False
Snow off?	TRUE	Boolean	n/a	Activity fuels only; Has snow off occurred within the past 3 months? True or False
Number of piles	4	Integer	n/a	Piled fuelbeds only: Number of piles in fuelbed.
Pile Group Name	Group1	String	n/a	Optional for piled fuelbeds; note that pile shape determines required inputs
Pile Shape	2	Integer	n/a	Piled fuelbeds only; Pile shape determines which dimensional inputs are required. See Pile Shape for specifications. 1=Half section sphere, 2=Paraboloids, 3=Half cylinder, 4=Half frustum of cone, 5=Cone with round ends, 6=Half ellipsoid, 7=Irregular solid
Width1	10	Double	Feet	Piled fuelbeds only; Min = 0 (no hard max)
Width2	10	Double	Feet	Piled fuelbeds only; Min = 0 (no hard max)
Height2	10	Double	Feet	Piled fuelbeds only; Min = 0 (no hard max)
Height2	10	Double	Feet	Piled fuelbeds only; Min = 0 (no hard max)
Length1	10	Double	Feet	Piled fuelbeds only; Min = 0 (no hard max)
Length2	10	Double	Feet	Piled fuelbeds only; Min = 0 (no hard max)
Packing Ratio	10	String	Percent	Piled fuelbeds only; 10%, 20% or 30%
Percent of pile that is soil	10	Double	Percent	Piled fuelbeds only; 0-100
Primary wood density	34.3	Double	lbs/ft3	Piled fuelbeds only; See Wood Density LUT
Percent Primary Species	75	Double	Percent	Piled fuelbeds only; 0-100

Full Variable Name	Sample input	Type	Units	Notes (recommended input ranges in parentheses)
Secondary wood density	57.4	Double	lbs/ft3	Piled fuelbeds only; See Wood Density LUT
Percent Secondary Species	25	Double	Percent	Piled fuelbeds only; 0-100
Pile Quality	1	String	n/a	Piled fuelbeds only; 1=Clean, 2=Dirty, 3=Really dirty

Running Consume in Batch Mode

Before you run Consume in batch mode, make sure that you have created a comma-delimited input file and saved it in the same folder as the Consume Batch program file.

1. Open a command prompt (From the Start Menu in MS Windows, select All Programs → Accessories → Command Prompt).
2. Change directories to where the Consume Batch files are stored.

   For example: type: `cd c:\ConsumeBatch`
3. Type: `java -jar ConsumeBatch.jar input_file output_file`

   For example, if your input file is named WAInput.csv and want your output file name to be WAOutput.csv, type:

   ```
   java –jar ConsumeBatch.jar WAInput.csv WAOutput.csv
   ```

   Note: ConsumeBatch.jar is the Consume Batch program file. Your specified input file must be located in the same folder as the ConsumeBatch.jar program file, and the output file will be written to the same folder.

Appendix A: Tips and Cautions

Setting up Consume: When you install Consume, the program contains sample projects and weather zones. When you are ready to start using Consume to enter your own data, you may want to delete the sample project and weather zone data to avoid any confusion.

Using online help: Use Consume**'s** on-line help screens to find information about screens and fields quickly. Select the help index from the **Help** button menu, or press **F1** to view a help screen for the current location of the cursor.

Using the navigation tree: Use the navigation tree to create and view projects, units, fuelbeds and weather zones. The navigation tree is disabled whenever you are editing a data screen. You must save or cancel your changes to use the navigation tree.

Deleting projects: When you delete a project, you are also deleting all units and fuelbeds associated with that project.

Pile groups: When you create pile groups or copy a unit or fuelbed into a project that has fuelbeds, each fuelbed is assigned a unique ID. This id uniquely identifies the pile groups. Unlike Units and fuel beds Pile group names do not have to be unique. The ID number maintains data integrity. It is a good idea, however to name pile groups with distinct names.

Deleting pile groups: When you delete a pile group, it will also delete any pile group scenarios that had been associated with that specific pile Group.

Deleting weather zones: When you delete a weather zone, you also delete all the daily weather records associated with that weather zone. Any fuelbeds that included the deleted weather zone will be marked as invalid.

Initial 1000-hour fuel moisture: When measured or NFDRS 1000-hr fuel moistures are not available for activity fuelbeds, adjusted 1000-hour fuel moisture is critical in predicting large woody fuel consumption. To get accurate adjusted 1000-hour fuel moisture, the value you enter in the Initial 1000-hour fuel

moisture field for a weather zone must accurately reflect the actual fuel moisture of the large woody fuels on the units in the weather zone.

Using Consume reports with word processors: Reports can be saved to specific word processor formats. From the report browse screen, click the envelope icon. You can save your report as a Microsoft Word document (.doc), Excel spreadsheet (.xls), rich text format (.rtf) or Adobe Acrobat file (.pdf).

Using Consume reports with spreadsheet programs: Reports can be saved to specific spreadsheet formats. From the report browse screen, click the envelope icon. You will be prompted to enter the file type. Use a Consume report file in a spreadsheet program to analyze the report information further (for example, to create a chart showing consumption at different levels of fuel moisture).

Making backups: You should make regular backup copies of your weather zone data. Use the Consume export function in the File menu to export your work. Each project and weather zone must be exported individually. Consume will write an export folder to your selected folder. To avoid overwriting this backup folder in the event you would uninstall or upgrade the program, save the export files outside of the Consume program folder.

Managing exported Consume data: You can use exported projects as backups and share them with other Consume users. To avoid corrupting your exported data, keep the export folders intact. The Consume Export File (.cef) relies on seven source xml files in the shared folder.

Importing projects into Consume: Use the Consume import function in the File menu to import new projects or to restore projects from a backup. Consume will ask you to select a Consume Export File (.cef); this file must be stored in a folder with its seven associated xml export files.

Importing weather data into Consume: If you need Consume to estimate an adjusted 1000-hr fuel moisture and have access to daily observation records from the Weather Information Management System, you can use the Consume import function

in the File menu to import daily weather observation files. Consume expects a WIMS daily observation (dobs) file.

Woody Fuel Time lag Categories: This User's Guide refers to fuels by time lag category (1-hr, 10-hr, and so on). The following table shows fuels by time lag category, and their corresponding diameters.

Diameter *(inches)*	**Time lag** *(hrs)*
0.0-0.25	1
0.26-1.0	10
1.1-3	100
3.1-9	1000*
9.1-20	10,000
20.1+	10,000**

* The true definition for 1000-hr fuels is 3 to 8 inches in diameter. However, it is common practice among forest managers to define 1000-hr fuels as 3 to 9 inches in diameter. Consume has adopted the 3- to 9-inch-diameter definition.

**Fuels 20.1 inches or more in diameter have a time lag greater than 10,000 hrs.

Appendix B: Troubleshooting

This appendix provides troubleshooting information. If you do not find the answer to your problem here, see "Consume Support" at the end of this section.

Validation

Every time you attempt to save a new or edited project, unit, fuelbed or weather screen, Consume will validate your data entry. This validation compares your data to a range of allowable entries. The range of values for each entry should accommodate any realistic scenario.

If you have validation error(s), Consume will list the variables that are outside of the hard limits. In some cases a change to one section, (for example, a unit or weather zone) may cause a fuelbed to go invalid. Even after changing the unit or weather zone, you may need to go to the fuelbed and save it to force a re-validation.

The icons of invalid items in the navigation tree are shown in red. Once you have resolved the validation problems, the icons will return to their normal color. The status bar at the bottom of the main screen also indicates if the item you have selected in the navigation tree is valid or invalid.

To display validation errors for an invalid item in the navigation tree:

1. Select the project, unit, fuelbed or weather zone.

2. Select **Save** from the **File** menu or type CTRL-S.

3. Consume will list any validation errors associated with the selected item and ask you if you still wish to save it.

4. Correct the validation problems and resave your work on each screen that had validation errors.

5. Consume will revalidate each item upon saving. If no problems were identified, Consume will save the information.

If problems remain, Consume will list them as validation errors.

Consume Support

For more help on installation or use of Consume, contact the Consume support help desk by one of the following methods:

On the Web: Go to:
http://www.fs.fed.us/pnw/fera/products/consume.html

By E-mail: Send questions or comments to
consumehelp@fs.fed.us .

To ensure timely receipt of future updates to Consume, please email us with your contact information.

By Phone: Contact the Fire and Environmental Applications Team of the Pacific Wildland Fire Sciences Laboratory, Pacific Northwest Research Station, USDA-Forest Service at (206) 732-7826.

Appendix C: Scientific Background

This appendix provides scientific background for the Consume program, including:

- An introduction to the research and assumptions on which Consume is based.
- A general overview of the algorithms Consume uses.
- Documentation of the major equations used to calculate consumption.

Flowcharts

The following paragraphs describe the symbols used to depict the flow of the program. All the charts flow from the top down. Side branches show the relative order of data used during the processing of the calculations.

Rectangles represent input data, including any measured or estimated value that is necessary for the calculations performed by Consume. Examples are fuel loadings, fuel moisture measurements, duff depth, and weather data.

Hexagons represent processes. These processes may contain any number of individual calculations. The result of the process is represented by the title of the process (e.g., duff reduction). Examples are consumption calculations, fuel moisture estimates, and duff reduction equations.

Diamonds represent a decision. Consume must often choose between different processes according to conditions present on a unit to calculate various parameters properly. The diamond shape shows where a decision is made, and the paths taken as a result of the decision.

Introduction

In the early 1980s, the Fire and Environmental Resource Application Group (FERA) of the Pacific Northwest Research Station began to develop fuel-consumption models and emission factors for prescribed burning planning in the Pacific Northwest. Consume 1.0 incorporated a set of consumption algorithms formulated from data collected at operational burns. During the 1990's, FERA began developing models of fuel consumption by combustion stage for other fuel types beyond the Pacific Northwest and different configurations of fuels. In addition, FERA began developing a new system to characterize fuels called the Fuel Characteristic System that allowed managers to select different fuel loadings for input into Consume**.**

Consume 2.1 included calculations for activity-piled, activity-non-piled, and natural fuels. In addition, Consume 2.1 allowed the user to use measured 1000-hr (MEAS-Th), adjusted 1000-hr (ADJ-Th), or NFDRS 1000-hr (NFDRS-Th) fuel moisture values to calculate fuel consumption for activity, non-piled fuels. Finally, emission factors were added to Consume 2.1, allowing estimation of emissions.

FERA received a grant from the Interagency Joint Fire Science Program (JFSP) to enhance Consume by predicting fuel consumption and smoke emissions in all wildland fuelbeds in the United States. Consume 3.0 includes new consumption algorithms based on recent research on the flaming and smoldering combustion phases in various natural fuelbed types in the United States. The recently released Fuel Characteristic Classification system has also been incorporated into Consume 3.0 to make use of the national fuelbed database of fuelbed loadings.

Consume Algorithms

Consume includes separate equations to calculate consumption of activity, natural and piled fuels**.** Each equation set is discussed separately in the following sections.

Activity Fuels Algorithms

Activity fuels are defined as fuels resulting from or altered by forestry practices such as timber harvesting or thinning. Consume 3.0 uses many of the same equations as in Consume 2.1 with the following modifications: Canopy, shrub, and nonwoody vegetation, basal accumulation and squirrel midden equations are new and are the same whether fuels are designated as activity or natural. The equations have been modified slightly to accommodate small changes in the Consume 3.0 user interface. Woody fuel accumulations, including jackpots, piles and windrows are calculated by the Consume 2.1 pile group wizard but are listed in the Woody fuels stratum. Litter-lichen-moss and ground fuel consumption are calculated from empirically based forest floor reduction equations developed for natural fuels.

Summary of activity fuel equations

Stratum	Equations used
Canopy	Default equations (applicable to activity and natural fuels). Details are provided under natural fuel equations.
Shrub	Default equations (applicable to activity and natural fuels). Details are provided under natural fuel equations.
Nonwoody vegetation	Default equations (applicable to activity and natural fuels). Details are provided under natural fuel equations.
Woody fuels	Sum of sound, rotten, stumps and woody fuel accumulations.
Sound wood	Sum of sound wood subcategories.
0 to ¼ inch	100% flaming consumption.
¼ to 1 inch	100% flaming consumption.
1 to 3 inches	100-hr equation from Consume 2.1.
3 to 9 inches	1000-hr equation from Consume 2.1.
9 to 20 inches	10,000-hr equation from Consume 2.1.
> 20 inches	> 10,000-hr equation from Consume 2.1.

Stratum	Equations used
Rotten wood	Sum of rotten wood subcategories.
3 to 9 inches	1000-hr equation from Consume 2.1.
9 to 20 inches	10,000-hr equation from Consume 2.1.
> 20 inches	> 10,000-hr equation from Consume 2.1.
Stumps	Default equations (applicable to activity and natural fuels).
Woody fuel accumulations	See pile group equations.
Litter-Lichen-Moss	Default equations (applicable to activity and natural fuels).
Ground fuels	Sum of Duff, Basal accumulations and Squirrel middens.
Duff	Duff equations from Consume 2.1.
Basal accumulations	Default equations (applicable to activity and natural fuels)
Squirrel middens	Default equations (applicable to activity and natural fuels). Valid only for boreal region fuelbeds.

Canopy Consumption

See Natural Fuels Equations – Canopy Stratum.

Shrub Consumption

See Natural Fuels Equations – Shrub Stratum.

Nonwoody Vegetation Consumption

See Natural Fuels Equations – Nonwoody Vegetation Stratum.

Woody Fuel Consumption

Small (1-hr and 10-hr) Woody Fuel Consumption

Consume assumes that all 1-hr and 10-hr activity fuels are consumed during a burn in the flaming phase of combustion, regardless of weather, location, or other conditions. Managers generally do not meet objectives if they burn a unit when only a small portion of the 1-hr and 10-hr fuels are consumed.

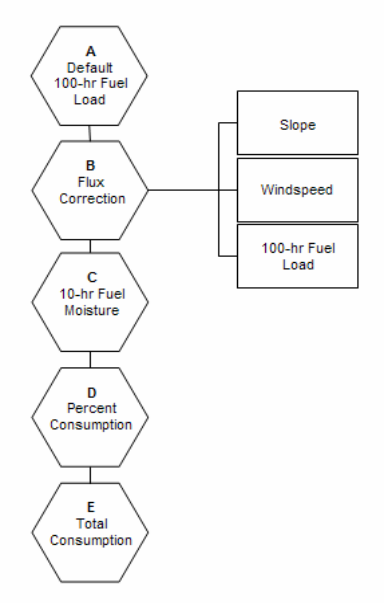
The consumption of 1-hr and 10-hr fuels equals their pre-burn loadings in tons per acre.

1-hr Fuel Consumption (tons/acre) = 1-hr Fuel Load (tons/acre)

10-hr Fuel Consumption (tons/acre) = 10-hr Fuel Load (tons/acre)

Medium (100-hr) Woody Fuel Consumption

The equations for 100-hr fuel consumption were derived from fuel consumption theory, with several of the coefficients determined from a burn study (Ottmar *et al.* 1990) and from fire spread research (Rothermel 1972). The following flow chart shows the factors that are used in determining 100-hr fuel consumption. Consume uses this algorithm to calculate consumption of 100-hr fuels. The lettered equations are explained below.



Equation A: Default 100-hr fuel load

Consume currently assumes a default 100-hr fuel load of 4.8 tons per acre (Howard 1981, Ottmar *et al.* 1993).

Default 100-hr Fuel load (tons/acre) = 4.8

Equation B: Heat flux correction

A theoretical heat flux correction formula is used to calculate the drying of fuels during ignition and consumption. Consume calculates the heat flux correction based on a ratio of 100-hr fuel loading, default 100-hr fuel loading, slope, and wind speed.

$$\textbf{Heat Flux Correction}\ \text{(dimensionless)} = \left(\frac{\text{100-hour Fuel Load}}{\text{Default 100-hour Fuel Load}}\right) * \left(1 + \frac{\text{Slope - 20}}{60} + \frac{\text{Windspeed}}{4}\right)$$

100-hr Fuel Load (tons/acre)**:** 100-hr fuel loading of unit.

Default 100-hr Fuel Load (tons/acre): Default value of 4.8.

Slope (%): Average slope of fuelbed.

Wind speed : Mid-flame wind speed at time of burn (miles/hr).

20 (%): Slope of typical fuelbed.

60 (dimensionless): Coefficient (slope required to double rate of fire spread [Rothermel 1972]).

Equation C: 10-hr fuel moisture correction

Consume uses 10-hr fuel moisture as part of the calculation to determine percent consumption of 100-hr fuels, 10-hr fuel moisture is adjusted based on propagating heat flux correction (Equation B).

$$\textbf{10-hr FM Correction}\ (\%) = \text{Fuel Moisture Flux (\%)} * \left(\frac{\ln(\text{Heat flux correction})}{\ln(2)}\right)$$

Fuel Moisture Flux (%): 3.0 % (amount of change in moisture content for each doubling of flux [Rothermel 1972]).

Heat Flux Correction (dimensionless): See Equation B.

Equation D: Adjusted 10-hr fuel moisture content

The 10-hr fuel moisture correction from Equation C is used to adjust 10-hr fuel moisture (%), using the following equation:

Adjusted 10-hr Fuel Moisture (%) = 10-hr FM - 10-hr FM Correction

10-hr FM (%): Fuel moisture of 0.25-1 inch woody fuels

10-hr FM Correction (%): See Equation C.

Equation E: Percentage consumption of 100-hr fuels

Consume uses the following theoretical equation to determine percentage consumption of 100-hr fuels.

For units with an adjusted 10-hr fuel moisture < 26.7%:

Percent 100-hr Consumption (%) = 0.9 - (Adjusted 10-hr FM - 12) * 0.0535

Adjusted 10-hr Fuel Moisture (%): See Equation D.

12 (%): Moisture content at which 100-hr fuels will not completely consume. (Rothermel 1972).

0.0535 (dimensionless): Slope of the line determined from actual data regression. (Ottmar *et al.* 1990).

For units with an adjusted 10-hr fuel moisture < 29.3%:

Percent 100-hr Consumption (%) = -169.08+ (Adjusted 10-hr FM) * 18.393 – (Adjusted 10-hr FM)^2 * 0.6646+ (Adjusted 10-hr FM)^3 * 0.00798

Note: This equation serves to smooth the %100-hr consumption equation.

For units with an adjusted 10-hr FM ≥ 29.3%:

% 100-hr Consumption (%) = 0

Equation F: Total 100-hr fuel consumption

Using the percentage of consumption (Equation E), Consume calculates the total consumption of 100-hr fuels in tons per acre.

Total 100-hr Fuel Consumption (tons/acre) = 100-hr Fuel Loading * (% 100-hr Fuel Consumption/100).

100-hr Fuel Loading (tons/acre)**:** Loading of 1-3 inch woody fuels.

Percent 100-hr Fuel Consumption (%)**:** See Equation E. Percent 100-hr Consumption is confined to 0-100%.

Large Woody Fuel Consumption

1000-hr fuel moisture

The average fuel moisture content of 1000-hr fuels in a unit to be burned is by far the most critical variable in determining how much fuel will be consumed (Sandberg and Ottmar 1983). The three types of 1000-hr fuel moisture readings that can be used in Consume are described below:

- **Measured 1000-hr fuel moisture (Meas-Th):** A 1000-hr fuel moisture derived by from collected fuel samples is the most accurate fuel moisture but is also very time-consuming to obtain. Twenty logs across the unit must be sampled, and the samples must be weighed then oven dried and reweighed to determine % moisture content
- **National Fire Danger Rating System 1000-hr fuel moisture (NFDR-Th):** This is the least accurate estimate of 1000-hr fuel moisture, but it is relatively east to obtain through use of nomograms of the NFDR-Th computer model (Deeming *et al.* 1977). It is based on daily relative humidity, temperature, and precipitation.
- **Adjusted 1000-hr fuel moisture (ADJ-Th):** This 1000-hr fuel moisture estimate is nearly as accurate as a measured 1000-hr fuel moisture. It is derived by the ADJ-Th model, which is almost identical to the NFDR-Th model. The NFDR-Th model predicts the *lowest* average fuel moisture, while the ADJ-Th model predicts *average* fuel moisture. The ADJ-Th can be obtained by using nomograms or the Consume computer model (Peterson and Ottmar 1991).

Adjusted 1000-hr Fuel Moisture

When the Consume User's Guide refers to the 1000-hr fuel moisture content, it refers to the moisture content of sound, woody material 3-8 inches in diameter that has been directly measured (MEAS-Th) or estimated using the ADJ-Th or NFDRS-Th fuel moisture models. Direct measurement of the 1000-hr fuel moisture content is the best predictor of fuel consumption. The adjusted 1000-hr

fuel moisture content is nearly as good a predictor as the measured and superior to the NFDRS-1000 hr value (Ottmar and Sandberg 1985).

Consume contains the adjusted 1000-hr fuel moisture model and can estimate this variable. The model is a modification of the 1000-hr fuel moisture model of the National Fire Danger Rating System to make better predictions for the consumption of Douglas fir, hemlock, mixed conifer, and lodgepole pine fuels common to the Pacific Northwest. The adjusted 1000-hr fuel moisture model requires daily measurements of rain duration, maximum and minimum relative humidity, and maximum and minimum temperature. For a detailed description of the model, see Ottmar and Sandberg (1985).

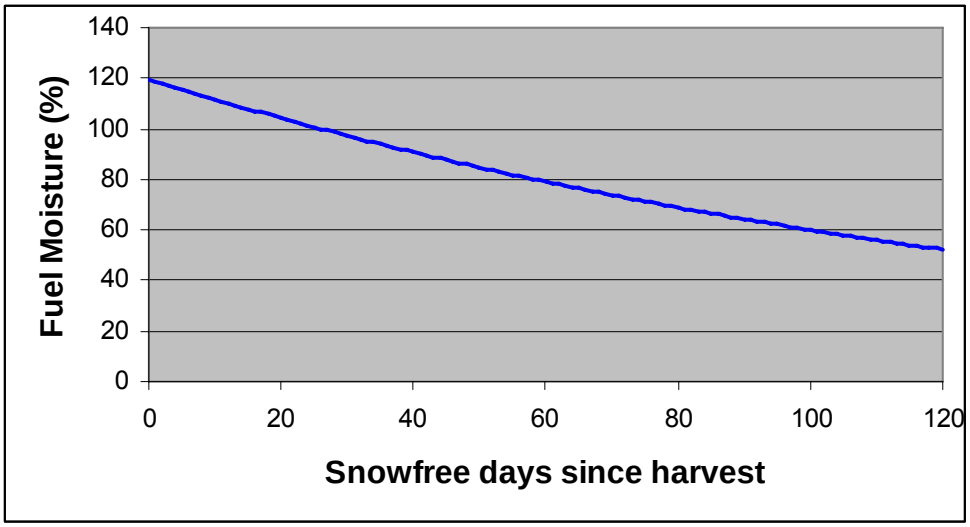
Diameter Reduction

Diameter reduction (DRED) is the reduction of the diameter of a cylindrical log caused by fire. It is measured in inches. Consume uses days of curing, fuel moisture, and consumption of 100-hr fuels to estimate the diameter reduction of large woody fuels. Diameter reduction for 1000- and 10,000-hr fuels is independent of the original diameter (Sandberg and Ottmar 1983). The flow chart and equations located on the following pages explain how Consume estimates diameter reduction.

Equation G: Evaluating if curing has occurred

After a harvest, wood is considered uncured if it has not had sufficient time to dry. Consume 3.0 considers wood cured if it reaches 60%. If a harvest has occurred within the last 3 months and/or snow off has not occurred, then wood is considered uncured. It takes approximately 3 months of snow-free days for wood to cure following harvest, as demonstrated by the following equation:

Uncured Fuel Moisture = $119.64\ e^{(-0.0069 * \text{Snow free days since harvest})}$

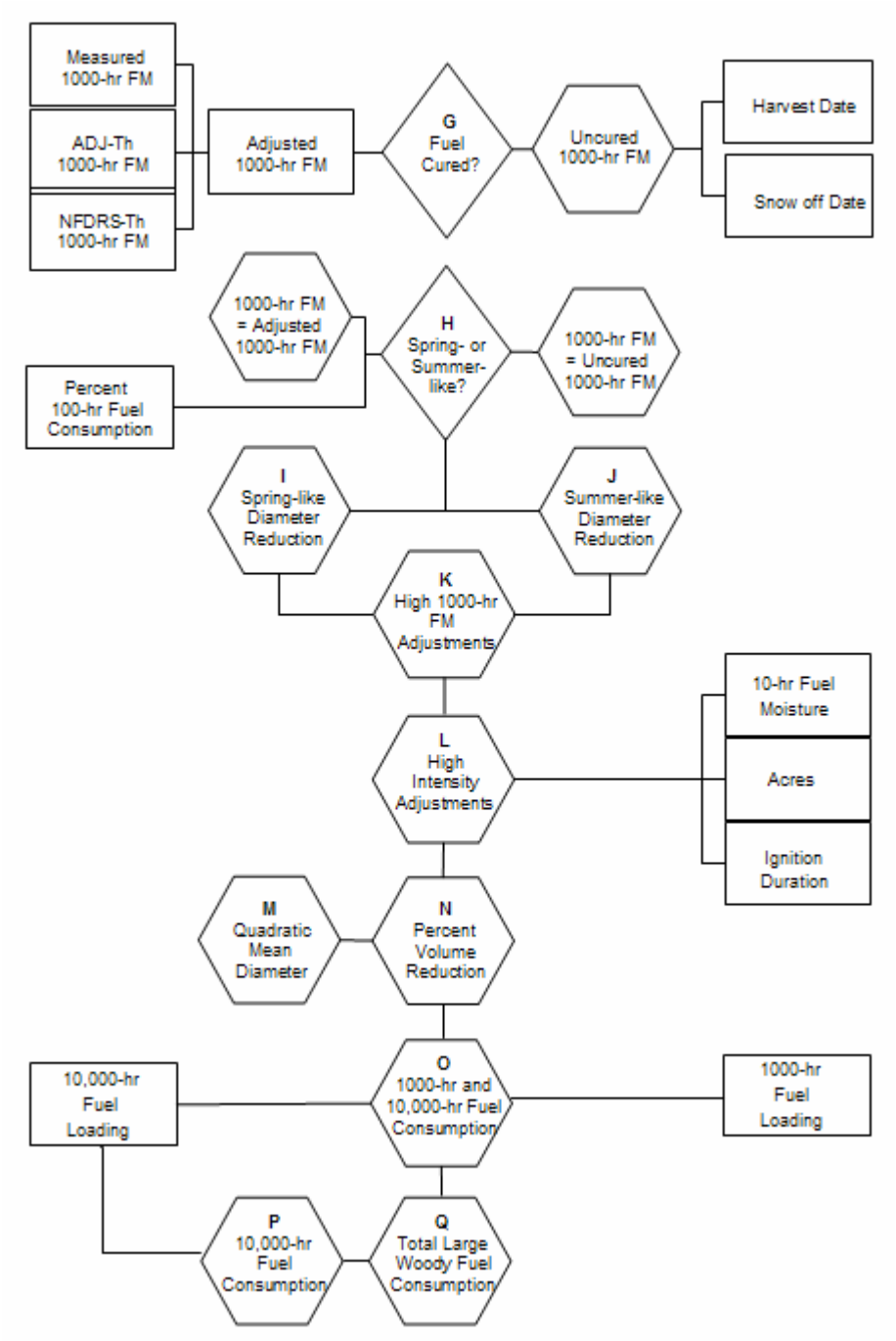


Consume then determines if the uncured fuel moisture is greater than the 1000-hr fuel moisture input by the user. If it is, Consume uses it instead of the 1000-hr fuel moisture in the diameter reduction equations (Equations I, J, K, and L).

Third, Consume determines if the selected 1000-hr fuel moisture (regardless of 1000-hr fuel moisture or uncured fuel moisture) is greater than 60%. If it is, the large woody fuels are uncured, and Consume uses the uncured fuel moisture in the diameter reduction equations (Equations I, J, K, and L). If 1000-hr fuel moisture is less than or equal to 60%, it is considered cured.

Consume uses this algorithm to calculate consumption of large (1000-hr and 10,000-hr) woody fuels. The lettered equations are explained below.

Large Woody Fuel Algorithm



Equation H: Evaluating whether spring-like burning conditions occurred

Consume uses the percent consumption of 100-hr fuels to find whether burning conditions are spring-like or summer-like. Between 75 and 85%, Consume uses a step function to smooth the transition between spring-like and summer-like conditions.

Burning conditions	**Percent 100-hr Fuel**
Spring-like	> 80 %
Summer-like	< 80 %
Transitional (triggers step	75-85 %

Equation I: Spring-like diameter reduction equation

If the consumption of 100-hr fuels is less than 80%, conditions are spring-like, and Consume uses one of the following equations to calculate diameter reduction in inches, depending on the type of fuel moisture data available (Ottmar *et al.* 1990):

Diameter Reduction (inches) = [-0.097 * (MEAS-Th)] + 4.747

Diameter Reduction (inches) = [-0.096 * (ADJ-Th)] + 4.6495

Diameter Reduction (inches) = [-0.120 * (NFDRS-Th)] + 4.305

Equation J: Summer-like diameter reduction equation

If the consumption of 100-hr fuels is greater than 80%, conditions are summer-like, and Consume uses one of the following equations to calculate diameter reduction in inches, depending on the type of fuel moisture data available (Ottmar *et al.* 1990):

Diameter Reduction (inches) = [-0.108 * (MEAS-Th)] + 5.68

Diameter Reduction (inches) = [-0.125 * (ADJ-Th)] + 6.27

Diameter Reduction (inches) = [-0.150 * (NFDRS-Th)] + 5.58

Equation K: High fuel moisture diameter reduction

If the 1000-fuel moisture is high (> 44%), it is necessary to smooth diameter reduction so that it approaches but never reaches zero. This prevents a negative diameter reduction. Once the diameter reduction drops to 0.5 inches or less, the following equations are used to estimate diameter reduction:

If the adjusted 1000-hr fuel moisture is between 44 and 60%, use the following equations to calculate diameter reduction in inches, depending on the type of fuel moisture data available:

Diameter Reduction (inches) = [-0.0178 * (MEAS-Th)] + 1.499

Diameter Reduction (inches) = [-0.0178 * (ADJ-Th)] + 1.499

Diameter Reduction (inches) = [-0.0178 * (NFDRS-Th)] + 1.499

If the adjusted 1000-hr fuel moisture is > 60%, Consume uses the following equation, regardless of the type of moisture data:

Diameter Reduction (inches) = [-0.005 * (1000-Th)] + 0.731

Equation L: High-intensity fire adjustment to diameter reduction

The intensity of fire can limit the consumption of large woody fuels. Mass ignition causes small fuels to be consumed more rapidly, thereby increasing the intensity of the fire. This can shorten the fire duration, causing large fuels to absorb less energy and have less consumption. Consume takes this into account by reducing the amount of diameter reduction of 1000-hr and 10,000-hr fuels as fires increase in intensity.

Several variables influence the possible levels of fire intensity. Consume uses 10-hr fuel moisture, duration of ignition time unit size, and the 1000-hr fuel moisture to determine fire intensity. The following table approximates how fire intensity affects diameter reduction (DRED).

Fire intensity	Approximate DRED reduction (%)
Extreme	33
Very high	22
High	11
Medium	Not reduced

Extreme-intensity fires

Consume uses the following factors to determine whether a fire is of extreme intensity:

- 10-hr fuel moisture content must be less than 15%,
- The 1000-hr fuel moisture must be less than or equal to 40%, or
- Unit size must be greater than or equal to 10 acres.

If a fire meets these conditions, Consume then evaluates if the size of the burn and speed of ignition result in a mass ignition. If ignition duration is less than maximum ignition duration, the intensity of the fire is extreme. Consume reduces diameter reduction by around 22 to 33%, depending on the 10-hr fuel moisture and the 1000-hr fuel moisture.

For units of 10 to 20 acres:

Maximum Ignition Duration (minutes) = Acres

For units of more than 20 acres:

Maximum Ignition Duration (minutes) = (0.5 * Acres) + 10

Maximum Ignition Duration (minutes): The total number of minutes that can elapse in the ignition period and still be considered a mass ignition.

Acres: The number of acres treated with prescribed fire.

Very-high-intensity fires

If a fire does not meet conditions for extreme-intensity fires, Consume uses the following factors to determine whether the fire is very high intensity:

- 10-hr fuel moisture content must be less than or equal to 15%.

- The 1000-hr fuel moisture must be less than or equal to 50%.

If a fire meets these conditions, Consume evaluates whether the size of the burn and speed of ignition result in a mass ignition. If ignition duration is less than maximum ignition duration, the intensity of the fire is very high. Consume reduces diameter reduction by around 11 to 22%, depending on the 10-hr fuel moisture and the 1000-hr fuel moisture.

For units of up to 20 acres:

Maximum Ignition Duration (minutes) **= 2 * Acres**

For units of more than 20 acres:

Maximum Ignition Duration (minutes) **= Acres + 20**

Maximum Ignition Duration (minutes)**:** The total number of minutes that can elapse in the ignition period and still be considered a mass ignition.

Acres: Number of acres treated with prescribed fire.

High-intensity fires

If a fire does not meet the conditions for very-high-intensity fires, Consume uses the following factors to determine whether the fire is high intensity:

- 10-hr fuel moisture content must be less than or equal to 18%.
- The 1000-hr fuel moisture must be less than or equal to 50%.

If a fire meets these conditions, Consume evaluates whether the size of the burn and speed of ignition result in a mass ignition. If ignition duration is less than maximum ignition duration, the intensity of the fire is high. Consume reduces diameter reduction by around 0 to 11%, depending on the 10-hr fuel moisture and the adjusted 1000-hr fuel moisture.

For units of up to 20 acres:

Maximum Ignition Duration (minutes) = 4 * Acres

For units of more than 20 acres:

Maximum Ignition Duration (minutes) = (2 * Acres) + 40

Maximum Ignition Duration (minutes)**:** The total number of minutes that can elapse in the ignition period and still be considered a mass ignition.

Acres: The number of acres treated with prescribed fire.

Medium-intensity fires

If a fire does not meet any of the above conditions, Consume does not reduce diameter reduction.

Table M: Quadratic mean diameters

The quadratic mean diameter (QMD) represents the diameter of a log in a woody size class with average *volume*. Quadratic mean diameter is used to convert calculated *inches* of diameter reduction into *%* volume reduction. The quadratic mean diameters of large woody fuels vary by size class and type of fuels (Peterson 1991, Ottmar 1998).

Size Class	QMD (in)
Activity-Non piled	
1000-hr	5.22
10,000-hr	12.10
>10,000-hr	25.00

Equation N: Percent volume reduction

Consume calculates the percent volume reduction of 1000-hr and 10,000-hr fuels with the following equations. Separate quadratic mean diameters are used for 1000-hr and 10,000-hr fuels.

For 1000-hr fuels, the volume reduction equation is:

$$\textbf{\% Volume Reduction} = 1 - \left(\frac{\text{1000-hour QMD} - \text{Diameter Reduction}}{\text{1000-hour QMD}} \right)^2$$

1000-hr QMD (inches): see Table M

Diameter reduction:

For 10,000-hr fuels, the volume reduction equation is:

$$\textbf{\% Volume Reduction} = 1 - \left(\frac{\text{10000-hour QMD} - \text{Diameter Reduction}}{\text{10000-hour QMD}} \right)^2$$

10,000-hr QMD (inches): see Table M

Equation O: 1000-hr and 10,000-hr fuel consumption equations

Consume calculates total 1000-hr and 10,000-hr consumption in tons per acre with the following equations:

1000-hr Fuel Consumption (tons/acre) = Percent 1000-hr Fuel Volume Reduction * 1000-hr Fuel Loading

10,000-hr Fuel Consumption (tons/acre) = Percent 10,000-hr Fuel Volume Reduction * 10,000-hr Fuel Loading

Table P: >10,000-hr fuel consumption

The percentage of consumption for materials 20 inches or more in diameter (>10,000-hr time lag fuels) is estimated by a formula determined from a small amount of diameter reduction data collected during 1980-1982. These data were difficult to interpret because most large logs were rotten in the center and consumed from the inside outward.

Consume uses the following table to calculate >10,000-hr fuel consumption:

1000-hr Fuel Moisture (%)	**>10,000-hr fuels** consumed **(%)**
35	0
34	1
33	2
32	3
31	4
30	5

Equation Q: Total Large Woody Fuel Consumption

Total large woody fuel consumption in tons per acre is the sum of the consumption of 1000-, 10,000-, and >10,000-hr time lag fuels in tons per acre.

Total Large Woody Fuel Consumption (tons/acre) **=** 1000-hr Fuel Consumption + 10,000-hr Fuel Consumption + >10,000-hr Fuel Consumption

Large Rotten Fuels Consumption

Consumption equations for rotten fuels greater than three inches in diameter (in the 1000-, 10,000-, and >10,000-hr time lag fuel categories) are calculated using the same equations as for the large sound woody fuels, but instead utilize the pre-burn rotten fuel loadings.

Stump Consumption

See Natural Fuels Equations – Woody Stratum – Stumps.

Total Activity Woody Fuel Consumption

Consume calculates total activity woody fuel consumption by adding together sound and rotten continuous woody fuel consumption (1-hr, 10-hr, 100-hr, 1000-hr, 10,000 and >10,000 hr fuels) and stump consumption.

Activity Woody Fuel Consumption by Combustion Stage

Small activity woody Fuels

All 1-hr and 10-hr time lag fuels are assumed to consume during the flaming stage. This is determined from field observations during the past 10 years.

Flaming 1-hr fuel consumption (tons/acre) **=** 1-hr fuel loading

> **Flaming 1-hr fuel consumption** (tons/acre): Consumption of 1-hour (0 to ¼ inch diameter) fuels in the flaming phase of combustion.
>
> **1-hr fuel loading** (tons/acre): Loading of 1-hr fuels.

Flaming 10-hr fuel consumption (tons/acre) = 10-hr fuel loading

Flaming 10-hr fuel consumption (tons/acre): Consumption of 10-hr (¼ to 1 inch diameter) fuels in the flaming phase of combustion.

10-hr fuel loading (tons/acre): 10-hr fuel loading.

Large activity woody fuels

Nearly 50 prescribed burns were monitored for flaming large fuel consumption. A non-linear exponential equation relating 100-hr time lag (1 to 3-inch diameter) fuel consumption to the large fuel flaming consumption portion was derived from these data (Ottmar 1983):

$$\textbf{Flaming portion} = 1.0 - e^{-\left[\frac{\left(\frac{(20.0-(\text{100-hour consumption}))}{20}-1.0\right)}{0.2313}\right]^{2.260}}$$

Flaming Portion (%): Proportion of total % diameter reduction for large fuels in the flaming stage of combustion.

Total 100-hr consumption (tons/acre) = Total 100-hr fuel consumption

The flaming portion is multiplied by the large fuel total diameter reduction to determine flaming diameter reduction using the following equation:

Flaming DRED (inches) = DRED * Flaming portion

Flaming Portion (%)**:** Flaming portion of large fuel diameter reduction.

DRED (inches)**:** Total large fuel diameter reduction.

Flaming 100-hr Fuel Consumption

A 1.68-inch diameter reduction is the quadratic mean of 100-hr woody fuels (1 to 3-inches in diameter) as determined from the fuels inventory data collected in 1980 (FERA). If the flaming diameter reduction of large woody fuels is greater than 1.68 inches, 100-hr fuels will consume entirely during the flaming stage of combustion. If the flaming diameter reduction of large woody fuels is less than 1.68 inches, then 100-hr fuels will not consume completely.

For flaming large fuel diameter reductions greater than 1.68 inches, flaming 100-hr fuel consumption is calculated as follows:

Flaming 100-hr consumption (tons/acre) = 100-hr fuel consumption.

Flaming 100-hr consumption (tons/acre)**:** Flaming 100-hr fuel consumption.

100-hr consumption (tons/acre)**:** Total 100-hr fuel consumption.

If the flaming diameter reduction is less than 1.68 inches, then the 100-hr material will not totally consume during the flaming stage. A volume reduction equation is used to calculate the % flaming consumption using flaming diameter reduction of the large woody fuels and total 1- to 3-inch diameter fuel loading:

$$\textbf{Flaming 100-hour consumption}\ (\text{tons/acre}) = 100\text{-hour loading} * \left[1 - \left(\frac{(1.68 - \text{FlamingDRED})^2}{(1.68)^2}\right)\right]$$

Flaming 100-hr consumption (tons/acre) = Flaming 100-hr fuel consumption.

Flaming DRED (inches) = large fuel flaming diameter reduction.

100-hr loading (tons/acre) = 100-hr fuel loading.

Flaming 1000-hr and 10,000-hr Fuel Consumption

The flaming diameter reduction is converted to percentage of flaming large fuel consumption using a volume reduction equation for 1000-hr (3 to 9-inch diameter) and 10,000-hr (9 to 20-inch diameter) fuels. Average quadratic mean reductions are used for the different size classes, based on the biomass studies by Peterson *et al.* (1989) and Howard (1981):

$$\textbf{Flaming \%1000-hr consumption}\ (\text{tons/acre}) = 1 - \frac{(1000\text{-hour quadratic mean diameter} - \text{Flaming DRED})^2}{(1000\text{-hour quadratic mean diameter})^2}$$

$$\textbf{Flaming \%10,000-hr consumption}\ (\text{tons/acre}) = 1 - \frac{(10000\text{-hour quadratic mean diameter} - \text{Flaming DRED})^2}{(10000\text{-hour quadratic mean diameter})^2}$$

Flaming % consumption (%) = flaming percentage of consumption.

Quadratic mean diameter (inches) = quadratic mean diameter for specific size class of fuel. See Table M.

Flaming DRED (inches) = flaming diameter reduction.

The total preburn loading of the 1000- and 10,000-fuels are multiplied by the percent flaming consumption to obtain flaming consumption for each size class in tons per acre:

Flaming 1000-hr consumption (tons/acre) = 1000-hr fuel loading * Flaming % 1000-hr consumption.

Flaming 10,000-hr consumption (tons/acre) = 10,000-hr fuel loading * Flaming % 10,000-hr consumption.

Flaming 1000-hr consumption (tons/acre) = flaming 1000-hr (3 to 9-inch diameter) woody fuel consumption.

Flaming 10,000-hr consumption (tons/acre) = flaming 10,000-hr (9 to 20-inch) woody fuel consumption.

1000-hr fuel loading (tons/acre) = 1000-hr fuel loading.

10,000-hr fuel loading (tons/acre) = 10,000-hr fuel loading in tons per acre.

Flaming 1000-hr consumption (%) = % flaming 1000-hr fuels.

Flaming 10,000-hr consumption (%) = % flaming 10,000-hr fuels.

Because the total consumption of the >10,000 woody fuels (20-inches or greater in diameter) is based on a percentage determined from fuel moisture, the flaming portion for large fuels is multiplied by the total consumed figure:

Flaming >10,000-hr consumption (tons/acre) = 10,000-hr consumption * Flaming % 10,000-hr consumption.

Flaming >10,000-hr consumption (tons/acre): Flaming consumption of 20+ inch woody fuels.

>10,000-hr consumption (tons/acre): Total 20+ inch woody fuel consumption.

Flaming >10,000-hr consumption (%): Flaming portion of large woody fuel diameter reduction.

Total Flaming Consumption of Activity Woody Fuels

The 1-, 10-, 100, 1000-, 10,000-, and >10,000-fuel consumption for the flaming stage are added to determine total flaming woody fuel consumption.

Flaming woody consumption (tons/acre) = 1-hr consumption + 10-hr consumption + Flaming 100-hr consumption + Flaming 1000-hr consumption + Flaming 10,000-hr consumption + Flaming >10,000-hr consumption.

Total Smoldering Consumption of Activity Woody Fuels

Smoldering woody fuel consumption is equal to the flaming woody fuel consumption subtracted from the total woody fuel consumption.

Smoldering woody consumption (tons per acre) = Total woody consumption - Flaming woody consumption

Litter-Lichen-Moss Consumption

See Natural Fuels Equations – LLM Stratum – Litter-Lichen-Moss.

Ground Fuels Consumption

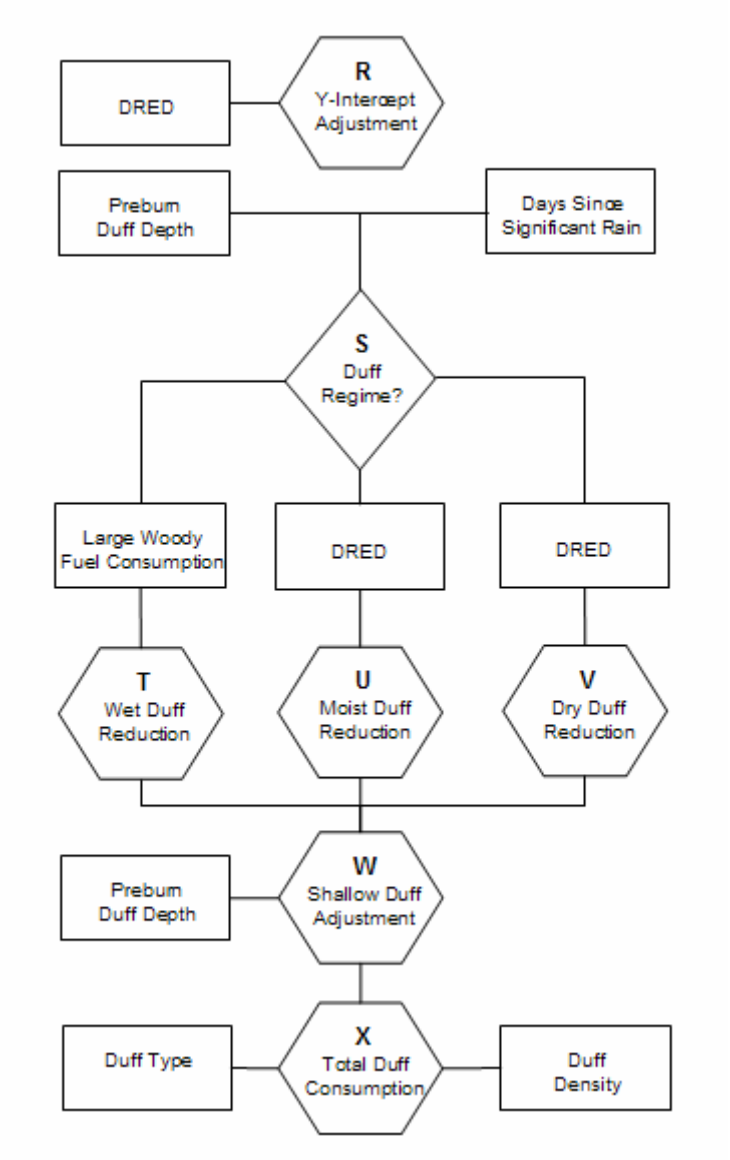
Ground Fuel consumption is the sum of duff, basal accumulation and squirrel middens consumption. Each ground fuel category is detailed below.

Duff Consumption

Major variables that control duff consumption include woody fuel consumption, diameter reduction, pre-burn duff depth, and duff moisture content. Because actual duff moisture content is difficult to measure and there are no reliable duff moisture models, Consume classifies duff as wet, moist, or dry based on the number of days since significant rain. The duff consumption algorithm is divided into separate regimes for wet, moist, and dry duff (Ottmar *et al.* 1985).

Consume uses this algorithm to calculate duff consumption. The lettered equations are explained below.

Duff Consumption Algorithm



Equation R: Y-intercept adjustment

Consume uses an adjustment factor to modify the duff reduction equations (T, U, and V) as they approach the Y axis. Without this Y-intercept adjustment, duff consumption would be overestimated for burns with very low consumption of large woody fuels. The adjustment factor is the absolute minimum of (Diameter Reduction/1.68) and 1.

$$\textbf{YADJ}\ (\text{dimensionless}) = \min\left(\left|\frac{\text{Diameter Reduction}}{1.68}\right|, 1\right)$$

Diameter Reduction (inches): Diameter reduction of large woody fuels (see Equations I, J, K, and L)

1.68 (inches): Average quadratic mean diameter of 100-hr fuels.

Equation S: Drying period equations

Consume estimates duff reduction under three moisture regimes. The selection of the appropriate moisture regime is dependent on the pre-burn duff depth and the days of drying prior to the burn.

Consume uses the pre-burn duff depth to estimate the days of drying necessary to change the duff moisture from wet to moist, and from moist to dry. These drying periods are then compared with the days since significant rainfall to select the appropriate duff reduction regime.

$$\textbf{Days to Moist} = 21 * \left(\frac{\text{Duff Depth}}{3}\right)^{1.18}$$

$$\textbf{Days to Dry} = 57 * \left(\frac{\text{Duff Depth}}{3}\right)^{1.18}$$

Days to Moist: The days without significant rainfall required to reach the threshold between the wet and moist regimes.

Days to Dry: The days without significant rainfall required to reach the threshold between the moist and dry regimes.

If days since significant rainfall are less than days to moist, Consume uses the wet duff regime. If days since significant rainfall are greater than days to moist, but less than days to dry, Consume uses the moist duff regime. If days since

significant rainfall are greater than days to dry, Consume uses the dry duff regime:

Days since significant rainfall*	Corresponding duff regime
≤ Days to moist	Wet duff regime
> Days to moist but < Days to dry	Moist duff regime
≥ days to dry	Dry duff regime

*** Days Since Significant Rainfall:** The number of days since a significant amount of rain fell. Significant rainfall is 0.25 inches. This is the minimum amount of rainfall required to saturate the duff layer (Cooper 1985).

Equation T: Wet duff reduction equation

If Consume determines (in Equation S) that the duff is wet, it uses the following equation to determine duff reduction (Ottmar *et al.* 1985):

Wet Duff Reduction (inches) = (0.537 * YADJ) + (0.057 * (1000-hr Consumption + 10,000-hr Consumption + >10,000-hr Consumption))

Wet Duff Reduction (inches)**:** Duff reduction in wet regime.

YADJ (dimensionless): Y-intercept adjustment. See Equation R.

1000-hr Consumption (tons/acre)**:** Consumption of 1000-hr fuels in tons per acre (see Equation O).

10,000-hr Consumption (tons/acre)**:** Consumption of 10,000-hr fuels in tons per acre (see Equation O).

>10,000-hr Consumption (tons/acre)**:** Consumption of >10,000-hr fuels in tons per acre (see Equation P).

To smooth the transition between wet and moist duff regimes, the following equation is used to correct wet duff reduction.

Adjusted wet duff reduction (inches) = Wet duff reduction + (Moist Duff Reduction - Wet Duff Reduction) * (Days Since Significant Rainfall) / (Days to Moist)

Equation U: Moist duff reduction equation

If Consume determines (in Equation S) that the duff is moist, it uses the following equation to determine duff reduction (Ottmar *et al.* 1985):

$$\textbf{Moist Duff Reduction} = \left(0.323 * \text{YADJ}\right) + \left(1.034 * \sqrt{\text{Diameter Reduction}}\right)$$

Moist Duff Reduction (inches): Duff reduction in moist regime.

YADJ (dimensionless): Y-intercept adjustment.

Diameter Reduction (dimensionless): Diameter reduction of large woody fuels in inches (see Equations I, J, K, and L).

Equation V: Dry duff reduction

If Consume determines that the duff is dry (Equation S), it uses the following equation to determine duff reduction:

$$\textbf{Dry Duff Reduction} = \text{Moist Duff Reduction} + \left(\frac{\text{Days Since Rainfall} - \text{Days to Dry}}{27}\right)$$

Dry Duff Reduction (inches)**:** Duff reduction in dry regime (inches)

Moist Duff Reduction (inches)**:** See Equation U.

Days Since Rainfall (days)**:** Days since significant rainfall.

Diameter Reduction (inches)**:** Diameter reduction of large woody fuels (see Equations I, J, K and L).

Days to Dry: See Equation S.

Equation W: Shallow duff adjustment

Shallow duff has more inorganic material in it, which reduces consumption. Consume makes an adjustment to account for this:

If preburn duff depth is less than 0.5 inch, duff reduction is multiplied by 0.5.

If preburn duff depth is greater than 2.5 inches, duff reduction is multiplied by 1

The transition between 0.5 and 2.5 inches is smoothed with a step function:

duff reduction is multiplied by (0.25 * totalDuffDepth) + 0.375.

Equation X: Total duff consumption

Total duff consumption in tons per acre is calculated using bulk density and duff reduction (Ottmar *et al.* 1993, Ottmar 1998a) (Equations T, U, or V, adjusted with Equation W if duff is shallow).

Total Duff Consumption (tons/acre) = Duff Reduction * Bulk density

Where duff bulk density varies by duff type and derivation:

Type	Derivation	BD
Upper Duff	Dead litter and moss	8
Upper Duff	Fibric peat (sphagnum or sedge)	8
Lower Duff	Humus or muck	18
Lower Duff	Humic peat	22

Basal Accumulation Consumption

See Natural Fuels Equations – Ground Fuels Stratum – Basal Accumulations.

Squirrel Midden Consumption

See Natural Fuels Equations – Ground Fuels Stratum – Squirrel Middens.

Ground Fuel Reduction by Combustion Phase

Reduction by combustion phase is estimated by multiplying individual ground fuel reductions by the corresponding proportions:

Combustion Phase	Upper duff	Lower duff	Basal accumulations	Squirrel middens
Flaming Reduction	0.10	0.00	0.10	0.10
Smoldering Reduction	0.70	0.20	0.40	0.30
Residual Reduction	0.20	0.80	0.50	0.60

Natural Fuels Algorithms

Natural fuels are fuels that have been created through natural processes. Most natural fuels equations have been completely updated in Consume 3.0. However, all woody fuel accumulations, including jackpots, piles and windrows are calculated by the Consume 2.1 pile group wizard.

Summary of natural fuels equations

Stratum	Equations used
Canopy	Default equations (applicable to activity and natural fuels).
Shrub	Default equations (applicable to activity and natural fuels).
Nonwoody vegetation	Default equations (applicable to activity and natural fuels).
Woody fuels	Sum of sound, rotten, stumps and woody fuel accumulations.
Sound wood	Sum of sound wood subcategories.
0 to ¼ inch	100% flaming consumption.
¼ to 1 inch	See western woody equation # and southern woody equation #
1 to 3 inches	See western woody equation # and southern woody equation #
3 to 9 inches	See western woody equation # and southern woody equation #
9 to 20 inches	See western woody equation # and southern woody equation #
> 20 inches	See western woody equation # and southern woody equation #
Rotten wood	Sum of rotten wood subcategories.
3 to 9 inches	See western woody equation # and southern woody equation #
9 to 20 inches	See western woody equation # and southern woody equation #
> 20 inches	See western woody equation # and southern woody equation #
Stumps	Default equations (applicable to activity and natural fuels).
Woody fuel accumulations	See pile group equations.
Litter-Lichen-Moss	See LLM stratum equations.
Ground fuels	Sum of Duff, Basal accumulations and Squirrel middens.
Duff	See duff equations.
Basal accumulations	Default equations (applicable to activity and natural fuels).
Squirrel middens	Default equations (applicable to activity and natural fuels). Valid only for boreal region fuelbeds.

Canopy Stratum

The following canopy consumption models apply to natural and activity fuels. There has been limited or no fuel consumption data collected for canopy stratum consumption. Consequently, proportions of consumption were assigned for flaming, smoldering, and residual stages of combustion (Roger Ottmar, expert opinion). These defaults will be used until canopy consumption data are available. To calculate consumption by combustion phase for each tree and snag subcategory, pre-burn loading values are multiplied by the proportion consumed. Total consumption for each subcategory (i.e., Overstory trees, Class 1 snags with foliage) is then calculated as the sum of consumption over the three phases of combustion.

General consumption equations

Consumption $_{\textbf{Combustion phase}}$ (tons/acre) = Preburn Loading $_{\text{Fuelbed category}}$ (tons/acre) x Proportion consumed $_{\text{Combustion phase}}$

Where:

Preburn Loading $_{\textbf{Fuelbed category}}$ (tons/acre) = loading of tree or snag category prior to burn. Note that preburn loading of trees only includes tree foliage. Input loadings include the following fuelbed categories: Overstory trees, Midstory trees, Understory trees, Class 1 Snags with foliage, Class 1 Snags without foliage, Class 2 Snags and Class 3 Snags

Proportion Consumed $_{\textbf{Combustion phase}}$ (dimensionless) = Proportion consumed by Flaming, Smoldering and Residual stages of combustion. See table below

Total Consumption $_{\textbf{Canopy category/subcategory}}$ (tons/acre) = $\sum$(Consumption$_{\text{Flaming}}$, Consumption$_{\text{Smoldering}}$, Consumption$_{\text{Residual}}$)

Where:

Canopy category/subcategory: Trees (Overstory foliage, Midstory foliage, Understory foliage), Snags (Class 1 Foliage, Class 1 Wood, Class 2, Class 3), and Ladder Fuels.

Consumption by Combustion Phase

Consumption by combustion phase is estimated by multiplying consumption in each canopy category and subcategory by the corresponding proportions:

Trees: Proportion of loading consumed by subcategory and combustion phase

Combustion stage	Proportion of overstory foliage loading Consumed	Proportion of midstory foliage loading Consumed	Proportion of understory foliage loading Consumed
Flaming	0.75	0.80	0.85
Smoldering	0.05	0.05	0.05
Residual	0.00	0.00	0.00

Snags: Proportion of loading consumed by subcategory and combustion phase

Combustion stage	Proportion of Class 1 foliage loading Consumed	Proportion of Class 1 wood loading Consumed	Proportion of Class 2 wood loading Consumed	Proportion of Class 3 wood loading Consumed
Flaming	0.75	0.03	0.05	0.10
Smoldering	0.04	0.01	0.01	0.20
Residual	0.01	0.01	0.01	0.20

Ladder fuels: Proportion of loading consumed by subcategory and combustion phase

Combustion stage	Proportion of Class 1 foliage loading Consumed
Flaming	0.75
Smoldering	0.10
Residual	0.00

Shrub Stratum

The following shrub consumption model applies to natural and activity fuels. We used generalized linear modeling (Splus Statistical Software) to create a proportional consumption model based on the western sage dataset (FERA, C. Wright, S. Prichard). Because the model involves multiple terms, we opted to use generalized modeling to avoid negative or unrealistically high extrapolations. Actual shrub consumption is calculated by multiplying the proportion consumed by pre-burn shrub loading.

Shrub consumption (tons/acre) = Total shrub loading (tons/acre) x Proportion consumed $_{\text{Shrubs}}$

Where:

Total shrub loading (tons/acre) = Shrub Loading $_{\text{Primary Layer}}$ + Shrub Loading $_{\text{Secondary Layer}}$

Proportion Consumed $_{\text{Shrubs}}$ (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = -2.6573 + (0.0956 x Preburn Loading $_{\text{Shrub}}$) + (0.0473 x Percent Black)

Preburn loading $_{\text{Shrub}}$ (tons/acre) = Total preburn shrub loading

Percent black (percent) = Percentage of surface fuel area blackened by burn

Consumption by combustion phase is estimated by multiplying live and dead shrub consumption by the corresponding proportions:

Combustion stage	Live Shrub	Dead Shrub
Flaming	0.95	0.90
Smoldering	0.05	0.10
Residual	0.00	0.00

Consume offers a calculator to estimate percent black (i.e., percentage blackened acres of a shrubland) for certain shrub types. The equation was developed from sagebrush consumption trials and is best suited to shrublands dominated by sagebrush and/or bitterbrush.

Percent Black (%) = 100* [exp(y)/(1 + exp(y)]

Where:

Y = [-1.6693 + (0.1185 * nonwoody percent cover) – (0.2453 * 10-hr FM)

+ (0.1697 * WindxSlopeCategory)]

Nonwoody Stratum

The following nonwoody consumption model applies to both natural and activity fuels. A simple linear model based on preburn nonwoody loading was calculated using FERA grassland consumption data (FERA, S. Prichard).

Nonwoody consumption (tons/acre) = 0.9274 x Preburn Loading $_{\text{Nonwoody vegetation}}$

Where:

0.9274 (dimensionless) = proportion of preburn loading consumed (see documentation below).

Preburn Loading $_{\textbf{Nonwoody vegetation}}$ (tons/acre) = Total preburn nonwoody vegetation loading.

Consumption by combustion phase is estimated by multiplying nonwoody consumption by the corresponding proportions:

Combustion stage	
Flaming	0.95
Smoldering	0.05
Residual	0.00

Woody Stratum

The following equations apply to natural fuels only.

Western Woody Equations (applicable to boreal and western regions)

1) 0 to ¼ inch Wood

Consumption $_{\textbf{0-1/4 inch wood}}$ (tons/acre) = Loading $_{\text{0-1/4 inch wood}}$

2) ¼ to 1 inch Wood

Consumption $_{\textbf{0-1/4 inch wood}}$ (tons/acre) = 0.8650 x Loading $_{\text{0-1/4 inch wood}}$

Where:

0.8650 (dimensionless) = proportion of preburn loading consumed (FERA)

3) 1 to 3 inch Wood

Consumption $_{\textbf{1-3 inch wood}}$ **(tons/acre)** = 0.7844 x Loading $_{\text{1-3 inch wood}}$ (tons/acre)

Where:

0.7844 (dimensionless) = proportion of preburn loading consumed (FERA)

4) 3 to 9 inch Sound Wood

Consumption $_{\textbf{3-9inch sound wood}}$ (tons/acre) = Loading $_{\text{3-9 inch sound wood}}$ (tons/acre) x Proportion consumed $_{\text{3-9 inch sound wood}}$

Proportion Consumed $_{\text{3-9 inch sound wood}}$ (dimensionless) = EXP (y) / (1 + EXP (y)

Where:

y = 3.1052 - (0.0559 x 1000hr FM)

1000-hr FM (%) = fuel moisture of 3-9 inch fuels

5) 9 to 20 inch Sound Wood

Consumption $_{\textbf{9-20 inch sound wood}}$ (tons/acre) = Loading $_{\text{9-20 inch sound wood}}$ (tons/acre) x Proportion consumed $_{\text{9-20 inch sound wood}}$

Proportion Consumed $_{\textbf{9-20 inch sound wood}}$ (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = 0.7869 - (0.0387 x 1000hr FM)

1000-hr FM (%) = fuel moisture of 3-9 inch fuels

6) > 20 inch Sound Wood

Consumption $_{\textbf{>20 inch sound wood}}$ (tons/acre) = Loading $_{\text{>20 inch sound wood}}$ (tons/acre) x Proportion consumed $_{\text{>20 inch sound wood}}$

Proportion Consume**d** $_{\textbf{>20 inch sound wood}}$ (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = 0.3960 - (0.0389 x 1000-hr FM)

1000-hr FM (%) = fuel moisture of 3-9 inch fuels

7) 3 to 9 inch Rotten Wood

Consumption $_{\text{3-9inch rotten wood}}$ (tons/acre) = Loading $_{\text{3-9 inch rotten wood}}$ (tons/acre) x Proportion consumed $_{\text{3-9 inch rotten wood}}$

Proportion Consumed $_{\text{3-9 inch rotten wood}}$ (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = 4.0139 - (0.0600 * Duff FM) + (0.8341 * Loading $_{\text{3-9 inch rotten wood}}$)

Duff FM (%) = fuel moisture of duff

Loading $_{\text{3-9 inch Rotten Wood}}$ (tons/acre) = preburn loading

8) 9 to 20 inch Rotten Wood

Consumption $_{\text{9-20 inch rotten wood}}$ (tons/acre) = Loading $_{\text{9-20 inch rotten wood}}$ (tons/acre) x Proportion consumed $_{\text{9-20 inch rotten wood}}$

Proportion Consumed $_{\text{9-20 inch rotten wood}}$ (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = 2.1218 - (0.0438 * Duff FM)

Duff FM (%) = fuel moisture of duff

9) >20 inch Rotten Wood

Consumption $_{\text{>20 inch rotten wood}}$ (tons/acre) = Loading $_{\text{>20 inch rotten wood}}$ (tons/acre) x Proportion consumed $_{\text{>20 inch rotten wood}}$

Proportion Consumed $_{\text{>20 inch rotten wood}}$ (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = 0.8022 - (0.0266 x Duff FM)

Duff FM (%) = fuel moisture of duff

Southern Woody Equations (applicable to southern fuels only)

1) 0 to ¼ inch Wood

Consumption $_{\text{0-1/4 inch wood}}$ (tons/acre) = Loading $_{\text{0-1/4 inch wood}}$

2) ¼ to 1 inch Wood

Consumption $_{\text{0-1/4 inch wood}}$ (tons/acre) = 0.8650 x Loading $_{\text{0-1/4 inch wood}}$

Where:

0.8650 (dimensionless) = proportion of preburn loading consumed (FERA)

3) 1 to 3 inch Wood

Consumption $_{\text{1-3 inch wood}}$ (tons/acre) = 0.4022 x Loading $_{\text{1-3 inch wood}}$ (tons/acre)

Where:

0.4022 (dimensionless) = proportion of preburn loading consumed (FERA)

4) 3 to 9 inch Sound Wood

Consumption $_{\text{3-9 inch sound wood}}$ (tons/acre) = Loading 3-9 inch sound wood (tons/acre) x Proportion consumed 3-9 inch sound wood

Proportion Consume**d** $_{\text{3-9 inch sound wood}}$ (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = 0.0302 - (0.0379 * Duff FM)

Duff FM (%) = fuel moisture of duff

5) 9 to 20 inch Sound Wood (*Western equation – no suitable model from Southern data*)

Consumption $_{\text{9-20 inch sound wood}}$ (tons/acre) = Loading 9-20 inch sound wood (tons/acre) x Proportion consumed 9-20 inch sound wood

Proportion Consumed $_{\text{9-20 inch sound wood}}$ (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = 0.7869 - (0.0387 x 1000hr FM)

1000-hr FM (%) = fuel moisture of 3-9 inch fuels

6) > 20 inch Sound Wood (*Western equation – no suitable model from Southern data*)

Consumption $_{\text{>20 inch sound wood}}$ (tons/acre) = Loading >20 inch sound wood (tons/acre) x Proportion consumed >20 inch sound wood

Proportion Consumed $_{\text{>20 inch sound wood}}$ (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = 0.3960 - (0.0389 x 1000-hr FM)

1000-hr FM (%) = fuel moisture of 3-9 inch fuels

7) 3 to 9 inch Rotten Wood

Consumption $_{\text{3-9 inch rotten wood}}$ (tons/acre) = Loading 3-9 inch rotten wood (tons/acre) x Proportion consumed 3-9 inch rotten wood

Proportion Consumed $_{\text{3-9 inch rotten wood}}$ (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = 0.5052 - (0.0434 * Duff FM)

Duff FM (%) = fuel moisture of duff

8) 9 to 20 inch Rotten Wood (*Western equation – no suitable model from Southern data*)

Consumption $_{\text{9-20 inch rotten wood}}$ (tons/acre) = Loading 9-20 inch rotten wood (tons/acre) x Proportion consumed 9-20 inch rotten wood

Proportion Consumed $_{\text{9-20 inch rotten wood}}$ (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = 2.1218 - (0.0438 * Duff FM)

Duff FM (%) = fuel moisture of duff

9) >20 inch Rotten Wood (*Western equation – no suitable model from Southern data*)

Consumption $_{>20 \text{ inch rotten wood}}$ (tons/acre) = Loading >20 inch rotten wood (tons/acre) x Proportion consumed >20 inch rotten wood

Proportion Consumed $_{>20 \text{ inch rotten wood}}$ (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = 0.8022 - (0.0266 x Duff FM)

Duff FM (%) = fuel moisture of duff

Consumption by Combustion Phase of Natural Woody Fuels

Consumption by combustion phase is estimated by multiplying the consumption of natural woody fuels by sound and rotten size class by the following proportions for flaming, smoldering, and residual phases of combustion.

Woody category	Flaming	Smoldering	Residual
Sound 0 to ¼	0.95	0.05	0.00
Sound ¼ to 1	0.90	0.10	0.00
Sound 1 to 3	0.85	0.10	0.05
Sound 3 to 9	0.60	0.30	0.10
Sound 9 to 20	0.40	0.40	0.20
Sound > 20	0.20	0.40	0.40
Rotten 3 to 9	0.20	0.30	0.50
Rotten 9 to 20	0.10	0.30	0.60
Rotten > 20	0.10	0.30	0.60

Stump Equations

The following equations apply to natural and activity fuels.

Consumption $_{\text{Stump Subcategory}}$ (tons/acre) = Loading $_{\text{Stump Subcategory}}$ (tons/acre) x Proportion **Consume**d $_{\text{Stump Subcategory}}$

Where:

Loading $_{\text{Stump type}}$ (tons/acre) = Preburn loading by stump subcategory, including sound, rotten or lightered stumps.

Proportion Consumed (dimensionless) = see table below

Stump Subcategory	Proportion Consumed*
Sound	0.10
Rotten	0.50
Lightered	0.50

* R. Ottmar, expert opinion.

Consumption by combustion phase of stumps is estimated by multiplying sound, rotten and lightered stump consumption by the corresponding proportions:

Stump subcategory	Flaming	Smoldering	Residual
Sound	0.50	0.50	0.00
Rotten	0.10	0.30	0.60
Lightered	0.40	0.30	0.30

Woody Fuel Accumulations

Consumption of piles, jackpots and windrows is calculated using Pile Equations (see below).

Litter Lichen Moss (LLM) Stratum

Because forest floor fuels, including litter, lichen, moss and duff, are usually measured as a depth rather than an actual loading, Consume calculates a forest floor reduction, partitions the overall forest floor reduction into litter, lichen, moss and duff reductions, and then multiplies inches reduced by respective bulk densities of litter, lichen, moss and duff to estimate consumption.

Consumption $_{\text{LLM Category}}$ (tons/acre) = Reduction $_{\text{LLM Category}}$ (inches) * Bulk density $_{\text{LLM Category}}$ (tons/acre-inch)

Where:

Reduction $_{\text{LLM Category}}$ (inches) = Reduction of moss, lichen or litter category (see forest floor reduction equations and individual reduction equations below)

Bulk density $_{\text{LLM Category}}$ (tons/acre-inch) = Bulk density of moss, lichen or litter category (see LLM Bulk Density Table). A note on litter types: In cases of multiple litter types, Consume takes a weighted average of bulk density based on relative percent cover.

LLM Bulk Density Table

LLM Category	tons/acre-inch
Ground lichen	0.5
Moss (both types)	1.5
Litter Type	
Short needle pine	3
Long needle pine	3
Other conifer	3
Deciduous hardwood	1.5
Evergreen hardwood	1.5
Palm frond	0.3
Grass	0.5

Forest Floor Reduction Equations

Consume calculates total forest floor reduction based on three regional equations (western, boreal and southern). All equations are empirically based from FERA consumption trials.

Boreal Forest Floor Reduction Equation

Forest Floor Reduction (inches) = Pre-burn forest floor depth x Proportion Forest Floor Reduced

Preburn forest floor depth (inches) = ∑Depths (Litter, Lichen, Moss, Duff) – input variables

Proportion forest floor reduced (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = 1.2383 - (0.0114 x Duff FM)

Duff FM (%) = fuel moisture of duff

Note: The actual modeled variable was Upper Duff FM (total Duff FM was not measured)

Southern Forest Floor Reduction Equation

A simple linear model was selected in favor of a generalized linear model because the GLM tended to over predict forest floor reduction. We removed the intercept in this model to avoid negative values at low input ranges.

Forest Floor Reduction (inches) = (-0.0061 x Duff FM) + (Pre-burn forest floor depth x Proportion Forest Floor Reduced

Where:

Duff FM (%) = fuel moisture of duff

Preburn forest floor depth (inches) = ∑Depths (Litter, Lichen, Moss, Duff) (input variables)

Western Forest Floor Reduction Equation

Forest Floor Reduction (inches) = Pre-burn forest floor depth x Proportion Forest Floor Reduced

Preburn forest floor depth (inches) = ∑Depths (Litter, Lichen, Moss, Duff) – input variables

Proportion forest floor reduced (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = -0.8085 - (0.0213 x Duff FM) + (1.0625 * Pre Forest Floor Depth)

Duff FM (%) = fuel moisture of duff

Litter, Lichen, and Moss Reduction Equation

Litter, lichen or moss reduction is calculated using conditional statements involving forest floor reduction and pre-burn depth. The example below shows litter reduction, but the same statements are applicable to lichen and moss:

If preburn $Depth_{Litter}$ is less than or equal to calculated Forest Floor Reduction, then:

Litter Reduction (inches) = preburn $Depth_{Litter}$ (inches)

If preburn $Depth_{Litter}$ is greater than calculated Forest Floor Reduction, then:

Litter Reduction (inches) = Forest Floor Reduction (inches)

Reduction by combustion phase is estimated by multiplying Litter, Lichen or Moss reduction by the corresponding proportions:

LLM Reduction by Combustion Phase

Combustion Phase	Litter	Lichen	Moss
Flaming Reduction	0.90	0.95	0.95
Smoldering Reduction	0.10	0.05	0.05
Residual Reduction	0.00	0.00	0.00

Ground Fuels Stratum

As with the Litter Lichen Moss Stratum, Consume calculates an overall forest floor reduction and then multiplies inches reduced by respective bulk densities of ground fuels, which include duff, basal accumulations and squirrel middens, to estimate consumption.

General consumption equation

Consumption $_{\textbf{Ground Fuel Type}}$ (tons/acre) = Reduction $_{\text{Ground Fuel Type}}$ (inches) * Bulk density $_{\text{Ground Fuel Type}}$ (tons/acre-inch)

Where:

Reduction $_{\textbf{Ground Fuel Type}}$ (inches) = Reduction of basal accumulation, duff or squirrel midden (see forest floor reduction and individual reduction equations below)

Bulk density $_{\textbf{Ground Fuel Type}}$ (tons/acre-inch) = Bulk density of ground fuel type (see Ground Fuel Bulk Density Table).

Ground Fuel Bulk Density Table

Type	Derivation	Bulk Density (tons/acre-inch)
Upper Duff	Dead litter and moss	8
Upper Duff	Fibric peat (sphagnum or sedge)	8
Lower Duff	Humus or muck	18
Lower Duff	Humic peat	22
Basal accumulation	n/a	12
Squirrel middens	n/a	12

Forest Floor Reduction Equations

Consume calculates total forest floor reduction based on three regional equations (western, boreal and southern). All equations are empirically based from FERA consumption trials.

Boreal Forest Floor Reduction Equation

Forest Floor Reduction (inches) = Pre-burn forest floor depth x Proportion Forest Floor Reduced

Preburn forest floor depth (inches) = ∑Depths (Litter, Lichen, Moss, Duff) – input variables

Proportion forest floor reduced (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = 1.2383 - (0.0114 x Duff FM)

Duff FM (%) = fuel moisture of duff

Note: The actual modeled variable was Upper Duff FM (total Duff FM was not measured)

Southern Forest Floor Reduction Equation

A simple linear model was selected in favor of a generalized linear model because the GLM tended to over predict forest floor reduction. We removed the intercept in this model to avoid negative values at low input ranges.

Forest Floor Reduction (inches) = (-0.0061 x Duff FM) + (Pre-burn forest floor depth x Proportion Forest Floor Reduced

Where:

Duff FM (%) = fuel moisture of duff

Preburn forest floor depth (inches) = ∑Depths (Litter, Lichen, Moss, Duff)

Western Forest Floor Reduction Equation

Forest Floor Reduction (inches) = Pre-burn forest floor depth x Proportion Forest Floor Reduced

Preburn forest floor depth (inches) = ∑Depths (Litter, Lichen, Moss, Duff) – input variables

Proportion forest floor reduced (dimensionless) = EXP (y) / (1 + EXP (y))

Where:

y = -0.8085 - (0.0213 x Duff FM) + (1.0625 * Pre Forest Floor Depth)

Duff FM (%) = fuel moisture of duff

Duff Reduction Equations

Duff reduction is calculated using conditional statements involving forest floor reduction, pre-burn duff depth and preburn litter lichen moss (LLM) depth.

If preburn $Depth_{Duff}$ is greater than preburn $Depth_{LLM}$, then

Duff Reduction (inches) = Forest Floor Reduction (inches) – preburn $Depth_{LLM}$ (inches)

If preburn duff depth is less than or equal to the depth of the LLM depth, then

Duff Reduction (inches) = 0

Duff reduction is further partitioned into upper duff and lower duff reduction using the following conditional statements:

Upper Duff Reduction

If $Depth_{Upper\ Duff}$ is less than Duff Reduction,

Upper Duff Reduction (inches) = preburn $Depth_{Upper\ Duff}$ (inches)

If $Depth_{Upper\ Duff}$ is greater than total Duff Reduction,

Upper Duff Reduction = Duff Reduction

Lower Duff Reduction

If $Depth_{Upper\ Duff}$ is less than total Duff Reduction,

Lower Duff Reduction (inches) = $Reduction_{Duff}$ - $Depth_{Upper\ Duff}$

If $Depth_{Upper\ Duff}$ is greater than total Duff Reduction,

Lower Duff Reduction = 0

Basal Accumulation Reduction Equations

Currently, there are no empirical data available on basal accumulation reduction. Consume assumes that basal accumulation reduction is equivalent to forest floor reduction.

Basal Accumulation Reduction (inches) = Forest Floor Reduction (inches)

Where:

> **Basal accumulation Reduction** (inches) = see region-specific Forest Floor Reduction equations above.

Squirrel Midden Reduction Equations

Squirrel middens are only applicable to Boreal regions. Currently, there are no empirical data available on squirrel midden reduction. Consume assumes that squirrel midden reduction is equivalent to the boreal forest floor reduction.

Basal Accumulation reduction (inches) = Forest Floor Reduction (inches)

Where:

> Squirrel midden reduction (inches) = see Boreal Forest Floor Reduction equation above.

Ground fuel reduction by combustion phase

Reduction by combustion phase is estimated by multiplying individual ground fuel reductions by the corresponding proportions:

Combustion Phase	Upper duff	Lower duff	Basal accumulations	Squirrel middens
Flaming Reduction	0.10	0.00	0.10	0.10
Smoldering Reduction	0.70	0.20	0.40	0.30
Residual Reduction	0.20	0.80	0.50	0.60

Piled Fuels

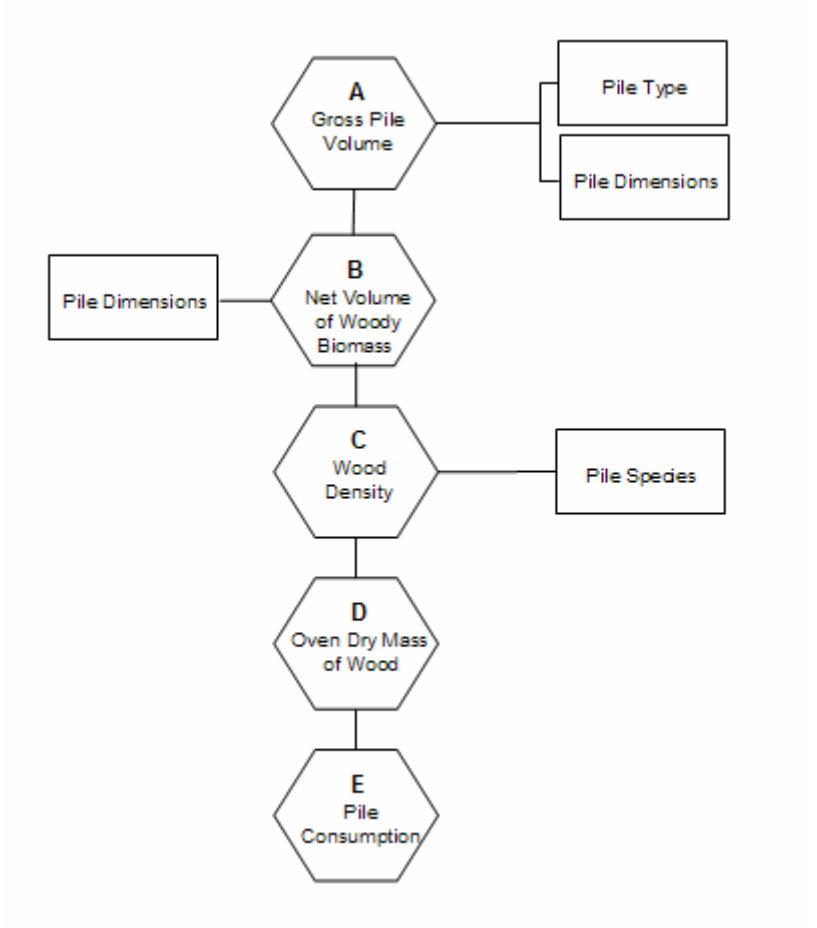
Consume uses a model developed by Hardy (1996) to calculate consumption of fuels from pile fires. Unlike other fuel categories, consumption of piles is not directly dependent upon fuel size. The major factors in determining consumption are:

- Total gross volume of the pile.
- Net volume of the woody biomass.
- Density or weighted-average density of the wood.
- Consumable (oven-dry) mass of wood.
- Proportion of mass consumed.

Consumption is calculated for a single pile definition. Consumption of multiple piles of the same shape, size and type is the single pile consumption times the number of piles.

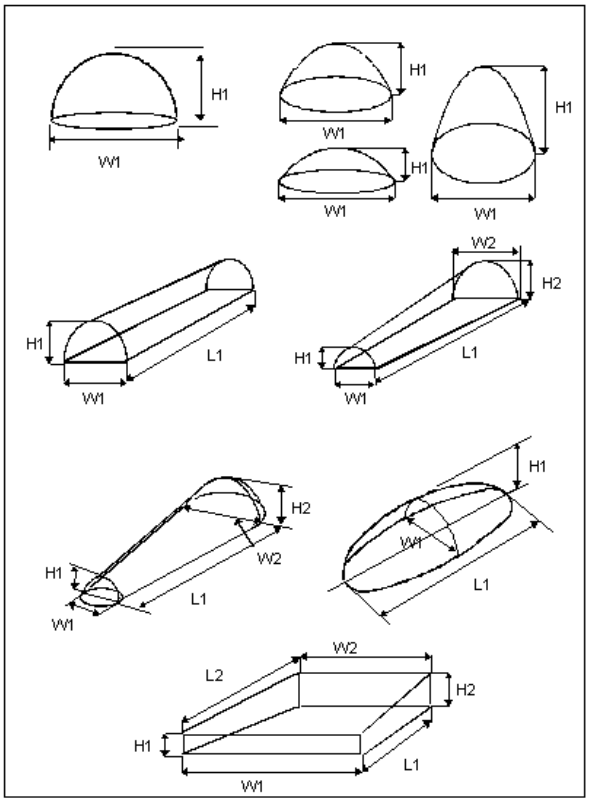
Consume uses this algorithm to calculate consumption for a given pile. The lettered equations are explained below.

Pile Consumption Algorithm



Equation A: Total Gross Volume of the Pile

The volume of a pile is dependent upon its shape. This model categorizes piles into one of seven generalized shapes as shown in following figure:



The volume for each shape is calculated using various lengths, heights and/or widths. The equations for each shape are listed below:

Pile Type	Volume Equation (ft^3)
Half section of sphere	$V = (2 * \pi * Height^3)/3$
Paraboloids	$V = (\pi * Height * Width^2)/8$
Half cylinder	$V = (\pi * Width * Length * Height)/4$
Half fustrum of cone	$V = [\pi * Length_1 * (Height_1^2 + Height_2^2 + (Height_1 * Height_2))]/6$
Cone with round ends	$V = [\pi * \{Length * (Width_1^2 + Width_2^2 + (Width_1 * Width_2)) + Width_1^2 + Width_2^2\}]/24$
Half ellipsoid	$V = (\pi * Width * Length * Height)/6$
Irregular solid	$V = [(Length_1 + Length_2) * (Width_1 + Width_2) * (Height_1 + Height_2)]/8$

Equation A-alternate: Net wood volume reduction

Some piles may contain a significant percentage of soil within the pile or mounded beneath the pile. Reduce the net wood volume using an estimate of the % of the pile occupied by soil.

Corrected net wood volume (ft^3) = Net wood volume * (100 - PileSoil)/100

Equation B: Net Volume of the Woody Biomass

Air comprises much of the gross volume of a pile. The ratio of wood volume to the total pile volume, the packing ratio, ranges from 6 to 26 %. Consume uses the following three default packing ratios:

- Piles with species content dominated by long-needled pines and/or broadleaf deciduous litter. Mean diameters of large woody fuels < 10 inches. Packing ratio = 10% (0.1).
- Piles dominated by short-needled conifers. Mean diameters of large woody fuels < 10 inches. Packing ratio = 20% (0.2).
- Highly compacted, clean piles with large logs (diameters > 10 inches), especially those built with a crane or loader. Packing ratio = 25% (0.25).

The net wood volume is the gross pile volume times the appropriate packing ratio.

Net Wood Volume (ft^3) = Gross pile volume (ft^3) * Packing ratio proportion.

Table C: Wood densities by tree species

The fuel loading of the pile is based on the oven dry density of the wood. If two species are identified, calculate a weighted-average density. If there are more than two species, and no single species represents a majority of the pile then sum the most abundant species until the sum equals or exceeds 50%. Select the most abundant species among those summed to represent the group.

The tree species wood densities available in Consume are listed in the following table. Most wood density values were compiled from the Wood Handbook (1999) assuming 12% moisture content. Common tree name followed by an asterisk (*) were taken from the Wood Density Database (http://www.worldagroforestry.org/sea/Products/AFDbases/WD/Index.htm) and had variable moisture contents from 12 to 15%.

Common names	Tree species	Density (lbs/ft3)
American basswood	*Tilia americana*	25.9
American beech	*Fagus grandifolia*	44.7
American chestnut	*Castanea dentate*	30.1
American elm	*Ulmus Americana*	34.9
American holly*	*Ilex opaca*	35.6
American hop hornbeam*	*Ostrya virginiana*	43.7
Austrailian pine (Casuarina)*	*Casuarina equisetifolia*	57.4
baldcypress	*Taxodium distichum*	32.2
balsam fir	*Abies balsamea*	23.1
balsam poplar	*Populus balsamifera*	23.8
bigleaf maple	*Acer macrophyllum*	30.8
bitternut hickory	*Carya cordiformis*	46.1
black ash	*Fraxinus nigra*	34.2
black cherry	*Prunus serotina*	34.9
black cottonwood*	*Populus balsamifera ssp. trichocarpa*	22.8
black oak	*Quercus velutina*	42.6
black spruce	*Picea mariana*	32.2
black tupelo	*Nyssa sylvatica*	34.9
black walnut	*Juglans nigra*	38.4

Common names	Tree species	Density (lbs/ft3)
black willow	*Salix nigra*	27.3
boxelder*	*Acer negundo*	33.7
bur oak	*Quercus macrocarpa*	44.7
California black oak*	*Quercus kelloggii*	36.2
California laurel*	*Umbellularia californica*	34.3
chestnut oak	*Quercus prinus*	46.1
coast redwood	*Sequoia sempervirens*	30.25
common hackberry	*Celtis occidentalis*	37
Douglas-fir	*Pseudotsuga menziesii*	30.8
eastern white pine	*Pinus strobes*	23.1
eastern cottonwood	*Populus deltoids*	28
eastern hemlock	*Tsuga canadensis*	28
eastern redcedar	*Juniperus virginiana*	32.85
Engelmann spruce	*Picea engelmannii*	23.1
grand fir	*Abies grandis*	25.9
green ash	*Fraxinus pennsylvanica*	39.1
gumbo limbo*	*Bursera simaruba*	18.7
hackberry*	*Celtis spp.*	42.5
honey mosquite*	*Prosopis glandulosa*	43.7
honeylocust	*Gleditsia triacanthos*	46.1
incense cedar	*Calocedrus decurrens*	25.9
ironwood (*Carpinus*)*	*Carpinus caroliniana*	43.7
jack pine	*Pinus banksiana*	30.1
koa*	*Acacia koa*	41.8
laurel oak	*Quercus laurifolia*	44
live oak*	*Quercus virginiana*	63.1
loblolly pine	*Pinus taeda*	35.6
lodgepole pine	*Pinus contorta*	28.7
longleaf pine	*Pinus palustris*	41.2
mahogany*	*Swietenia mahagoni*	44.0
noble fir	*Abies magnifica*	26.6
northern pin oak	*Quercus ellipsoidalis*	44
northern red oak	*Quercus rubra*	44
Oregon white oak*	*Quercus garryana*	44.9
Pacific madrone*	*Arbutus menziesii*	35.6
Pacific silver fir	*Abies amabilis*	30.1
paper birch	*Betula papyrifera*	38.4
paperbark tree (Melaleuca)*	*Melaleuca quinquenervia*	43.4

Common names	Tree species	Density (lbs/ft3)
persimmon*	*Diospyros virginiana*	52.0
pignut hickory	*Carya glabra*	52.4
pitch pine	*Pinus rigida*	36.3
pond pine	*Pinus serotina*	39.1
ponderosa pine	*Pinus ponderosa*	28
post oak	*Quercus stellata*	46.8
quaking aspen	*Populus tremuloides*	26.6
red alder	*Alnus rubra*	28.7
red mangrove*	*Rhizophora mangle*	61.2
red maple	*Acer rubrum*	37.7
red pine	*Pinus resinosa*	32.2
red spruce	*Picea rubens*	28
redbud*	*Cercis canadensis*	48.7
sand pine	*Pinus clausa*	30.8
sassafras	*Sassafras albidum*	32.2
scarlet oak	*Quercus coccinea*	46.8
shortleaf pine	*Pinus echinata*	35.6
silver maple	*Acer saccharinum*	32.85
Sitka spruce	*Picea sitchensis*	25.2
slash pine	*Pinus elliottii*	41.2
southern magnolia	*Magnolia grandiflora*	34.9
spruce pine	*Pinus glabra*	30.8
subalpine fir	*Abies lasiocarpa*	22.4
sugar maple	*Acer saccharum*	44
sugar pine	*Pinus lambertiana*	26.6
swamp chestnut oak	*Quercus michauxii*	46.8
sweetbay magnolia*	*Magnolia virginiana*	32.5
Sweetgum	*Liquidambar styraciflua*	36.3
tamarack	*Larix laricina*	37
tanoak	*Lithocarpus densiflorus*	38.7
Tasmanian blue gum (*Eucalyptus*)*	*Eucalyptus globules*	45.3
tuliptree	*Liriodendron tulipifera*	29.4
Virginia pine	*Pinus virginiana*	30.8
water oak	*Quercus nigra*	44
water tupelo	*Nyssa aquatica*	34.9
western hemlock	*Tsuga heterophylla*	31.5
western larch	*Larix occidentalis*	36.3

Common names	Tree species	Density (lbs/ft3)
western redcedar	*Thuja plicata*	22.4
western white pine	*Pinus monticola*	26.6
white ash	*Fraxinus americana*	41.9
white fir	*Abies concolor*	27.3
white oak	*Quercus alba*	47.5
white spruce	*Picea glauca*	28
willlow oak	*Quercus phellos*	48.2
yellow birch	*Betula alleghaniensis*	43.3

Equation D: Consumable (Oven-Dry) Mass of Wood

The consumable mass of wood in a pile is the net wood volume, times the wood density or weighted average wood density. Divide the loading in pounds by 2000 to get mass in tons.

Mass of Wood (lbs) = Net wood volume (ft^3) * Oven-dry density (lb/ft^3)

Equation E: Proportion of Mass Consumed

The percentage of mass consumed in burning piles ranges from 75 to 95 % (Hardy 1996). Several western states have smoke management-reporting programs that recommend values between 85 to 90%. Consume assumes the percentage of mass consumed is 90 % (0.90).

Mass of Wood Consumed (lbs) = 0.90 * Mass of wood (lbs)

Emission Algorithms

The rate of smoke emissions produced from a prescribed fire varies with the combustion phase of a fire. Less smoke is produced per ton of fuel during the efficient flaming stage than during the less efficient smoldering phase. Consequently, fuel consumption needs to be analyzed by combustion state if the best estimations for total emissions produced are to be made. Calculations have shown that a 65% error is associated with emission calculations using total fuel consumption only rather than breaking the consumption into combustion phases (Sandberg 1983).

Consume uses two approaches for estimating emissions. The first approach is used for non-piled fuels and calculates emissions based on a set of emission factors, which determine an emission factor, based on the type of fuel and the combustion phase of the burn. Emission factors for piled fuels are based on the soil content of the accumulation.

Emissions

Fuel consumption multiplied by an emission factor will give an estimate of total emissions. There are several emission factors, depending on type of burn (broadcast/under burn, crane pile, tractor pile), type of fuel (Douglas-fir, mixed conifer, ponderosa pine, hardwood, juniper, sage brush), and combustion stage (flaming, smoldering, and residual smoldering). The emission factors reported in Consume are calculated using the flaming and smoldering emission factors from Table 1 and weighted according to the amount of fuel consumed in each phase.

Table 1: Emissions factors used in Consume

		Emissions Factors by Pollutant (lb/ton)						
Fuel Type	**Combustion**	**PM**	**PM10[b]**	**$PM^{2.5}$**	**CO**	**CO_2**	**CH_4**	**NMHC**
Default	Flaming	23	15	13	90	2522	3	5
(Average of all	Smoldering	34	24	19	209	2285	11	10
factors)	Residual	34	24	19	209	2285	11	10
BROADCAST-BURNED SLASH (Ward *et al.* 1989)								
Douglas-fir/hemlock	Flaming	24.7	16.6	14.9	143	3385	4.6	4.2
(n=12)	Smoldering	35	27.6	26.1	463	2804	15.2	8.4
	Residual	35	27.6	26.1	463	2804	15.2	8.4
Hardwoods	Flaming	23	14	12.2	92	3389	4.4	5.2
(n=8)	Smoldering	38	25.9	23.4	366	2851	19.6	14

		Emissions Factors by Pollutant (lb/ton)						
Fuel Type	**Combustion**	**PM**	**PM10[b]**	**PM$^{2.5}$**	**CO**	**CO_2**	**CH_4**	**NMHC**
	Residual	38	25.9	23.4	366	2851	19.6	14
Ponderosa & lodgepole pine	Flaming	18.8	11.5	10	89	3401	3	3.6
(n=3)	Smoldering	48.6	36.7	34.2	285	2971	14.6	9.6
	Residual	48.6	36.7	34.2	285	2971	14.6	9.6
Mixed conifer	Flaming	22	11.7	9.6	53	3458	3	3.2
(n=3)	Smoldering	33.6	25.3	23.6	273	3023	17.6	13.2
	Residual	33.6	25.3	23.6	273	3023	17.6	13.2
Juniper	Flaming	21.9	15.3	13.9	82	3401	3.9	5.5
(n=6)	Smoldering	35.1	25.8	23.8	250	3050	20.5	15.5
	Residual	35.1	25.8	23.8	250	3050	20.5	15.5
BROADCAST-BURNED BRUSH (Hardy *et al.* 1998)								
Sagebrush	Flaming	45	31.8	29.1	155	3197	7.4	6.8
(n=4)	Smoldering	45.3	29.6	26.4	212	3118	12.4	14.5
	Residual	45.3	29.6	26.4	212	3118	12.4	14.5
Chaparral	Flaming	31.6	16.5	13.5	119	3326	3.4	17.2
(n=9)	Smoldering	40	24.7	21.6	197	3144	9	30.6
	Residual	40	24.7	21.6	197	3144	9	30.6
NEW EMISSIONS FACTORS (S. Baker personal communication, Missoula Fire Laboratory)								
Western Pine	Flaming	na	na	13.82	81.65	1663.32	2.89	2.77
(n=53, n=57)[c]	Smoldering	na	na	14.43	141.47	1551.59	6.25	3.77
	Residual	na	na	14.43	141.47	1551.59	6.25	3.77
Minnesota Oak	Flaming	na	na	10.02	61.19	1709.21	1.66	1.92
(n=7)	Smoldering	na	na	10.45	109.06	1609.45	6.64	3.75
	Residual	na	na	10.45	109.06	1609.45	6.64	3.75
Minnesota Pine	Flaming	na	na	11.71	64.62	1694.33	2.03	2.03
(n=4, n=5)[c]	Smoldering	na	na	13.44	90.77	1644.78	3.09	2.61
	Residual	na	na	13.44	90.77	1644.78	3.09	2.61
Southern Pine	Flaming	na	na	11.44	72.79	1680.72	2.04	2.48
(n=77, n=78)[c]	Smoldering	na	na	9.91	119.34	1601.54	3.76	4.04

		Emissions Factors by Pollutant (lb/ton)						
Fuel Type	**Combustion**	**PM**	**PM10[b]**	**$PM^{2.5}$**	**CO**	**CO_2**	**CH_4**	**NMHC**
	Residual	na	na	9.91	119.34	1601.54	3.76	4.04
Sage	Flaming	na	na	12.92	126.35	1589.82	3.12	4.35
(n=8)	Smoldering	na	na	8.36	184.22	1452.55	11.92	14.28
	Residual	na	na	8.36	184.22	1452.55	11.92	14.28
Minnesota Grass	Flaming	na	na	12.18	61.35	1698.00	2.12	3.82
(n=16, n=7)[c]	Smoldering	na	na	10.75	109.37	1629.92	4.32	4.25
	Residual	na	na	10.75	109.37	1629.92	4.32	4.25
Arizona Piles	Flaming	na	na	7.74	52.66	1714.61	3.28	3.56
(n=49, n=27)[c]	Smoldering	na	na	21.05	130.37	1544.93	11.03	6.78
	Residual	na	na	21.05	130.37	1544.93	11.03	6.78

[a] Fire-average values are weighed-averages based on measured carbon flux.

[b] PM10 values are calculated, not measured, and are derived from known size-class distributions of particulates using PM and PM2.5.

[c] Flaming and smoldering sample sizes, respectively.

Activity—non-piled and natural Fuels Emissions

Basic equations for activity—non-piled and natural emissions in all situations are:

$$\textbf{Total flaming emissions (lb)} = \frac{\text{Total flaming biomass consumption (lb)} * \text{Flaming EF (lb/ton)}}{\text{2000 (lb/ton)}}$$

EF (lb/ton) = Particulate matter (PM), 2.5 micron particulate matter (PM2.5), 10 micron particulate matter (PM 10), carbon monoxide (CO), carbon dioxide (CO2), methane (CH4), and non-methane hydrocarbon (NMHC)

$$\textbf{Total smoldering emissions (lb)} = \frac{\text{Total smoldering biomass consumption (lb)} * \text{Smoldering EF (lb/ton)}}{\text{2000 (lb/ton)}}$$

EF (lb/ton) = Particulate matter (PM), 2.5 micron particulate matter (PM2.5), 10 micron particulate matter (PM 10), carbon monoxide (CO),

carbon dioxide (CO2), methane (CH4), and non-methane hydrocarbon (NMHC)

Emissions Factors for Woody Fuel Accumulations (Piles, Jackpots and Windrows)

The mass of emissions produced by a woody fuel accumulation is calculated by multiplying the total mass of fuel consumed times the appropriate emission factor (Tables 2a and 2b). Two different sets of emissions factors are used based on the most current emissions data available (Hardy 1996, Baker 2005). Emission factors for PM (total particulate matter), PM_{10} (particulate matter less than 10 micrometers, mean diameter), and $PM_{2.5}$ (particulate matter less than 2.5 micrometers, mean diameter) are based on the combustion efficiency of the fire. Cleaner accumulations burn more efficiently and therefore produce less emissions.

Woody Fuel Accumulation Emissions (lb) = Emission factor (lb/ton) * Consumption (tons)

Table 2a: Emissions factors (lbs/ton) for particulate matter (PM, PM_{10}, $PM_{2.5}$) after Hardy (1996).

	PM	**PM10**	**PM2.5**
Clean	21.9	15.5	13.5
Dirty	27	20	17
Really dirty	36	28	23.6

Table 2b: Emissions factors (lbs/ton) for all other pollutants (CO, CO_2, CH_4 and NMHC) after Steven Baker (Personal Communication, Missoula Fire Laboratory).

	CO	**CO2**	**CH4**	**NMHC**
Flaming	52.66	1714.61	3.28	3.56
Smoldering	130.37	1544.93	11.03	6.78
Residual	130.37	1544.93	11.03	6.78

Appendix D: Reference Tables for the Consume Batch Mode Input File

Ecoregion Divisions

		Equation Type	
Ecoregion	**Type**	**activity**	**Natural**
120-Tundra	Boreal	1	4
130-Subarctic	Boreal	1	4
210-Warm Continental	Western	3	6
220-Hot Continental	Western	3	6
230-Subtropical	Southern	2	5
250-Prairie	Western	3	6
240-Marine	Western	3	6
260-Mediterranean	Western	3	6
310-Tropical/Subtropical Steppe Desert	Southern	2	5
320-Tropical/Subtropical Desert	Southern	2	5
330-Temperate Steppe	Western	3	6
340-Temperate Desert	Western	3	6
410-Savanna	Southern	2	5
420-Rainforest	Southern	2	5

Cover Types

CoverTypeID	Type/Number	Cover Type Name
1	SRM 101	Bluebunch Wheatgrass
2	SRM 102	Idaho Fescue
3	SRM 103	Green Fescue
4	SRM 104	Antelope Bitterbrush-Bluebunch Wheatgrass
5	SRM 105	Antelope Bitterbrush-Idaho Fescue
6	SRM 106	Bluegrass Scabland

CoverTypeID	Type/Number	Cover Type Name
7	SRM 107	Western Juniper-Big Sagebrush-Bluebunch Wheatgrass
8	SRM 108	Alpine Idaho Fescue
9	SRM 109	Ponderosa Pine - Shrubland
10	SRM 110	Ponderosa Pine - Grassland
11	SRM 201	Blue Oak Woodland
12	SRM 202	Coast Live Oak Woodland
13	SRM 203	Riparian Woodland
14	SAF 1	Jack Pine
15	SAF 5	Balsam Fir
16	SAF 12	Black Spruce (Eastern)
17	SAF 13	Black Spruce-Tamarack
18	SAF 107	White Spruce (Eastern)
19	SAF 38	Tamarack
20	SAF 16	Aspen (Eastern)
21	SAF 17	Pin Cherry
22	SAF 18	Paper Birch (Eastern)
23	SAF 32	Red Spruce
24	SAF 33	Red Spruce-Balsam Fir
25	SAF 34	Red Spruce-Fraser Fir
26	SAF 30	Red Spruce-Yellow Birch
27	SAF 31	Red Spruce-Sugar Maple-Beech
28	SAF 35	Paper Birch-Red Spruce-Balsam Fir
29	SAF 37	Northern White Cedar
30	SAF 15	Red Pine
31	SAF 21	Eastern White Pine
32	SAF 22	White Pine-Hemlock
33	SAF 23	Eastern Hemlock
34	SAF 20	White Pine-Northern Red Oak-Red Maple
35	SAF 51	White Pine-Chestnut Oak
36	SAF 24	Hemlock-Yellow Birch
37	SAF 27	Sugar Maple
38	SAF 25	Sugar Maple-Beech-Yellow Birch
39	SAF 26	Sugar Maple-Basswood
40	SAF 28	Black Cherry-Maple
41	SAF 60	Beech-Sugar Maple
42	SAF 108	Red Maple
43	SAF 14	Northern Pin Oak
44	SAF 19	Gray Birch-Red Maple
45	SAF 39	Black Ash-American Elm-Red Maple

CoverTypeID	Type/Number	Cover Type Name
46	SAF 109	Hawthorn
47	SAF 40	Post Oak-Blackjack Oak
48	SAF 42	Bur Oak (Eastern)
49	SAF 43	Bear Oak
50	SAF 44	Chestnut Oak
51	SAF 52	White Oak-Black Oak-Northern Red Oak
52	SAF 53	White Oak
53	SAF 110	Black Oak
54	SAF 55	Northern Red Oak
55	SAF 50	Black Locust
56	SAF 57	Yellow-Poplar
57	SAF 58	Yellow-Poplar-Eastern Hemlock
58	SAF 59	Yellow-Poplar-White Oak-Northern Red Oak
59	SAF 61	River Birch-Sycamore
60	SAF 62	Silver Maple-American Elm
61	SAF 64	Sassafras-Persimmon
62	SAF 65	Pin Oak-Sweetgum
63	SAF 45	Pitch Pine
64	SAF 46	Eastern Redcedar
65	SAF 69	Sand Pine
66	SAF 70	Longleaf Pine
67	SAF 83	Longleaf Pine-Slash Pine
68	SAF 75	Shortleaf Pine
69	SAF 79	Virginia Pine
70	SAF 81	Loblolly Pine
71	SAF 80	Loblolly Pine-Shortleaf Pine
72	SAF 84	Slash Pine
73	SAF 111	South Florida Slash Pine
74	SAF 98	Pond Pine
75	SAF 71	Longleaf Pine-Scrub Oak
76	SAF 76	Shortleaf Pine-Oak
77	SAF 78	Virginia Pine-Oak
78	SAF 82	Loblolly Pine-Hardwood
79	SAF 85	Slash Pine-Hardwood
80	SAF 63	Cottonwood (Southern)
81	SAF 88	Willow Oak-Water Oak-Diamondleaf Oak
82	SAF 89	Live Oak (Southern)
83	SAF 91	Swamp Chestnut Oak-Cherrybark oak
84	SAF 92	Sweetgum-Willow Oak

CoverTypeID	Type/Number	Cover Type Name
85	SAF 93	Sugarberry-American Elm-Green Ash
86	SAF 94	Sycamore-Sweetgum-American Elm
87	SAF 95	Black Willow
88	SAF 96	Overcup Oak-Water Hickory
89	SAF 101	Baldcypress
90	SAF 102	Baldcypress-Tupelo
91	SAF 103	Water Tupelo-Swamp Tupelo
92	SAF 104	Sweetbay-Swamp Tupelo-Redbay
93	SAF 66	Ashe Juniper-Redberry (Pinchot) Juniper
94	SAF 67	Mohr's ("Shin") Oak
95	SAF 68	Mesquite (Southern)
96	SAF 72	Southern Scrub Oak
97	SAF 73	Southern Redcedar
98	SAF 74	Cabbage Palmetto
99	SAF 87	Sweetgum-Yellow-Poplar
100	SAF 97	Atlantic White-Cedar
101	SAF 100	Pondcypress
102	SAF 105	Tropical Hardwoods (Florida)
103	SAF 106	Mangrove
104	SAF 201	White Spruce (Western)
105	SAF 251	White Spruce-Aspen
106	SAF 202	White Spruce-Paper Birch
107	SAF 252	Paper Birch (Western)
108	SAF 203	Balsam Poplar
109	SAF 204	Black Spruce (Western)
110	SAF 253	Black Spruce-White Spruce
111	SAF 254	Black Spruce-Paper Birch
112	SAF 205	Mountain Hemlock
113	SAF 206	Engelmann Spruce-Subalpine Fir
114	SAF 207	Red Fir
115	SAF 208	Whitebark Pine
116	SAF 209	Bristlecone Pine
117	SAF 256	California Mixed Subalpine
118	SAF 210	Interior Douglas-Fir
119	SAF 211	White Fir
120	SAF 212	Western Larch
121	SAF 213	Grand Fir
122	SAF 215	Western White Pine
123	SAF 216	Blue Spruce

CoverTypeID	Type/Number	Cover Type Name
124	SAF 217	Aspen (Western)
125	SAF 218	Lodgepole Pine
126	SAF 219	Limber Pine
127	SAF 220	Rocky Mountain Juniper
128	SAF 221	Red Alder
129	SAF 222	Black Cottonwood-Willow
130	SAF 223	Sitka Spruce
131	SAF 224	Western Hemlock
132	SAF 225	Western Hemlock-Sitka Spruce
133	SAF 226	Coastal True Fir-Hemlock
134	SAF 227	Western Redcedar-Western Hemlock
135	SAF 228	Western Redcedar
136	SAF 229	Pacific Douglas-Fir
137	SAF 230	Douglas-Fir-Western Hemlock
138	SAF 231	Port Orford-Cedar
139	SAF 232	Redwood
140	SAF 233	Oregon White Oak
141	SAF 234	Douglas-Fir-Tanoak-Pacific Madrone
142	SAF 235	Cottonwood-Willow (Western)
143	SAF 236	Bur Oak (Western)
144	SAF 237	Interior Ponderosa Pine
145	SAF 238	Western Juniper
146	SAF 239	Pinyon-Juniper
147	SAF 240	Arizona Cypress
148	SAF 241	Western Live Oak
149	SAF 242	Mesquite (Western)
150	SAF 243	Sierra Nevada Mixed Conifer
151	SAF 244	Pacific Ponderosa Pine-Douglas-Fir
152	SAF 245	Pacific Ponderosa Pine
153	SAF 246	California Black Oak
154	SAF 247	Jeffrey Pine
155	SAF 248	Knobcone Pine
156	SAF 249	Canyon Live Oak
157	SAF 250	Blue Oak-Digger Pine
158	SAF 255	California Coast Live Oak
159	SRM 204	Northern Coastal Shrub
160	SRM 205	Coastal Sage Shrub
161	SRM 206	Chamise Chaparral
162	SRM 207	Scrub Oak Mixed Chaparral

CoverTypeID	Type/Number	Cover Type Name
163	SRM 208	Ceanothus Mixed Chaparral
164	SRM 209	Montane Shrubland
165	SRM 210	Bitterbrush
166	SRM 211	Creosote Bush Shrub
167	SRM 212	Blackbush
168	SRM 213	Alpine Grassland (Pacific Southwest)
169	SRM 214	Coastal Prairie
170	SRM 215	Valley Grassland (Pacific Southwest)
171	SRM 216	Montane Meadows
172	SRM 217	Wetlands (Pacific Southwest)
173	SRM 301	Bluebunch Wheatgrass-Blue Grama
174	SRM 302	Bluebunch Wheatgrass-Sandberg Bluegrass
175	SRM 303	Bluebunch Wheatgrass-Western Wheatgrass
176	SRM 304	Idaho Fescue-Bluebunch Wheatgrass
177	SRM 305	Idaho Fescue-Richardson Wheatgrass
178	SRM 306	Idaho Fescue-Slender Wheatgrass
179	SRM 307	Idaho Fescue-Threadleaf Sedge
180	SRM 308	Idaho Fescue-Tufted Hairgrass
181	SRM 309	Idaho Fescue-Western Wheatgrass
182	SRM 310	Needle-and-Thread - Blue Grama
183	SRM 311	Rough Fescue-Bluebunch Wheatgrass
184	SRM 312	Rough Fescue-Idaho Fescue
185	SRM 313	Tufted Hairgrass-Sedge
186	SRM 314	Big Sagebrush-Bluebunch Wheatgrass
187	SRM 315	Big Sagebrush-Idaho Fescue
188	SRM 316	Big Sagebrush-Rough Fescue
189	SRM 317	Bitterbrush-Bluebunch Wheatgrass
190	SRM 318	Bitterbrush-Idaho Fescue
191	SRM 319	Bitterbrush-Rough Fescue
192	SRM 320	Black Sagebrush-Bluebunch Wheatgrass
193	SRM 321	Black Sagebrush-Idaho Fescue
194	SRM 322	Curlleaf Mountain-Mahogany-Bluebunch Wheatgrass
195	SRM 323	Shrubby Cinquefoil-Rough Fescue
196	SRM 324	Threetip Sagebrush-Idaho Fescue
197	SRM 401	Basin Big Sagebrush
198	SRM 402	Mountain Big Sagebrush
199	SRM 403	Wyoming Big Sagebrush
200	SRM 404	Treetip Sagebrush
201	SRM 405	Black Sagebrush

CoverTypeID	Type/Number	Cover Type Name
202	SRM 406	Low Sagebrush
203	SRM 407	Stiff Sagebrush
204	SRM 408	Other Sagebrush Types
205	SRM 409	Tall Forb (Great Basin)
206	SRM 410	Alpine Rangeland (Great Basin)
207	SRM 411	Aspen Woodland
208	SRM 412	Juniper-Pinyon Woodland
209	SRM 413	Gambel Oak
210	SRM 414	Salt Desert Shrub
211	SRM 415	Curlleaf Mountain-Mahogany
212	SRM 416	True Mountain-Mahogany
213	SRM 417	Littleleaf Mountain-Mahogany
214	SRM 418	Bigtooth Maple
215	SRM 419	Bittercherry
216	SRM 420	Snowbush
217	SRM 421	Chokecherry-Serviceberry-Rose
218	SRM 422	Riparian (Great Basin)
219	SRM 501	Saltbush-Greasewood
220	SRM 502	Grama-Galetta
221	SRM 503	Arizona Chaparral
222	SRM 504	Juniper-Pinyon Pine Woodland
223	SRM 505	Grama-Tobosa Shrub
224	SRM 506	Creosotebush-Bursage
225	SRM 507	Palo Verde-Cactus
226	SRM 508	Creosotebush-Tarbush
227	SRM 509	Oak-Juniper Woodland and Mahogany-Oak
228	SRM 601	Bluestem Prairie
229	SRM 602	Bluestem-Prairie Sandreed
230	SRM 603	Prairie Sandreed-Needlegrass
231	SRM 604	Bluestem-Grama Prairie
232	SRM 605	Sandsage Prairie
233	SRM 606	Wheatgrass-Bluestem-Needlegrass
234	SRM 607	Wheatgrass-Needlegrass
235	SRM 608	Wheatgrass-Grama-Needlegrass
236	SRM 609	Wheatgrass-Grama
237	SRM 610	Wheatgrass
238	SRM 611	Blue Grama-Buffalograss
239	SRM 612	Sagebrush-Grass
240	SRM 613	Fescue Grassland

CoverTypeID	Type/Number	Cover Type Name
241	SRM 614	Crested Wheatgrass
242	SRM 615	Wheatgrass-Saltgrass-Grama
243	SRM 701	Alkali Sacaton-Tobosagrass
244	SRM 702	Black Grama-Alkali Sacaton
245	SRM 703	Black Grama-Sideoats Grama
246	SRM 704	Blue Grama-Western Wheatgrass
247	SRM 705	Blue Grama-Galetta
248	SRM 706	Blue Grama-Sideoats Grama
249	SRM 707	Blue Grama-Sideoats Grama-Black Grama
250	SRM 708	Bluestem-Dropseed
251	SRM 709	Bluestem-Grama
252	SRM 710	Bluestem Prairie
253	SRM 711	Bluestem-Sacahuista Prairie
254	SRM 712	Galetta-Alkali Sacaton
255	SRM 713	Grama-Muhly-Threeawn
256	SRM 714	Grama-Bluestem
257	SRM 715	Grama-Buffalograss
258	SRM 716	Grama-Feathergrass
259	SRM 717	Little Bluestem-Indiangrass-Texas Wintergrass
260	SRM 718	Mesquite-Grama
261	SRM 719	Mesquite-Liveoak-Seacoast Bluestem
262	SRM 720	Sand Bluestem-Little Bluestem Dunes
263	SRM 721	Sand Bluestem-Little Bluestem Prairie
264	SRM 722	Sand Sagebrush-Mixed Prairie
265	SRM 723	Sea Oats
266	SRM 724	Sideoats Grama-New Mexico Feathergrass-Winterfat
267	SRM 725	Vine Mesquite-Alkali Sacaton
268	SRM 726	Cordgrass
269	SRM 727	Mesquite-Buffalograss
270	SRM 728	Mesquite-Granjeno-Acacia
271	SRM 729	Mesquite
272	SRM 730	Sand Shinnery Oak
273	SRM 731	Cross Timbers-Oklahoma
274	SRM 732	Cross Timbers-Texas (Little Bluestem Post Oak)
275	SRM 733	Juniper-Oak
276	SRM 734	Mesquite-Oak
277	SRM 735	Sideoats Grama-Sumac-Juniper
278	SRM 801	Savanna
279	SRM 802	Missouri Prairie

CoverTypeID	Type/Number	Cover Type Name
280	SRM 803	Missouri Glade
281	SRM 804	Tall Fescue
282	SRM 805	Riparian (Southeastern)
283	SRM 806	Gulf Coast Salt Marsh
284	SRM 807	Gulf Coast Fresh Marsh
285	SRM 808	Sand Pine Scrub
286	SRM 809	Mixed Hardwood and Pine
287	SRM 810	Longleaf Pine-Turkey Oak Hills
288	SRM 811	South Florida Flatwoods
289	SRM 812	North Florida Flatwoods
290	SRM 813	Cutthroat Seeps
291	SRM 814	Cabbage Palms Flatwoods
292	SRM 815	Unpland Hardwood Hammocks
293	SRM 816	Cabbage Palm Hammocks
294	SRM 817	Oak Hammocks
295	SRM 818	Florida Salt Marsh
296	SRM 819	Freshwater Marsh and Ponds
297	SRM 820	Everglades Flatwoods
298	SRM 821	Pitcher Plant Bogs
299	SRM 822	Slough (Southeastern)
300	SRM 901	Alder (Alaska)
301	SRM 902	Alpine Herb (Alaska)
302	SRM 903	Beach Wildrye-Mixed Forb
303	SRM 904	Black Spruce-Lichen
304	SRM 905	Bluejoint Reedgrass
305	SRM 906	Broadleaf Forest
306	SRM 907	Dryas
307	SRM 908	Fescue
308	SRM 909	Freshwater Marsh
309	SRM 910	Hairgrass
310	SRM 911	Lichen Tundra
311	SRM 912	Low Scrub Shrub Birch-Ericaceous
312	SRM 913	Low Scrub Swamp
313	SRM 914	Mesic Sedge-Grass-Herb Meadow Tundra
314	SRM 915	Mixed Herb-Herbaceous
315	SRM 916	Sedge-Shrub Tundra
316	SRM 917	Tall Shrub Swamp (Alaska)
317	SRM 918	Tussock Tundra
318	SRM 919	Wet Meadow Tundra (Alaska)

CoverTypeID	Type/Number	Cover Type Name
319	SRM 920	White Spruce-Paper Birch
320	SRM 921	Willow
321	Unknown	Unknown

Volume Equations by Pile Shape

Pile Shape	Volume Equation (ft3)	Required dimensional input
Half section of sphere	$V = (2 * \pi * Height^3)/3$	Height1, Width1
Paraboloids	$V = (\pi * Height * Width^2)/8$	Height1, Width1, Length1
Half cylinder	$V = (\pi * Width * Length * Height)/4$	Height1, Height2, Length1
Half fustrum of cone	$V = [\pi * Length_1 * (Height_1^2 + Height_2^2 + (Height_1 * Height_2))]/6$	Height1, Height2, Length1
Cone with round ends	$V = [\pi * \{Length * (Width_1^2 + Width_2^2 + (Width_1 * Width_2)) + Width_1^2 + Width_2^2\}]/24$	Width1, Width2, Length1
Half ellipsoid	$V = (\pi * Width * Length * Height)/6$	Height1, Width1, Length1
Irregular solid	$V = [(Length_1 + Length_2) * (Width_1 + Width_2) * (Height_1 + Height_2)]/8$	Height1, Height2, Width1, Width2, Length1, Length2

Wood Densities by Tree Species

You can enter your own wood density values or use this look up table as a reference. Unless otherwise noted, wood densities were taken from the Wood Handbook General Technical Report 113. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 463 p.

Common names	Species	Density (lbs/ft3)
American basswood	Tilia americana	25.9
American beech	Fagus grandifolia	44.7
American chestnut	Castanea dentata	30.1
American elm	Ulmus americana	34.9
American holly	Ilex opaca*	35.6
American hop hornbeam	Ostrya virginiana*	43.7
Austrailian pine (Casuarina)	Casuarina equisetifolia*	57.4
baldcypress	Taxodium distichum	32.2
balsam fir	Abies balsamea	23.1
balsam poplar	Populus balsamifera	23.8
bigleaf maple	Acer macrophyllum	30.8
bitternut hickory	Carya cordiformis	46.1
black ash	Fraxinus nigra	34.2
black cherry	Prunus serotina	34.9
black cottonwood	Populus balsamifera ssp. trichocarpa*	22.8
black oak	Quercus velutina	42.6
black spruce	Picea mariana	32.2
black tupelo	Nyssa sylvatica	34.9
black walnut	Juglans nigra	38.4
black willow	Salix nigra	27.3
boxelder	Acer negundo*	33.7
bur oak	Quercus macrocarpa	44.7
California black oak	Quercus kelloggii*	36.2
California laurel	Umbellularia californica*	34.3
chestnut oak	Quercus prinus	46.1
coast redwood	Sequoia sempervirens	30.25
common hackberry	Celtis occidentalis	37
Douglas-fir	Pseudotsuga menziesii	30.8
eastern cottonwood	Populus deltoides	28
eastern hemlock	Tsuga canadensis	28
eastern redcedar	Juniperus virginiana	32.85
eastern white pine	Pinus strobus	23.1

Common names	Species	Density (lbs/ft3)
Engelmann spruce	Picea engelmannii	23.1
grand fir	Abies grandis	25.9
green ash	Fraxinus pennsylvanica	39.1
gumbo limbo	Bursera simaruba*	18.7
hackberry	Celtis spp.*	42.5
honey mosquite	Prosopis glandulosa*	43.7
honeylocust	Gleditsia triacanthos	46.1
incense cedar	Calocedrus decurrens	25.9
ironwood (Carpinus)	Carpinus caroliniana*	43.7
jack pine	Pinus banksiana	30.1
koa	Acacia koa*	41.8
laurel oak	Quercus laurifolia	44
live oak	Quercus virginiana*	63.1
loblolly pine	Pinus taeda	35.6
lodgepole pine	Pinus contorta	28.7
longleaf pine	Pinus palustris	41.2
mahogany	Swietenia mahagoni*	44.0
noble fir	Abies magnifica	26.6
northern pin oak	Quercus ellipsoidalis	44
northern red oak	Quercus rubra	44
Oregon white oak	Quercus garryana*	44.9
Pacific madrone	Arbutus menziesii*	35.6
Pacific silver fir	Abies amabilis	30.1
paper birch	Betula papyrifera	38.4
paperbark tree (Melaleuca)	Melaleuca quinquenervia*	43.4
persimmon	Diospyros virginiana*	52.0
pignut hickory	Carya glabra	52.4
pitch pine	Pinus rigida	36.3
pond pine	Pinus serotina	39.1
ponderosa pine	Pinus ponderosa	28
post oak	Quercus stellata	46.8
quaking aspen	Populus tremuloides	26.6
red alder	Alnus rubra	28.7
red mangrove	Rhizophora mangle*	61.2
red maple	Acer rubrum	37.7
red pine	Pinus resinosa	32.2
red spruce	Picea rubens	28
Redbud	Cercis canadensis*	48.7
sand pine	Pinus clausa	30.8

Common names	Species	Density (lbs/ft3)
sassafras	Sassafras albidum	32.2
scarlet oak	Quercus coccinea	46.8
shortleaf pine	Pinus echinata	35.6
silver maple	Acer saccharinum	32.85
Sitka spruce	Picea sitchensis	25.2
slash pine	Pinus elliottii	41.2
southern magnolia	Magnolia grandiflora	34.9
spruce pine	Pinus glabra	30.8
subalpine fir	Abies lasiocarpa	22.4
sugar maple	Acer saccharum	44
sugar pine	Pinus lambertiana	26.6
swamp chestnut oak	Quercus michauxii	46.8
sweetbay magnolia	Magnolia virginiana*	32.5
sweetgum	Liquidambar styraciflua	36.3
tamarack	Larix laricina	37
tanoak	Lithocarpus densiflorus*	38.7
Tasmanian blue gum (Eucalyptus)	Eucalyptus globulus*	45.3
tuliptree	Liriodendron tulipifera	29.4
Virginia pine	Pinus virginiana	30.8
water oak	Quercus nigra	44
water tupelo	Nyssa aquatica	34.9
western hemlock	Tsuga heterophylla	31.5
western larch	Larix occidentalis	36.3
western redcedar	Thuja plicata	22.4
western white pine	Pinus monticola	26.6
white ash	Fraxinus americana	41.9
white fir	Abies concolor	27.3
white oak	Quercus alba	47.5
white spruce	Picea glauca	28
willlow oak	Quercus phellos	48.2
yellow birch	Betula alleghaniensis	43.3

* Source = Online Wood Density Database
http://www.worldagroforestry.org/sea/Products/AFDbases/WD/Index.htm

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Glossary

0-to-¼ inch woody fuels: Sound downed woody debris with a 0 to ¼ inch diameter size class (1-hour time lag fuels), ¼ to 1 inches, 1 to 3 inches, 3 to 9 inches, 9 to 20 inches, and greater than 20 inches.

¼-to-1-inch woody fuels: Sound downed woody debris with a ¼-to-1-inch diameter size class (10-hour time lag fuels).

1-to-3-inch woody fuels: Sound downed woody debris with a 1-to-3 inch diameter size class (100-hour time lag fuels).

3-to-9-inch woody fuels: Sound and rotten downed woody debris in a 3-to-9 inch diameter size class (1000-hour time lag fuels).

9-to-20-inch woody fuels: Sound and rotten downed woody debris in a 9-to-20-inch diameter size class (10,000-hour time lag fuels).

>20-inch woody fuels: Sound and rotten downed woody debris with a >20-inch diameter size class (>10,000-hour time lag fuels).

10-hour fuel moisture: Moisture content (percent) of ¼-to-1-inch diameter sound, woody fuels.

1000-hour fuel moisture (1000-Th): Moisture content (percent) of 3-to-9 inch diameter sound, woody fuels.

1000-hour fuel moisture source: 1000-hour fuel moistures can be directly measured (MEAS-Th), or estimated using the ADJ-Th or NFDRS-Th fuel moisture models.

Activity fuels (activity fuelbed type): Fuels resulting from or altered by forestry practices such as timber harvesting, thinning, etc., as opposed to naturally created fuels.

Adjusted 1000-hour fuel moisture (ADJ-Th): Adjusted 1000-hour fuel moisture is an estimated fuel moisture (derived from temperature, relative humidity, and precipitation data) that represents the average unit fuel moisture of large woody fuels in the Pacific Northwest more precisely than the National Fire Danger Rating System. Adjusted 1000-hour fuel moisture predicts the fuel moisture of Douglas fir, hemlock, mixed conifers, lodgepole pine and long-needled pine.

Avalanche: Change agent (natural event) in which a mass of snow and ice slides down an incline and pushes over trees and shrubs.

Basal accumulation: Needles, twigs, bark pieces, litter, and duff that accumulate and form over time at the base of trees creating a deeper organic layer than the surrounding area. A category of the Ground fuel stratum.

Basal accumulation derivation: Derivation of basal accumulation. The 7 derivation options include: bark slough, branches, broadleaf deciduous leaves, broadleaf evergreen leaves, grass, needle litter, or palm fronds.

Broadleaf: A conventional term applied to trees and shrubs of the flowering plant class Angiospermae, in contrast to the generally needle-leaved cone-bearing plant class Gymnospermae.

Broadleaf forest: Vegetation form. A forest dominated by broadleaf trees with a percentage canopy cover of greater than 60% and height exceeding 6 feet.

Burn date: The date the unit was burned or is planned to be burned.

Canopy stratum: The fuel layer within the fuelbed that characterizes the fuels in the tree (branches and foliage only), snag, and ladder fuel categories of the canopy stratum.

CH_4: Methane.

Change agent: Natural or management-induced activity that alters certain fuelbed characteristics and creates a new combustion environment. Change agent categories include fuel treatments, prescribed fire, natural events, wildfire, change over time, land use change, and vegetation treatments and timber harvest.

Chipping: Change agent (fuel treatment) in which woody fuels are broken into small pieces.

Clearcut: A timber harvest method in which all, or nearly all, trees in a stand of timber are cut in one operation.

CO: Carbon monoxide.

CO_2: Carbon dioxide.

Combustion phase: A unique burn environment composed of specific types of fuelbed stratum. These stages are flaming, smoldering, and residual smoldering.

Conifer forest: Vegetation form. A forest dominated by needle-leaf trees with a percentage canopy cover of greater than 60% and height exceeding 6 feet.

Consumption: The amount of fuels by weight consumed within a specific combustion phase for a fuel category within a fuelbed stratum.

Continuous woody fuels: Sound and rotten woody fuels in the following diameter size classes: 0 to ¼ inch, ¼ to 1 inch, 1 to 3 inch, 3 to 9 inch, 9 to 20 inch, and >20 inches.

Cover type: The existing vegetation of an area based on the Society of American Foresters forest cover types (Eyre 1980) and the Society for Range Management rangeland cover types (Shiflet 1994).

Crown: The part of a tree or woody plant bearing live branches and foliage.

Crown fire: A fire that advances by moving among the canopy of trees or shrubs.

Daily observation: A record of conditions within a Weather Zone.

Days since rain: The number of days since a significant amount of rain (i.e., > ¼ inches) fell in a 48-hour period.

Depth: The extent downward, backward, or inward. For example, the depth of a duff layer of litter, lichen and/or moss.

Diameter reduction (DRED): Reduction in the diameter of a cylindrical log caused by fire.

Discontinuous woody fuels: Fuel that is discontinuous along a horizontal plane. For example, tree stumps and woody fuel accumulations are generally widely spaced along the ground surface to be considered discontinuous.

Ditching/draining: Change agent (land use change) that channels water away from an area, often creating a drier combustion environment.

Duff: The partially decomposed organic material on the forest floor that lies beneath litter and is often referred to as the F (fermentation) and H (humus) layers.

Duff derivation: The parent material from which duff was derived. Examples of the parent material include needles, moss, bark flakes, or woody debris.

Duff fuel moisture: The moisture content of duff, expressed as percentage of oven dry weight.

Ecoregion division: Fuelbeds are organized geographically into Bailey's Ecoregion Divisions (Bailey 1998), classified by differing vegetation and regional climates. Ecoregion Divisions include: tundra, subartic, warm continental, hot continental, subtropical, prairie, marine, Mediterranean, tropical/subtropical steppe desert, tropical/subtropical desert, temperate steppe, temperate desert, savanna, and rainforest.

Emissions: Pollutants such as carbon monoxide and particulate matter that are released to the atmosphere from the combustion of biomass.

Emission factors: The quantity of pollutant released to the atmosphere per unit weight of fuel consumed.

Evergreen: Plants that remain green all year by retaining at least some of their leaves at all times.

FCCS Number. The identification number of a FCCS national fuelbed.

FCCS (Fuel Characteristic Classification System): A catalog of inherent physical properties of wildland fuelbeds and associated calculations of fuel characteristics and fire potentials.

Fire exclusion: Change agent (change over time) in which fires have been either actively suppressed or removed from an area through land use changes and/or cessation of aboriginal burning.

Flaming phase combustion: The phase of a fire during which fuel is ignited and consumed by flaming combustion.

Flood: Change agent (natural event) in which large volumes of water disturb trees and shrubs, often concentrating biomass creating large fuel accumulations.

Fuel: Any combustible material that will burn during a wildland fire.

Fuelbed: An area of similar fuel characteristics within a Unit. There may be one or more fuelbeds within a unit. Fuelbeds into are organized into 6 horizontal strata that represent unique combustion environments. In addition, each fuelbed stratum is further broken down into one or more fuel categories and subcategories.

Fuel category and subcategory: Each fuelbed stratum is composed of one or more fuel categories. Fuel categories can be further broken down into fuel subcategories. Examples of fuel categories in the ground fuel stratum include duff and basal accumulation. Examples of fuel subcategories in the ground fuel stratum include upper and lower duff layers.

Fuel loading: The oven-dry weight of combustible material expressed as mass of fuels per unit area (tons/acre).

Fuel moisture: The amount of water present in fuels. Generally, fuel moisture content is expressed as a percentage of a material's oven-dry weight.

Fuelbed name: Name of the fuelbed (user-defined or from FCCS database library).

Fuelbed stratum: A fuelbed stratum describes a horizontal layer of a fuelbed that represents a more or less independent combustion environment. Fuelbed strata include canopy, shrub, nonwoody vegetation (i.e., grasses and herbs), downed woody fuel, moss-lichen-litter, and ground fuels.

Fuelbed type: Under the Fuelbed Screen in Consume 3.0, fuelbeds are classified as “activity” (fuels resulting from timber harvests or other activities) or “natural” fuels (living vegetation and dead woody fuels that have fallen or died through natural causes).

Grassland: Vegetation form. Landscapes characterized by grasses and other erect herbs, usually without trees or shrubs.

Grazing: Change agent (land use change) in which cattle and other herbivores are allowed to feed on grass and herbaceous plants.

Ground fuel stratum: The fuel stratum that characterizes the duff, squirrel midden, and basal accumulation fuel categories.

Ground lichen: Lichens are composite plants consisting of an algae and a fungus living together in a mutually beneficial relationship. The Litter Lichen Moss stratum only includes lichens that are on the ground surface.

Hard maximum: Maximum value allowed for a particular gradient variable. If an entry exceeds a hard maximum, users will receive an error message and the entry will not be recorded.

Hard minimum: Minimum value allowed for a particular gradient variable. If an entry exceeds a hard minimum, users will receive an error message and the entry will not be recorded.

Harvest date: In Consume 3.0, this option may be checked if the fuelbed was harvested in the last 3 months.

Heat load: Amount of heat produced from the consumption of fuels (btu/acre).

Herbs: Plants that lacks a permanent woody stem and die back to the ground each year.

High-intensity fire: A fire caused by mass ignition of a unit, resulting in long flame lengths, violent fire behavior, fire whirls, and high intensities. Research has shown that high intensity fires consume a smaller quantity of fuels than moderate intensity fires.

Hours of rainfall: The total hours of rainfall in the 24-hour observation period.

Humic peat: Accumulation of partially decomposed plant material.

Ice storm: Change agent (natural event) in which rain freezes and coats vegetation with ice, causing damage and/or mortality to existing vegetation and creating large fuel accumulations.

Initial 1000-hour fuel moisture: The moisture content (percentage) of cured, 3-to-9 inch diameter sound, woody fuels on the starting date of a weather zone.

Insect and disease: Change agent (natural event) in which insects and diseases attack and kill vegetation causing a build-up of dead fuels.

Introduction of exotic species: Change agent (change over time) in which foreign plant species invade native landscapes.

Jackpot: Natural accumulation and concentration of woody debris. Subcategory of woody fuel accumulation.

Ladder fuels: Fuels that provide vertical continuity between the surface fuels and crown fuels generally in a forested stand, contributing to torching and crowning potentials.

Landslide: Change agent (natural event) in which a mass of rock and mud slide down an incline and disturbs trees and shrubs, altering fuel characteristics.

Large fuels: Dead wood consisting of sound or rotten wood greater than 3 inches in diameter.

Latitude: A measurement of the distance of a location from the equator. Each degree of latitude runs in an east-west direction parallel to the equator.

Length of ignition: Duration of ignition in minutes.

Lightered stumps: Stumps that contain concentrations of pitch and other resinous volatiles and burn vigorously when ignited.

Litter: The top layer of the forest or rangeland floor, composed of loose debris of dead sticks, branches, twigs, dead grass, and recently fallen leaves or needles; little altered in structure by decomposition.

Litter arrangement: The distribution of leaves, needles, cones and other debris that comprise the litter layer. The three litter arrangement categories include fluffy, normal, and perched.

Litter, lichen and moss stratum: The top layer of the forest or rangeland floor composed of loose debris of dead sticks, branches, twigs, dead grass, and recently fallen leaves or needles, live moss and lichen (live and dead).

Logging methods-equipment damage: Change agent (vegetation treatment/timber harvest) in which damage to vegetation from mechanical treating fuels or harvest can result in altered fuel characteristics.

Lop and scatter: Change agent (fuel treatment) in which cutting woody fuels into smaller pieces and scattering them across the area.

Lower duff layer: The lower half of the duff layer, generally containing a majority of the humic or highly decayed material. The lower duff layer is denser than the upper duff layer.

Mastication: Change agent (fuel treatment) in which woody fuels are ground into smaller pieces and scattered across the area altering the woody fuel category.

Maximum relative humidity: Highest relative humidity during a 24-hour observation period in a weather zone.

Maximum temperature: Highest air temperature during a 24-hour observation period in a weather zone.

Meas-Th: A 1000-hour fuel moisture that is was measured directly and represents the average unit fuel moisture of large 3 to 8 inch diameter woody fuels.

Mid-flame wind speed: The speed of wind (miles per hour) measured at the midpoint height of flames.

Midstory: Intermediate and co-dominant trees in the canopy. A subcategory of trees in the Canopy Stratum.

Minimum relative humidity: Lowest relative humidity during a 24-hour observation period in a weather zone.

Minimum temperature: Lowest air temperature during a 24-hour observation period in a weather zone.

Mixed forest: Vegetation form. A forest in which the evergreen and deciduous species contribute 25 to 75% of total tree cover in both the dominant and co-dominant strata.

Moss: A plant in the phylum Bryophyta; usually occurring in a wet habitat.

Moss type: The type of moss (e.g. sphagnum or other moss) that comprise the majority of mosses for a particular fuelbed.

National Fire Danger Rating System: A system established by the USDA Forest Service to assess daily fire danger based on the relationships between fuel moisture and fire behavior.

Natural fuels (natural fuelbed type): Live vegetation or woody fuels that have fallen or died through natural causes. Generally, a unit is considered to be composed of natural fuels if there have been no mechanical treatments for ten years or more.

NFDRS-Th: A 1000-hour fuel moisture content that was calculated in the National Fire Danger Rating System.

NMHC: Non-methane hydrocarbon.

Nonwoody fuel stratum: The fuel layer that characterizes the grass, sedge, and other herbaceous fuels.

Organization: A government or private entity that is responsible for managing projects.

Overstory: A subcategory of trees in the Canopy Stratum. Dominant and emergent trees in the canopy. Loading values only apply to tree canopies (branches and foliage).

Particle density: The density of wood or foliage that does not include the bulk air space between individual pieces of wood or foliage (lbs/ft3)

Particulate matter (PM): Particles less than 100 microns in diameter (a micron is one millionth of a meter).

Planar intersect method: The planar intersect method involves counting intersections of woody pieces along an intersect line. Volume is estimated from the size and quantity of woody material crossing the intersect line and is converted to loading in tons/acre using particle densities of the woody fuels.

PM 2.5: Particulate matter with particles less than 2.5 microns in diameter (a micron is one millionth of a meter).

PM 10: Particulate matter with particles less than 10 microns in diameter (a micron is one millionth of a meter).

PM_{10}: Inhalable particulate matter are particles less than or equal to 10 microns in diameter.

$PM_{2.5}$: Respirable particulate matter are particles less than 2.5 microns in size and are often referred to as "$PM_{2.5}$". Respirable particles have a long residence time in the atmosphere and penetrate deeply into the lungs. Particulate emissions from smoke are primarily in the respirable size range.

Paving: Change agent (land use change) in which paving area alters the fuelbed categories.

Peat: Part of the duff category that generally develops under more or less water-saturated conditions through the incomplete decomposition of plant and animal constituents.

Percent cover: Percentage of a fixed area covered by a fuelbed category measured by the vertical projection of its outermost perimeter.

Percent canopy loading consumed: Percentage of canopy loading consumed by fire. Users may specify this percent. If no inputs are provided, Consume assigns a default value depending on treatment type (prescribed burn = 0%, wildland fire for use = 40%, wildfire = 60%).

Percent live: Percentage of plant material that is live.

Percent primary species (PS%): Percentage of woody fuel accumulation that is composed of the primary pile species.

Percent secondary species (SS%): Percentage of woody fuel accumulation that is composed of the secondary pile species.

Permit number: The permit number issued by the organization authorizing the burn. This is an optional entry.

Pile (see Woody Fuel Accumulation): A generic term for woody fuel accumulations, including three types: jackpots, piles and windrows. The specific definition of a pile is a woody fuel accumulation that is formed into a pile for future burning.

Pile and burn: Change agent (fuel treatment) in which logging slash or naturally accumulated debris is arranged into individual piles and burned.

Pile group: Any grouping of woody fuel accumulations, or piles, with the same shape and dimensions.

Pile mass: Calculated mass (oven dry tons/acre) of a woody fuel accumulation or pile group.

Pile packing ratio: The percentage of a pile, jackpot or windrow that is composed of fuel particles, the remainder being air space among the individual particles.

Pile quality: Relative amount of soil in a woody fuel accumulation (clean = 0, dirty = >0-10%, and really dirty = 10-30%).

Pile shape: The overall geometric shape of the pile, jackpot or windrow. Required dimensional inputs are dependent on pile shape.

Pile volume: Calculated volume of a woody fuel accumulation or pile group (ft^3).

Prescribed burn: Change agent (fuel treatment) and treatment type. A controlled application of fire to wildland fuels to obtain planned objectives for silviculture, wildlife habitat management, grazing, fire hazard reduction, etc.

Primary nonwoody layer: The primary category of nonwoody vegetation in the nonwoody stratum.

Primary shrub layer: The primary category of shrubs in the shrub stratum.

Project: A project consists of one ore more units that are organized and managed as a single endeavor by an organization. Projects may be planned (prescribed burn) or unplanned (wildfire).

Project end date: The date the project ended or is planned to end.

Project status: There are four categories of projects in Consume: Planned, Active, Completed and Archived. Users specify a project category by first selecting a project status.

Project start date: The date the project either started or is planned to begin.

Pruning: Change agent (vegetation treatment) in which lower branches of trees and shrubs are removed, reducing the ladder fuels.

Radius: The length of a line segment between the center and circumference of log or branch wood.

Relative cover: The relative percentage (0-100%) of a fixed area covered by a species or fuelbed category.

Relative humidity: A measure of air humidity, calculated as the ratio of the mass of water vapor to mass of dry air in a volume (percentage).

Residual fertilization: Change agent (vegetation treatment/timber harvest) in which nutrients are added to the soil and cause increased growth of vegetation and greater accumulation of fuels.

Residual phase combustion (or Residual smoldering): The phase of combustion following the smoldering phase. Residual phase combustion may last for an extended period of time and generally consumes woody fuels larger than 2 inches in diameter.

Restoration work: Change agent (vegetation treatment/timber harvest) in which an area is restored to a “natural fire regime condition” by removing or treating fuels through a variety of management practices such as prescribed burning, chipping, or mastication.

Rotten stumps: Partially decomposed stumps.

Rotten wood: Partially decomposed wood debris with obvious signs of decay such that the material falls apart when kicked. The three rotten wood diameter classes are 3 to 9 inches, 9 to 20 inches, and > 20 inches.

Salvage: Change agent (vegetation treatment/timber harvest) in which dead and in some cases live trees are removed from an area that has been burned by a wildfire. Salvage logging generally removes material from the site.

Savanna: Vegetation form. A tropical or subtropical plant community characterized by trees and shrubs scattered among a cover of grasses, herbs and forbs. Savannas have sparse (5-24%) tree or shrub cover with continuous grass cover.

Secondary nonwoody layer: Optional nonwoody vegetation layer with a different species composition and/or height than the primary nnwoody layer.

Secondary shrub layer: Optional shrub layer with a different species composition and/or height than the primary shrub layer.

Selection cut: Change agent (vegetation treatment/timber harvest) in which individual trees of all size classes are removed more or less uniformly throughout the stand to maintain an uneven-aged stand and achieve other stand structural objectives. The activity generally reduces the tree density and alters the canopy fuel categories.

Shrub: Woody perennial plant differing from a tree by its low stature and by generally producing several basal stems instead of a single bole.

Shrubland: Vegetation form. Landscape characterized by shrubs with little if any tree cover.

Shrub stratum: The fuel layer that characterizes the shrub fuels. Shrubs are woody perennial plants differing from trees in their low stature and by generally producing several basal stems instead of a single bole.

Significant rainfall: The amount of rainfall in a 48-hour period required to saturate the duff layer ($\geq$ 0.25 inch).

Slash: Vegetation form. Debris left as a result of forest and other vegetation being altered by forestry practices and other land use activities (e.g., timber harvesting, thinning and pruning, road construction). Slash includes material such as logs, splinters or chips, tree branches and tops, and uprooted stumps, trees and shrubs.

Slope: Slope gradient of ground surface in percent.

Small fuels: Dead wood consisting of sound or rotten wood 0 to 3 inches in diameter.

Smoldering phase combustion: The phase of a combustion that follows the flaming stage during which the overall reaction rate of the combustion has diminished to a point at which concentrations of combustible gases above the fuel are too low to support a persistent flame envelope. The smoldering phase is often characterized by large amounts of smoke.

Snags: Standing dead tree greater than 4.5 feet tall. Snags are classified into four decay class categories: class 1 with foliage, class 1 without foliage, class 2, and class 3.

Snags - class 1 with foliage: Standing, recently dead trees greater than 4.5 feet tall, predominately sound with fine and coarse branches, top and foliage intact.

Snags - class 1 without foliage: Standing, recently dead trees greater than 4.5 feet tall, predominately sound with fine and coarse branches, top intact.

Snags - class 2: Standing dead trees greater than 4.5 feet tall with coarse branches and bark intact.

Snags - class 3: Standing dead tree greater than 4.5 feet tall that is predominately rotten with no bark intact.

Snow-off date: In Consume 3.0, this option is checked if snow completed melted from the site in the past 3 months.

Sound stump: Stumps that have minimal decay.

Sound wood: Woody debris that has minimal decay. The six sound wood diameter classes in the FCCS include 0-to-¼ inch, ¼-to-1 inch, 1-to-3 inches, 3-to-9 inches, 9-to-20 inches, and >20 inches.

Squirrel middens: A category of the ground fuel stratum generally only applicable to boreal spruce-dominated forests. Squirrel middens are mounds of cone scales and other cone debris accumulated over time from squirrels exacting seeds. The mounds are composed of very pure organic matter that can burn for extended periods of time.

Structural class: The classification of the form or appearance of a plant community. The FCCS uses the stand structure class of forest vegetation forms. The 7 classes describe the number of canopy layers, relative size of trees, stage of understory development and relative degree of stand closure.

Stump: The part of a tree remaining attached to the roots after the trunk is cut.

Stumpwooding: Change agent (vegetation treatment/timber harvest) in which stumps or wood from the stumps are removed or harvested. The activity generally removes material from the site.

Thinning: Change agent (vegetation treatment/timber harvest) in which individual trees of all size classes are more or less uniformly removed throughout the stand to generally increase productive or achieve other stand structural objectives. The activity generally reduces the tree density.

Time lag: The time necessary for a fuel particle to lose approximately 63 percent of the difference between its initial fuel moisture content and its equilibrium moisture content. The time lag of sound or rotten round wood fuels depends on their diameter.

Total canopy loading: Sum of all canopy category loadings (tons/acre).

Total continuous woody fuel loading: Sum of continuous woody fuels (i.e., sound and rotten wood categories) (tons/acre).

Total nonwoody loading: Sum of primary and secondary Nonwoody vegetation layer loadings (tons/acre).

Total shrub loading: Sum of primary and secondary shrub layer loadings (tons/acre).

Total consumption: Calculated total fuel consumption of a fuelbed, unit or project (tons/acre). Consumption could be listed in different units

Treatment type: The three burn treatment options include prescribed burn, wildland fire for use, and wildfire. Unless users specify otherwise, percentage of canopy loading consumed (%) is dependent on treatment type.

Tree: A category of the Canopy Stratum. Trees are tall, perennial woody plants greater than 4.5 feet having a main trunk and branches forming a distinct elevated crown; includes both gymnosperms and angiosperms. Loading values for tree subcategories (overstory, midstory and understory) involve the canopy (branches and foliage) only.

Turpentining: Change agent (vegetation treatment/timber harvest) in which turpentine is collected from pine trees. Turpentining generally causes scarring and pitching on the bole of trees.

Understory: A subcategory of trees in the Canopy Stratum. The understory layer is composed of tree seedlings and saplings separated from the overstory and midstory by a gap. Loading values only apply to tree canopies (branches and foliage).

Upper duff layer: The upper half of the duff layer that generally contains the fermentation (F) layer and may contain a portion of the humic (H) layer. The upper duff layer is less dense than the lower duff layer.

Unit: A burn unit encompasses the area to be treated by fire or the area involved in a wildfire. Units are assigned to a single project and can consist of one or more fuelbeds that are burned together. Units can be planned and accomplished independently of other units within the same project and can be spatially contiguous or spatially separated.

Vegetation form: A physiognomic level of classification based on the “formation class” level in the United States National Vegetation Classification System (Grossman *et al.* 1998), which represents the general shape and structure of vegetation. Vegetation forms are based on relative cover of the dominant life form. The seven general vegetation forms in the FCCS include conifer forest, broadleaf forest, mixed forest, shrubland, grassland, and savanna.

Weather zone: An unspecified area containing a weather station that is representative of the unit’s area, and used to estimate the 1000-hour fuel moisture content of woody fuels. The relationship to unit is optional as the 1000-hour fuel moisture content can be entered directly without entering using daily observations from a Weather Zone.

Wildfire: Fires that burn out of control in a forest, shrubland or grassland.

Wildland fire use: The management of naturally ignited fires to achieve resource benefits, where fire is a major component of the ecosystem.

Windrow: A type of woody fuel accumulation that has been piled into a continuous row.

Wood density: Density of wood by tree species (lbs/ft^3).

Woody fuel accumulations: The accumulation of woody debris because of land use activities (e.g., timber harvest, thinning) and natural events (e.g., wind, avalanche, wildfire). The three subcategories of woody fuel accumulations include jackpots, piles, and windrows. The generic term for woody fuel accumulation in Consume is piles.

Woody fuel stratum: A fuel layer that characterizes the sound and rotten woody fuels, stumps, and woody fuel accumulations.

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