Joint Fire Science Program
Fire Science
RESEARCH SUPPORTING SOUND DECISIONS
Manager's Viewpoint

# Modification and validation of fuel consumption models for shrub and forested lands in the Southwest, Pacific Northwest, Rockies, Midwest, Southeast, and Alaska

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## Problem

Although a tremendous amount of research has gone into the development of fuel consumption models, little work has been directed toward shrub-dominated ecosystems (i.e., chaparral, sage, and palmetto/galberry), and to fuel consumption during the smoldering phase of fires.

## Approach

This effort aims to incorporate current knowledge of fuel consumption in shrub-dominated ecosystems into a fuel consumption software product designed for national use and for a variety of fuel types. Seventy-one sites were inventoried and burned in black and white spruce/hardwood forests (Alaska), chaparral (California), ponderosa pine/mixed-conifer forests (Oregon), and pine/hardwood forests (South Carolina, Tennessee, and Florida). Additionally, thirty-five sites were inventoried and burned in sagebrush on BLM, National Park Service, and U.S. Fish and Wildlife Service lands in eastern Oregon, Nevada, Wyoming, Utah, and California. Data from all burns have been compiled and analyzed. Consumption models were built for fuel categories within the following fuelbed types: black and white spruce/hardwoods, longleaf and loblolly pine, ponderosa pine, grasslands, and sagebrush.

The results from this research were captured in the development of a fuel consumption software product designed for national use. The product is called Consume v 3.0 and can be run on a personal computer. Consume v 3.0 predicts the amount of fuel consumption, emissions, and heat release from the burning of activity fuels, piled debris, and natural fuels based on weather information, fuel loading, fuel moisture, and a number of other factors. The intent was to apply Consume to most forest, shrub, and grassland systems in North America.

## Project Findings

No findings or conclusions. Resulting end-state was development of the Consume v 3.0 software.

## Application by Land Managers

Consume is designed for resource managers, fire managers, researchers, air quality regulators, and carbon modelers with some working knowledge of Microsoft Windows applications. The software predicts the amount of fuel consumption and emissions during wildland fires in all fuel bed types based on fuel loadings, weather conditions, site environmental data, and fuel moisture. Using these predictions, resource managers can determine when and where to conduct a prescribed burn (or manage a wildland fire) to achieve desired objectives, while reducing impacts on other resources and for smoke reporting.

Consume v 3.0 was developed in coordination with the Fuel Characteristic Classification System (FCCS). Fuel loading values from the FCCS fuelbed reference library can be accessed directly in Consume or imported from customized FCCS fuelbeds. With its built-in link to the FCCS, Consume v 3.0 can be used for most forest, shrublands, and grasslands in North America and may be applicable to other areas of the world.

Consume can be used at any spatial scale, from a single fuelbed in a burn unit to national assessments. It is most commonly applied to burn units confined to a single project area, e.g., within a watershed or small subset of a national forest district or BLM resource area. Anyone who is comfortable using Microsoft Windows applications will be able to easily navigate the Consume v 3.0 user-interface. However, a working knowledge of fuels and prescribed fire prescriptions is still required to obtain and interpret model results.

Consume contains a library of files for FCCS fuel loadings. Fuels are organized into six strata: canopy, shrub, non-woody vegetation, downed woody fuels, a litter-lichen-moss layer, and ground fuels. Each stratum is further broken down into one or more fuelbed categories. Users can select a fuel loadings file based on selection criteria (e.g., eco-region, vegetation form, cover type or change agent) or the FCCS fuel bed identification number. Alternatively, users can enter their own fuel data directly. Additional inputs include information about the project, burn unit, type of fire, weather conditions, and environmental data such as fuel moistures, mid-flame windspeed, slope, and whether the fuel bed was created through natural processes or timber harvest activities.

Consume improves on previous efforts by predicting fuel consumption, emissions, and heat release for three rather than two combustion phases (flaming, smoldering, and residual) for each fuel bed stratum and category based on input fuel loadings and environmental conditions. Users can specify a variety of report options, including consumption or emissions by date, fire combustion phase, and range of 1,000-hour fuel moistures. Consumption and emissions by 1,000-hour fuel moistures also can be viewed graphically to determine favorable burn conditions. Fuel consumption and fire emissions may be reported at multiple spatial scales, including projects, units, fuel beds, and fuel strata. Users also may use a scenario-testing tool to model prescribed burns under a variety of environmental conditions to determine favorable burning conditions. Results can be printed directly in Consume or exported into spreadsheets, databases, or statistical packages for additional analysis.

Consume contains a library of fuel loading models/tools exported from FCCS and an update option to remain current with future versions of FCCS. Consume can be run in batch mode to support linkages with BlueSky, SmokeTracs, and other applications on operating systems that do not support the Microsoft Windows-based user interface.

Most of the work in the area of fuel consumption prior to this was targeted at prescribed burning following forest harvest. This study introduces new models for shrublands (including chaparral, sage, and palmetto/galberry types), hardwood forests (including southern and eastern regions of the U.S.), and boreal forests (including white spruce, black spruce and hardwood forests of Alaska). Consume 3.0 also resolved differences in fuel consumption between the relatively short flaming phase of combustion and the longer smoldering/residual phases of combustion that generally contribute the majority of wildland fire emissions. For obtaining accurate estimates of fuel consumption and emissions, the Consume program is arguably the best tool currently available due to these improvements over previous modeling tools. It does

not, however, produce predictions for related first-order fire effects such as overstory mortality and soil heating; thus inference and/or other tools such as BehavePlus or FOFEM must be used to predict those first-order effects.

**Deliverables and Technology Transfer**

The Fire and Environmental Research Applications Team completed Consume version 3.0 and has posted the application and related literature at http://www.fs.fed.us/pnw/fera/products/consume.html

Consume v 3.0 is the principle science delivery product for this project. Other deliverables include a Consume v 3.0 User's Guide with scientific documentation (proposed as a general technical report) and a journal manuscript in preparation describing the fuel consumption equations. A final report was also completed and is available at the web site above as well as through the JFSP completed projects page.

Web-based and downloadable self-taught tutorial is available at http://www.fs.fed.us/pnw/fera/products/tutorials/index.html

Workshops were designed to teach land managers enough about the three FERA tools, including Consume v 3.0, that they can go out and teach others. These workshops are three days each and attended by approximately 10-15 managers. A teaching cadre of 5 demonstrates in the classroom and in the field how to use each tool, and how they can be used in an integrated fashion. Workshops have been held in Georgia (November 2005), Hawaii (February 2006), Oregon (May 2006) and Alaska (August 2006). The final two in the series are planned for southern California (March 2007) and Albuquerque (May 2007). An additional workshop is being offered in association with the University of Idaho in Moscow, Idaho (April 2007).