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Consume 3.0—A Software Tool for Computing Fuel Consumption

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RESEARCH SUPPORTING SOUND DECISIONS

Fuel, heat and oxygen—though its nature is always the same, fire behaves differently all the time. Consume 3.0, a software tool, calculates the amount of fuel consumption in different fire scenarios, enabling managers to plan fire activities to further land management goals.

Consume 3.0—A Software Tool for Computing Fuel Consumption

Summary

Knowing when, where and how fire should be applied is critical for land managers planning to use fire prescriptively for land management goals, or allowing fires ignited naturally to burn. Myriad variables need to be taken into consideration to determine how fire will consume different fuels. Consume, version 3.0 is a user-friendly software that incorporates the Fuel Characteristic Classification System (FCCS) to predict fuel consumption, pollutant emissions, and heat release. A flexible tool, Consume 3.0 makes these calculations based on fuel loadings, fuel moisture and other environmental factors.

Key Findings

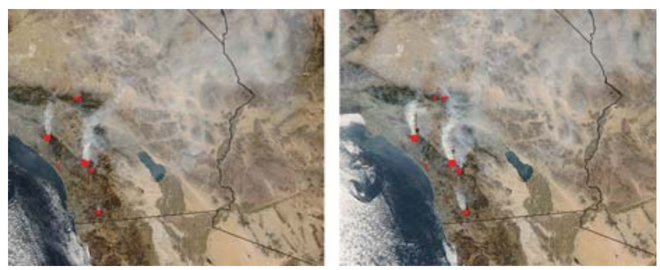
- Consume 3.0 resolves differences in fuel consumption between the flaming phase of consumption and the smoldering phase that usually causes the majority of wildfire emissions.
- The 3.0 version of Consume includes consumption models for fuel categories in additional fuel types such as black and white spruce/hardwoods; longleaf and loblolly pine; ponderosa pine; grasslands; and sagebrush.
- Consume 3.0 works within the Microsoft Windows operating system. However, calculations are handled in a Java-based engine and can be run separately in batch mode detached from the Windows environment. A wide variety of operating systems, such as Macintosh, Unix and Linux can thus be used.

Introduction

A breeze is blowing, the sky turns a red haze, and a plume of ascending white offers a warning. Homeowner or hiker, the observer thinks: everything is about to change. Where I stand, will this fire roar like an industrial engine burning through everything in its path? Will this fire produce a pall of smoke that will impact the health of the neighboring community or reduce the visibility for tourists? Though its character is always the same—made of heat, fuel and oxygen—fire burns fuels differently, changing the way it impacts the environment. The hiker, the homeowner, the fire crew, the land manager assess: how will this fire change the landscape I am seeing today? How will the smoke impact me today?

Woody fuel consumption was predicted by category—whether one-hour fuels such as grasses, or larger diameter fuels that take longer to burn. Litter and duff consumption was predicted by looking at the pre-burn loading, and the amount the forest floor materials were reduced after a modeled burn.

Most Americans learn in elementary school about the fire triangle. Remove one arm of the triangle, heat for instance, and you take away fire. Or deprive the three-sided model of oxygen, and you suffocate fire. And everyone knows that fire needs something to feed on. But beyond our elementary school introduction, many Americans who do not live or work close to the land (and that's almost everybody), aren't aware of the variables that can affect fire. How hot does chaparral burn? How fast does a grass fire spread? How much smoke does a flaming fire produce? Or a smoldering one?



Smoke from the 2007 Southern California fires. Credit: NASA/MODIS Rapid Response.

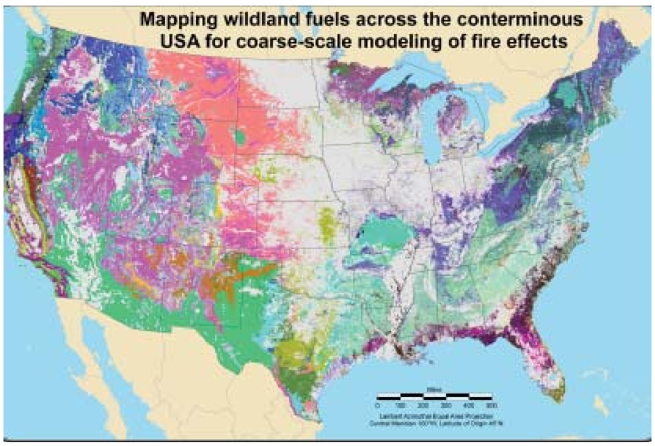
With so many ecosystems in the world, and seasons, and shifting weather, land managers face challenges when trying to plan to use fire—whether set prescriptively or ignited naturally and allowed to burn—to help restore healthier wildland conditions. Roger Ottmar, Research Forester with the Fire and Environmental Research Applications Team of the Pacific Northwest Research Station considered fire science's computing tools. Where could improvements be made?

Sense and computability

It all started in the early 1980s, when FERA—the Fire and Environmental Resource Application Group of the Pacific Northwest Research Station—began developing models that could calculate fuel consumption and emissions for prescribed burns in the Pacific Northwest. That first iteration was Consume 1.0, a software tool that calculated consumption from data researchers had collected during prescribed burns.

In the 1990s, FERA expanded the software's capability. The new version could tell the application user the amount of fuel consumption by combustion stage for fuel types outside of the Pacific Northwest, and by different configurations of fuels. By the time version 2.1 was ready, it also allowed input of factors contributing to emissions, and therefore pollutants, providing a greater level of flexibility.

FERA also began developing a new system that classified fuels by their characteristics: the Fuel Characteristic Classification System (FCCS). By using this system, a manager could build fuelbeds with different fuelbed characertistics and account for fuel loadings, whether the fuels were piled, not piled, or naturally placed, to run fuel consumption and emission calculations. When Ottmar and his team set out to enhance the Consume software, they strove to enable it to predict fuel consumption and smoke emissions for all wildland fuel types in the United States using the FCCS as the fuelbed engine. Engrossed thus, the scientists saw Consume 3.0 begin to take shape.



Developed by FERA, the FCCS, now linked to Consume 3.0, classifies fuels by their characteristics. By looking at fuel maps for different areas, managers can see the type of combustibles they will have to work with when planning to use fire. Credit: USDA Forest Service, Pacific Northwest Research Station.

Calling forth the sources

If two heads are better than one, then most certainly what is contained in the knowledge and experience of several hundred fire and fuel managers is a bonanza. By doing what the wise everywhere do, Ottmar and his team went to the source for the best information on which fuel types face increased wildland fire risk and for those in which current fuel consumption data was limited.

By surveying professionals at national and regional workshops, and fire effects, smoke management and burn boss national training classes, the team was able to determine which fuelbed types should be a priority for this study. Through interviews with personnel of many federal agencies, the team selected five fuelbed types for further study: Sage in the Intermountain, Pacific Northwest and Rockies, with west coast and interior chaparral and oak brush in the Southwest and Rockies and palmetto-galberry in the Southeast; ponderosa pine and fir in the Intermountain, Pacific Northwest, Rockies and Southwest; black spruce, white spruce, and birch and aspen hardwoods in Alaska; longleaf pine and sandhill-hardwood pine transition in the South; and marsh grass, and tall grass prairie in the South and Midwest. "The broad array of fuel characteristics in our selected fuel types required a flexible study design that allowed tailoring of consumption measures for each fuel type and their associated variables," Ottmar explains. To do this, the scientists conducted an extensive review of the literature on potential fuel consumption methods, in addition to inventorying and burning 106 sites for their project.

The team also took another detailed look at 32 sites that were burned prior to their project, and they incorporated this information into the development of fuel consumption models for the 3.0 version of Consume they were building.

Scientist conducting field measurements.

To a choice, wisely

Ottmar and the team had assembled the raw material of data they would use to craft the updated software. The scientists chose user-friendly and widely accessible operating systems as the framework in which to run Consume 3.0. With familiarity of Microsoft Windows applications, a user can enlist Consume 3.0 to predict the amount of fuel consumption, emissions, and heat release for a particular fuel scenario, such as a logged area, or a place where debris has been piled, or a stand where natural fuel conditions can be found. The software will factor in weather conditions, the amount of fuels on site and the amount of moisture in those fuels, and many other variables to produce a modeled result.

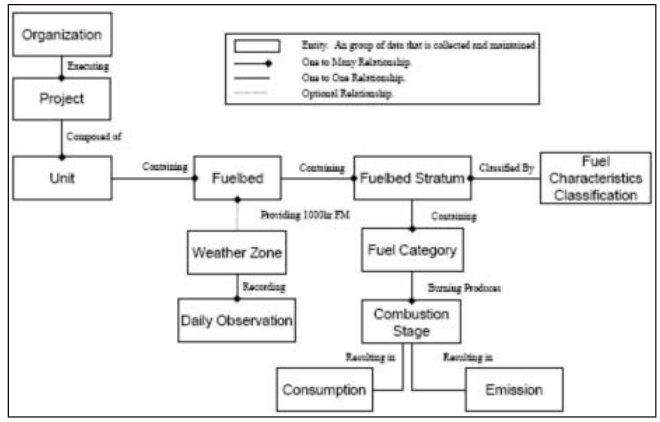
For the land manager wanting to employ fire as a restorative tool while also wishing to minimize impacts to public health and other resources, the simulations are invaluable.

For the land manager wanting to employ fire as a restorative tool while also wishing to minimize impacts to public health and other resources, the simulations are invaluable. Results from Consume 3.0 can tell managers the best time and place to carry out burns to meet a number of their critical objectives, Ottmar explains, "…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."

Prescribed burning.

Because the FCCS was developed to work with Consume, managers have at their disposal an array of fuel loading values from this national fuelbed reference library. "With its built-in link to the FCCS, Consume can be used for most forest, shrub and grasslands in North America and may be applicable to other areas of the world," Ottmar offers. The scientists recognized that some users would need Consume to run in batch mode as part of a larger modeling effort. To that end, the team developed the software so that its Java-based calculator engine can be run outside of the Windows environment. The calculating function is compatible with a wide variety of operating systems, such as Macintosh, Unix and Linux. Output files can be imported into other models, the team explains, and analyzed in spreadsheet or statistical software.

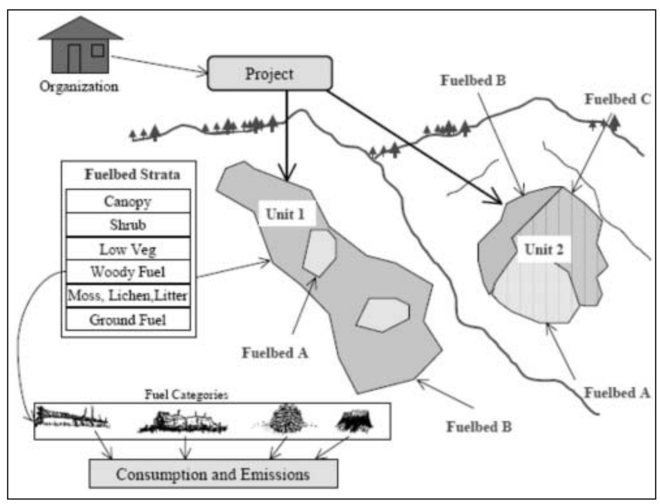
Wildland fire.



Consume 3.0 allows users to input ever greater detail to more accurately model real world conditions. Credit: Final Report JFSP Project Number 98-1-9-06.

Open for reinterpretation

Consume 3.0 is available for downloading online, as well as on compact disk. The scientists explain that as knowledge changes, so too will Consume. New shrub algorithms that are developed will be incorporated into Consume, and updates will also occur as the FCCS adds information on additional fuel beds. Since little fuel consumption work has been completed in the northeast and Midwestern hardwoods, for example, they see opportunities for new data improving Consume's abilities which the Joint Fire Science Program recently funded. Other new features deliver more subtlety related to the products of combustion.



The real world is more complex than software tools often allow. Consume 3.0 enables users to model multiple units for one project, multiple fuelbed types for each unit, multiple fuel layers for each fuelbed, and emissions and consumption by combustion stage for each of those layers. Credit: Final Report JFSP Project Number 98-1-9-06.

Fire consumption is based on complex chemistry involving the type of fuel, and how efficiently it can burn. Wet wood smokes and wood too dry burns very fast with little smoke. Using a tool that can accurately model these drastic variations is critical for managers making decisions, as visibility and healthful air quality are often major concerns for communities that will be affected by fire. Consume 3.0 resolves differences in fuel consumption between the flaming phase of consumption and the smoldering phase that usually causes the majority of wildfire emissions.

This version of the software also includes the ability to more accurately model real-world conditions rather than restricting the software data to homogenous characteristics. Users can now program multiple units within one project, as well as input multiple fuelbed types within each unit. Adding to further flexibility and detail, the software can accept data for each fuelbed broken down by fuelbed layer. And going down to ever smaller detail, the software has the ability to look at emissions and consumption by combustion stage for each fuelbed layer. Through this virtual window on the world, the manager, the application user, the planner can simulate fuel consumption, smoke effects, and heat release.

Forest floor fire.

Management Implications

- Managers can use Consume 3.0 to help with decisions as they plan for prescribed fire or wildland fire use because the software predicts fuel consumption, pollutant emissions, and heat release based on fuel loadings, fuel moisture, and other environmental factors.
- With the information from Consume 3.0's models, managers can plan when and where to conduct fire use for land management goals.
- Managers will find Consume 3.0 a user-friendly application that works with their Microsoft Windows knowledge and skills. Because Consume 3.0 imports data from the FCCS, managers will find the outputs have calculated the array of factors with different fuel types, fuel conditions, weather factors, consumption and emission by combustion phase and by fuelbed category—all formatted to feed other models and produce workable reports.

Further Information: Publications and Web Resources

Ottmar, Roger D., Susan J. Prichard, Robert E. Vihnanek, and David V. Sandberg. 2006. Modification and validation of fuel consumption models for shrub and forested lands in the Southwest, Pacific Northwest, Rockies, Midwest, Southeast, and Alaska. JFSP Final Report 98-1-9-06. Online at: http://www.fs.fed.us/pnw/fera/research/smoke/Consume/Consume30_users_guide.pdf

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Scientist Profile

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