



Prescribed fire in shrubland has been less extensively studied than in forest areas. Here a burn in big sagebrush near Cody, Wyoming was used to help document fuel consumption.

Filling in the Blanks for Prescribed Fire in Shrublands: Developing Information to Support Improved Fire Planning

Summary

By collecting information on fuel loading, fuel consumption, fuel moisture, site conditions and fire weather on fires in a variety of shrubland types, researchers are developing a fuller knowledge of shrubland fire effects. Results are being integrated into the software package CONSUME, a user-friendly software tool for predicting fuel consumption and emissions for fire, fuel and smoke management planning.

Shrubland types studied include chamise chaparral in California, big sagebrush in Montana, pine flatwoods in Florida and Georgia, and pitch pine scrub in the New Jersey Pinelands. Measurements were made of fuel characteristics before and after prescribed fires in the four vegetation communities in order to improve managers' abilities to plan prescribed burns in these shrubland types. The outcomes of this research project contribute to our understanding and management of fire effects in shrub ecosystems where data were previously limited.

Key Findings

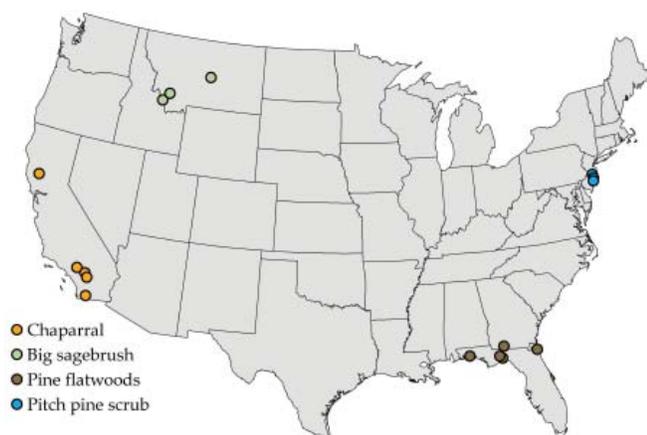
- New big sagebrush data collected in this study will expand the range of environmental conditions under which the CONSUME model is applicable. Using the model, predictive outputs compare favorably with those derived independently.
- Because of different topographic and fuel conditions, pine flatwood shrubland fires are distinctly different from big sagebrush fires. Expected predictors of fuel consumption include type and amount of understory shrubs, litter quantity, relative humidity, wind speed, and live and dead fuel moisture.
- Data from prescribed fires in chamise chaparral fires were difficult to collect. A technique for retrospective estimation of fuel consumption was employed. Additional work is needed to develop a more robust data set for model development and validation.
- In pitch pine scrub, field research combined with existing data from the Northern Research Station has provided data on typical fuel consumption from surface fuels. Additional shrub fuel research is needed.
- Research results will be incorporated into the CONSUME software package, making it more useful and accurate for estimating fire effects in shrublands.

What about the shrublands?

For decades, researchers have quantified and modeled fuel consumption during wildland fires in both “natural” and managed forest types. Progress in understanding shrubland fires has lagged, and what research has been done has generally been limited to a few ecological types. However, fire-adapted ecosystems dominated by shrub species occur across several hundred million acres in the U.S. These shrublands include, among others, a wide variety of forms of chaparral, various types of sagebrush, southern pine flatwoods, and pitch pine scrub.

Why study these shrubland types?

In developing this research plan, researchers wanted to study a broad cross-section of shrubland types. The four types studied represent a significant proportion of the national shrubland inventory. It is believed that their variety and geographic diversity will provide insight for prescribed burns in other related shrubland types.



The four shrubland types occur both in remote areas and at the wildland urban interface. Many are home to sensitive, rare, threatened and endangered species of plants and animals. Each of the four have a wide geographic range and extensive prescribed burning is already being conducted. Increasingly, land managers are required to

assess the environmental impacts of land management decisions, including these kinds of ongoing prescribed burns. They need improved information on fire effectiveness and on impacts, including fuel consumption, smoke emissions, nutrient cycling, plant succession, plant and tree mortality, wildlife habitat, soil heating and carbon cycling. It was intended that the data and software improvements from this research would help meet this need.

Designing the project

The project team was from the Forest Service, Pacific Northwest Research Station. Principal investigators were Clint Wright, Roger Ottmar, Sue Ferguson and Robert Vihnanek. Field data collection and analysis was conducted by the Pacific Wildland Fire Sciences Laboratory in Seattle. Because of the wide geographic area involved, a key to project success was the help received from cooperators across the nation and from amongst a host of government agencies.

From the beginning, the goal was to develop fuel consumption data that could improve the predictive capability of the software program CONSUME, the current version of which is 3.0. By collecting actual data on specific types of prescribed shrubland fires, researchers are striving to make CONSUME a more accurate and useful management tool for fire practitioners.

According to Clint Wright, another major goal was to provide more accurate information for measuring smoke and other environmental impacts of shrubland fires. He says, “We see this research as the start of a scientific foundation for managing fire effects for a number of different shrub ecosystems where it was lacking before the study.”

A tool of increasing importance

CONSUME was developed by the Fire and Environmental Research Applications (FERA) Team at the Forest Service Pacific Wildland Fire Sciences Laboratory. It is a user-friendly software application designed for resource managers, regulators and scientists. Users can input fuel characteristics, ignition patterns, fuel conditions, and meteorological attributes. CONSUME will output

fuel consumption and emissions by combustion phase and by fuelbed category. It also imports data from the Fuel Characteristic Classification System (FCCS). Outputs are meant to support burn planning and smoke management. In this research project researchers were striving to make CONSUME more accurate and useful for prescribed shrubland fires. The improved models coming from this research are being incorporated in updated software tools.

Shrubland fires are different

Prescribed fires for shrublands have some notable differences from fires in forested land. In forests, a large proportion of the fuelbed is made up of dead and down organic matter. In shrublands, a much larger proportion of the fuel is living and standing dead vegetation, which can have a significant effect on how these fires burn, and the amount and characteristics of the smoke. Some shrublands are close to populated areas and contain a high proportion of living plants, so fuel consumption and smoke generation are important concerns because of potential negative impacts on human health, transportation safety, air quality and visibility.



Shrubland fires, whether wildfire or prescribed burns, often generate large quantities of smoke as well as having other environmental impacts. Documenting these effects, as with this fire in California chaparral, can assist burn planners and community environmental officials.

Research methods

Because of the widely varying characteristics of the four shrubland ecosystem types, sampling methods were adjusted to best match the fuels in each type. The general approach was to consult with fire managers in each region to identify upcoming prescribed fires, and to sample areas with relatively homogenous vegetation composition and structure inside those fire boundaries. Within these sample areas, grids were established to sample pre-burn and post-burn biomass. Multiple fire locations and research plots were studied for each shrubland type. For each plot, the pre-burn fuel loading, topography, day-of-burn weather and fuel moisture were measured.

In the case of the chamise chaparral plots, researchers encountered difficulties identifying suitable prescribed burn areas, and the sampling and measurement process was modified to work with data from areas that had already been burned. By evaluating data on the degree of consumption of the residual wood in these areas, researchers were able to retrospectively estimate fuel consumption.



An important step in the research is documenting pre-burn vegetation quantity and characteristics, as shown here weighing big sagebrush in a Montana prescribed burn area.

Research results

Big sagebrush in Montana

Sagebrush ecosystems have the largest range of any habitat type in the United States. They cover nearly 470,000 square miles across eleven western states. In many of these areas, big sagebrush (*Artemisia tridentata*) is the dominant species. The research studied results from prescribed burns on 11 sets of experimental plots in big sagebrush at three locations in Montana. Some of the fires were under moderate to marginal burning conditions. This circumstance allowed researchers to build on an existing data set from big sagebrush prescribed burns and to expand the range of conditions under which results can be appropriately applied.

According to Wright, the results from the big sagebrush shrubland research has already been incorporated into CONSUME as a model for all shrub fuels. Continuing research in big sagebrush has confirmed the general validity of modeled results, with some small adjustments to mathematical constants used in the software.



Shrublands dominated by sagebrush cover wide areas of eleven western states. Data for CONSUME were gathered from prescribed burns in big sage at three locations in Montana.

Pine flatwoods in Georgia and Florida

Pine flatwoods represent an extensive ecosystem in Florida and southern coastal Georgia, covering approximately 50 percent of the land area in this region. Here pine forests grow on sandy low-lying areas and often include longleaf pine (*Pinus palustris*) and slash pine (*P. elliottii*). These forests have very little topographic relief

and today often have a shrubby understory that includes saw palmetto, gallberry and other low, woody species. In northern Florida many stands on public lands are burned on a 2–4 year rotation. Much of the prescribed burning in the flatwoods occurs to maintain low to moderate fuel loading to mitigate a potential high-intensity fire, but some burning programs are intended to promote wildlife habitat or other ecosystem functions.



Prescribed burns in Florida and Georgia flatwood shrublands simulate the frequent, historic low-intensity fires that gave these open pine lands their character.

The usual goal is to maintain the open character of the forest and to promote pine regeneration and thereby maintain the forested habitat, especially in longleaf pine areas. These burns simulate the frequent historic low-intensity fires in these forests, although there are wide differences in burn intervals, especially on privately owned land. Wright notes, “Differences in rotation, as you might expect, create forest and fuelbeds of quite differing character.”

In this part of the project, researchers studied before and after burn information at 28 locations between 2004 and 2006. Sample sites represented a range of fuel loadings. Fires studied were during the January–April time period, and in July. Because of the distinctly different topographic and fuel conditions here from western shrublands such as big sagebrush, new and different variables will be incorporated into the fuel consumption equations in CONSUME. Data processing and model development are ongoing. Predictors of fuel consumption are expected to be fuel loading, relative humidity, wind speed, and live and dead fuel moisture.

Chamise chaparral in California

Perhaps the most challenging shrubland type was California chamise chaparral. Chamise (*Adenostoma fasciculatum*) is a multi-branched, flowering evergreen shrub that grows to heights up to 12 feet and is common in California chaparral. In some cases it completely dominates the vegetative growth in these areas, forming almost pure and dense stands. Because of the volatile character of its foliage it has a propensity to burn intensely, although the research did not focus on the specific aspect of volatile oils in chamise plants and their contribution to fuel consumption. It is frequently burned both in wildfires and prescribed burns.

Several sites on the San Bernardino and Cleveland National Forests in southern California were sampled.

Wright also indicated that researchers did collect pre-burn samples in northern California on the Mendocino National Forest, where he noted, “the plants achieve a pretty remarkable size, but the sites were not burned during the study.”

Researchers had difficulty identifying suitable areas within planned chamise chaparral burns because of a limited number of scheduled prescribed burns during the research time period, narrow prescribed burning weather windows and very steep slopes. They chose to modify the experimental method to instead retrospectively study areas that had recently seen wildfire. The investigation measured the basal stems of standing skeletons that were typically left unconsumed to estimate the proportion of each plant that was consumed. Wright notes, “The areas we sampled were predominantly chamise, with small quantities of associated chaparral species such as manzanita and various species of *Ceanothus*.”



California chaparral fires are often difficult to study because of steep topography and a narrow prescribed burning weather window. In this research, post fire vegetation was evaluated to improve the accuracy of fuel consumption predictions.

Using this retrospective information, the research calculated the proportion of the fuel load removed by burning. An unplanned benefit of this technique was a more finely divided size-class categorization for chamise as well as for whitethorn, hoaryleaf ceanothus, mountain mahogany and manzanita. Work to form this data into a model to predict fuel consumption is ongoing. It is believed that further development of the retrospective methods used could lead to a robust data set for model validation in the future.

Pitch pine scrub in New Jersey

The final shrubland type studied in this project was pitch pine scrub in the New Jersey Pinelands. Both naturally caused wildfires and prescribed fires frequently occur in these forests, typically suppressing the understory but having less effect on the overstory pitch pines (*Pinus rigida*) and other tree species. Many of these areas have a long history of regular fires of varying intensity. For this project, data from four plots burned in 2007 and 2008 were collected from areas with a pitch pine or mixed pine and oak overstory and a shrubby understory composed of a mixture of primarily deciduous species. Shrub fuel loadings ranged from 0.8 to 5.2 tons per acre.

The information collected in this portion of the project, along with data collected by researchers from

the Forest Service Northern Research Station, is felt to represent typical fuel loading and consumption in pitch pine scrub. However researchers feel that additional shrub fuel consumption data are needed to refine the results in this shrubland type.

Building a better model

As previously mentioned, the data for the research work in big sagebrush has already been used to make CONSUME more suited to evaluation of all shrubland fire behavior and environmental effects. As the data for fires in pine flatwoods, chamise chaparral, and pitch pine scrub are analyzed, the team will refine models for these specific shrubland types.

With specific reference to chaparral, researchers hope to be able to collect additional fuel consumption data in the fall of 2009 and 2010 in conjunction with another research effort. Some of the chaparral fuel data were presented at the Pacific Coast Fire Conference in December 2008. With all of the shrubland types, as data become available refinements will be incorporated into CONSUME, improving its usefulness for planning fires in all shrubland types.

Shrubland fires and the environment

The refinements which have been made to CONSUME are already in use in environmental planning. State air permitting and regulatory agencies in Washington and Oregon use CONSUME along with other tools to manage smoke from wildland fires. CONSUME output can also be used with the smoke dispersion model V-Smoke and is integrated into the BlueSky smoke modeling framework.

The Washington Department of Natural Resources used CONSUME with the BlueSky modeling framework to make burn/no burn decisions on a daily basis for a multi-day prescribed fire on the Okanogan-Wenatchee National Forest in 2007. While BlueSky is a very powerful suite of models, it is not typically run by on-the-ground managers, however, V-Smoke is widely used by the fire management community throughout the southern states.

CONSUME's improved ability to better estimate shrubland fuel consumption and the resulting smoke will make emission inventories more accurate. The U.S. EPA is using emissions estimates derived from CONSUME, including estimates of carbon and emissions for a North America emissions inventory. A NASA-funded research project will likewise develop estimates of carbon and other emissions for all of North America using CONSUME.

Further Information: Publications and Web Resources

CONSUME download: http://www.fs.fed.us/pnw/fera/research/smoke/consume/consume_download.shtml

CONSUME software tutorial and demonstration:
<http://www.fs.fed.us/pnw/fera/research/tutorials/consume.shtml>

Management Implications

- The CONSUME 3.0 software package for estimating fuel consumption and forecasting emissions is being improved with specific, research-supported information on fires in shrublands.
- CONSUME 3.0 is available for download by users from the FERA team website: <http://www.fs.fed.us/pnw/fera/research/smoke/consume/index.shtml>.
- The initial shrubland data used for CONSUME is based on results of research in big sagebrush prescribed burns. As chamise chaparral, pine flatwoods, and pitch pine scrub models are developed, CONSUME will be updated with increasing specificity for these shrubland types.
- CONSUME outputs can be used with the V-Smoke and BlueSky smoke modeling packages to improve estimates of smoke emissions from shrubland fires.
- The refined CONSUME outputs for shrubland fires increase the value of this tool for making emission estimates and carbon inventory studies.

Effects of fall and spring prescribed burning in sagebrush steppe in east-central Oregon:
http://www.fs.fed.us/database/feis/research_project_summaries/Sapsis90/all.html

Wright, Clinton S., Roger D. Ottmar, Sue A. Ferguson, and Robert E. Vihnanek. 2007. Fuel consumption and flammability thresholds in shrub-dominated ecosystems. Final Report, Joint Fire Science Program, Project 03-1-3-06.

Wright, Clinton S.; Prichard, Susan J. Biomass consumption during prescribed fires in big sagebrush ecosystems. In: Andrews, Patricia L.; Butler, Bret W., comps. Fuels management—How to measure success: Conference Proceedings. 28-30 March 2006; Portland, OR. Proceedings RMRS-P-41. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. pp. 489-500, 2006.

Scientist Profile

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