SOUTHERN Fire Exchange
Uniting Fire Science and Natural Resource Management

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Predicting Smoke Movement: User-Friendly Computer Models

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PREDICTING SMOKE MOVEMENT: AN OVERVIEW

Smoke management is one of the most important considerations in all fire prescriptions. In many situations it is the first planning step–the rest of the prescription is built around smoke dispersal in a specific direction. National Weather Service forecasts provide a key source of information for determining smoke column rise and transport. However, smoke composition and dispersal will also be influenced by fire size and fuel conditions. A variety of models have been developed for integrating many of these factors into reliable predictions of smoke dispersal and effects. Most states and fire management agencies have specialists trained to use these models, especially the more complex systems. However, some of the less complex models are also available for use across the South, whether you are planning a small burn in fine fuels or a large, mixed-fuel fire.

This fact sheet introduces the primary models that can be used for most prescribed fires in the region. It describes the types of input, output, and fire situations for each model; what you will need to make them work for you; and information on how you can learn more about each one. In a survey of almost 1,000 fire managers across the South in 2009, over half identified better smoke modeling and prediction as an important information need (needs assessment summary available at https://southernfireexchange.org/about-us/). This and subsequent fact sheets are steps toward meeting that need by assuring that users are aware of existing technology.

WHICH MODELS WORK BEST IN DIFFERENT SITUATIONS?

Four general models will provide most of the assistance you need for smoke management planning:

1. Simple Smoke Screening model,
2. VSmoke/VSmoke-GIS,
3. Fire Emission Production Simulator (FEPS), and
4. HYSPLIT[1].

Simple Smoke Screening Model

The Simple Smoke Screening model is a graphical tool available through the Florida Department of Agriculture (http://fireweather.fdacs.gov/Simple-Smoke/) and works well for fires less than 300 acres, burned during the day. This model plots a cone for the projected smoke column on a map or satellite image just as you may have done by hand with a ruler and compass. It is based on the wind forecast direction, burn acres, fuel type (4 categories), and ignition method. It is important to note this model only predicts the downwind smoke impact zone; it does not predict smoke concentrations which depend on fuel conditions, and timing and quantity of smoke production.

VSmoke

A more detailed planning tool is the VSmoke Model available at http://webcam.srs.fs.fed.us/tools/vsmoke/download.shtml. VSmoke estimates downwind concentrations of particulate matter at 31 fixed distances, and how far and how well a person may see through the smoke plume at each distance. It also estimates smoke plume dimensions at each of the 31 points. Inputs to the model include: weather forecasts for wind direction, speed, mixing height, and atmospheric stability; and fuel loading and consumption as calculated by the Fire Emission Production Simulator (FEPS). The VSmoke-GIS version allows the user to plot the plume and concentrations on a map using ARCGIS. A report is prepared with tables showing concentrations and visibility. The original VSmoke models require considerable understanding of the model and its inputs.

An easy-to-use web-based version of VSmoke is also available on the Georgia Forestry Commission's website (http://weather.gfc.state.ga.us/googlevsmoke/vsmoke-good2.html). It produces smoke plume overlays on a map or satellite image that represent expected downwind concentrations of particulate matter relative to the Air Quality Index (which is defined on the website) and potential health impacts (Figure 1). Inputs include the same weather variables as the original VSmoke, as well as fuel type (12 classes), fuel moisture conditions, fuel loading, burn unit size, and ignition method. The web-based version of VSmoke is being further developed to estimate visibility impacts as well.

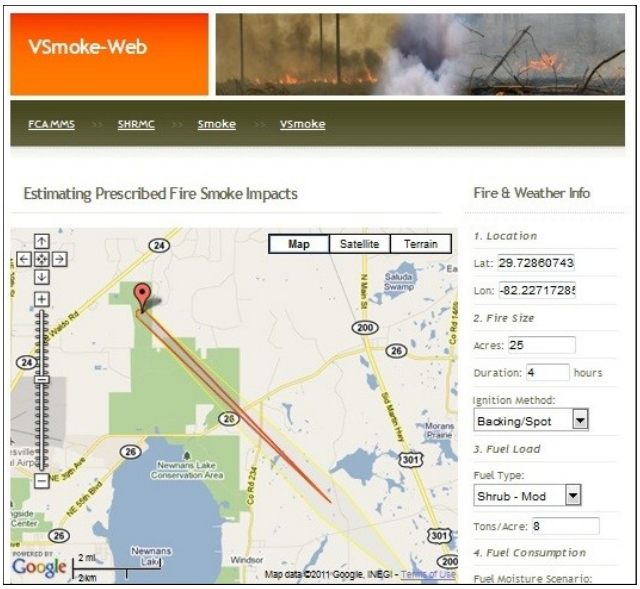

Figure 1. The web-based version of VSmoke produces smoke plume overlays on a map or satellite image.

Fire Emission Production Simulator (FEPS)

The Fire Emission Production Simulator does not predict smoke dispersal direction and pattern; however, it does estimate consumption, emissions, and heat release/plume buoyancy based on prescribed burn fuel characteristics. This information becomes especially important on large burn units. Outputs from this model are used as inputs to the three VSmoke software programs. A more detailed description, manuals and a download of the FEPS model (for MS Windows®) are available at www.fs.fed.us/pnw/fera/feps/index.shtml. To run FEPS on Windows 7 or higher, download the Fuel and Fire Tools package at https://depts.washington.edu/fft/ which contains FEPS and other fire models.

HYSPLIT

The HYSPLIT[1] model (www.arl.noaa.gov/HYSPLIT_info.php) links to current NOAA weather forecasts, to project plume dispersion and downwind concentrations from fires or a variety of other sources, within the next 48 hours. The model can be downloaded to a PC or run interactively on the Air Resources Laboratory's READY webpage (https://www.ready.noaa.gov/index.php). The model requires considerable user interaction and training but has the advantage of projecting plumes based on real-time meteorological data rather than user-supplied weather parameters. HYSPLIT is valuable to burners for estimating how the plume is expected to disperse during the day as winds shift direction. Only registered users can use the model in forecasting mode; the website contains instructions on how to register with NOAA.

WHERE CAN YOU GET MORE INFORMATION ABOUT THESE AND OTHER MODELS?

Predicting smoke dispersion and concentration has been the focus of research and modeling for over 50 years. The 1976 Southern Forestry Smoke Management Guidebook (www.treesearch.fs.fed.us/pubs/683) provided detailed procedures and tables for evaluating smoke concerns. Two national references about smoke describe the different types of models that are used for predicting smoke dispersion as well as a large body of information on smoke and air quality[2, 3]. An updated version of the 2001 guide will be published soon. Today, most work is carried on by multiple agency collaborations such as SHRMC in the South, which is one of five Fire Consortia for the Advanced Modeling of Meteorology and Smoke (www.airfire.org), and the US Forest Service Fire and Environmental Research Applications and Atmosphere and Fire Interactions Research Teams in the Pacific Northwest (https://www.fs.usda.gov/pnw/). All these websites are entry points for learning more about both simple and complex models that are currently available. For readers who work with the Wildland Fire Decision Support System (WFDSS), a new Air Quality Portal (https://wfdss.usgs.gov/wfdss/WFDSS_Home.shtml) includes a variety of tools for smoke management and planning. For an introduction to the major characteristics of smoke models, an archived webinar is available at www.forestrywebinars.net/webinars/using-smoke-prediction-models-for-prescribed-burning-planning.

REFERENCES

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[2] Hardy, C., Ottmar, R., Peterson, J., Core, J., & Seamon, P. (eds). (2001). *Smoke management guide for prescribed and wildland fire*. PMS 420-2, NFES 1279. Boise, ID: National Wildfire Coordination Group. 226 p. Available for download www.treesearch.fs.fed.us/pubs/5388.

[3] Sandberg, D., Ottmar, R., Peterson, J., & Core, J. (2002). *Wildland fire in ecosystems: effects of fire on air.* General Technical Report RMRS-GTR-42-vol. 5. Ogden, UT: USDA Forest Service, Rocky Mountain Research Station. 79 p. Available for download www.fs.fed.us/rm/pubs/rmrs_gtr042_5.pdf.

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