

FARSITE: A Fire Area Simulator for Fire Managers¹

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Abstract: A fire growth model (FARSITE) has been developed for use on personal computers (PC's). Because PC's are commonly used by land and fire managers, this portable platform would be an accustomed means to bring fire growth modeling technology to management applications. The FARSITE model is intended for use in projecting the growth of prescribed natural fires for wilderness areas. The PC model requires the support of a geographic information system (GIS) to manage and provide landscape data. FARSITE currently uses a stream of weather and wind changes along with landscape data downloaded from the GIS to model fire growth.

Computerized fire growth models have been the subject of research for about 20 years. Despite numerous management applications (Andrews 1989), these models still remain largely in the realm of research. Some obstacles to implementing a fire growth model for management purposes have been technological; different approaches to developing a realistic model for simulating wildland fire spread and behavior have different technical problems to overcome. Practical limitations have also created obstacles, mainly with the availability of computer hardware and software as well as landscape data. Until recently, computers and geographic information systems (GIS) with adequate spatial coverage of the themes necessary for running a fire growth model have not been widely available to potential users.

Many of these difficulties are no longer limiting. Advances in computer technology and increasing prevalence of GIS no longer impede the transfer of fire growth modeling technology to user applications. Personal computers are now commonplace and a familiar tool for most managers. These computers are thus a logical platform for a fire growth model that can be easily accepted in an accustomed environment.

This paper briefly describes an implementation of the FARSITE Fire Area Simulator designed for fire management uses on a personal computer.

Fire Growth Models

The FARSITE model uses Huygens' principle of wave propagation (Richards 1990) to expand fire fronts. This method, named for the 17th century Dutch mathematician who studied light waves, treats fire as a wave that spreads

using points on its edge as independent sources of new wavelets. The approach was first used by Sanderlin and Sunderson (1975) and Sanderlin and Van Gelder (1977) to model fire growth (other methods using Huygens' principle in fire modeling were described by Anderson and others 1982, Beer 1990, French and others 1990, Richards 1990, Knight and Coleman 1993, Wallace 1993). The Huygens' approach differs from models based on "cellular automata" that spread fire as a contagion process between cells of a regular grid (Green 1983, Green and others 1983, Kourtz and O'Reagan 1971, Kourtz and others 1977). The cellular automata approach has been pursued by many researchers, too numerous to mention here. Models based on Huygens' principle are well suited to the relatively limited resources of personal computers. Huygens' principle requires information only from points on the fire edge. This makes efficient use of computer time and memory compared to cellular models. In cellular models, distortions to the fire shape resulting from the grid must be minimized by calculating fire spread to unburned cells within a wide radius of each active cell (French 1992).

The applicability of Huygens' principle to fire growth modeling has been demonstrated by a number of studies. Although they have not been comprehensively validated, fire spread patterns predicted by models using Huygen's principle have generally agreed with those observed (Anderson 1982, Finney 1994, French 1992, Sanderlin and Sunderson 1975). Many validations will eventually be needed for defining the strengths and weaknesses of these models.

Features of FARSITE

In general, Huygens' principle enables a logical implementation of existing fire behavior models. Each point on the fire front contains information on the time, direction, and rate of fire spread. These are essential components of existing models of surface fire spread, fire acceleration, crown fire and transition to crown fire, as well as spotting. FARSITE incorporates models for surface fire spread (Andrews 1986, Rothermel 1972) as well as transition to crown fire and crown fire spread (Rothermel 1991, Van Wagner 1977, 1993) and spotting distances.

A user interface for the FARSITE model has been developed for the Microsoft WINDOWS operating environment. This graphical interface allows considerable device independence among the widely varying hardware capabilities of personal computers. The FARSITE model requires the user to identify the data files (containing landscape, weather, and wind data). The mouse control

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mechanism is then used to input ignitions on the displayed landscape. These ignitions can be points, lines, or existing fire shapes (drawn as a series of line segments). In a similar fashion, users can make minor modifications to the landscape including control lines or fuel type changes. The duration of the simulation is determined by the desired ending date and time. Fire maps and area and perimeter data and graphs can be output to files or printed. Current plans are to test the preliminary version of FARSITE written for 32-bit WINDOWS (WIN32s) during the 1994 fire season at Yosemite and Sequoia and Kings Canyon National Parks in California. The primary purpose of the test phase will be to incorporate management suggestions for interface features. The first general release of FARSITE for the personal computer is scheduled for 1995.

Although fire growth models will likely make some aspects of fire management easier, the true limitations of these models will probably soon become apparent. Weather forecasts along with the absence of 3-dimensional wind fields in complex terrain are likely to be a major source of error for a long time.

Conclusions

The transfer of fire growth modeling to user-applications has recently been encouraged by new demands for managing and researching ecosystem processes across landscapes. The PC version of the FARSITE model should be helpful in managing fire as a landscape process. When implemented on other platforms, it may also be useful for simulating fire as an ecosystem process over larger time and space scales.

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References

- Anderson, D.H.; Catchpole, E.A.; DeMestre, N.J.; Parkes, T. 1982. **Modeling the spread of grass fires.** *J. Austral. Math. Soc. (Ser. B.)* 23: 451-466.
- Andrews, P.L. 1986. **BEHAVE: fire behavior prediction and fuel modeling system-BURN subsystem, Part 1.** USDA For. Serv. Gen. Tech. Rep. INT-194.
- Andrews, P.L. 1989. **Application of fire growth simulation models in fire management.** Proc. 10th Conf. Fire and Forest Meteorology, Ottawa Canada; 317-321.
- Beer, T. 1990. **The Australian National Bushfire Model Project.** *Mathematical and Computer Modelling* 13(12): 49-56.
- Finney, M.A. 1994. **Modeling the spread and behavior of prescribed natural fires.** In: Proc. 12th Conf. Fire and Forest Meteorology, Jeekyll Island GA. In press.
- French, I.A.; Anderson, D.H.; Catchpole, E.A. 1990. **Graphical simulation of bushfire spread.** *Mathematical and Computer Modelling* 13(12): 67-71.
- French, I.A. 1992. **Visualisation techniques for the computer simulation of bushfires in two dimensions.** University of New South Wales, Australian Defence Force Academy. M.S. Thesis.
- Green, D.G. 1983. **Shapes of simulated fires in discrete fuels.** *Ecological Modelling* 20: 21-32.
- Green, D.G.; Gill, A.M.; Noble, I. R. 1983. **Fire shapes and the adequacy of fire-spread models.** *Ecological Modelling* 20: 33-45.
- Knight, I.; Coleman, J. 1993. **A fire perimeter expansion algorithm based on Huygen's wavelet propagation.** *International Journal of Wildland Fire* 3(2): 73-84.
- Kourtz, P.; O'Reagan, W.G. 1971. **A model for a small forest fire to simulate burned and burning areas for use in a detection model.** *Forest Science* 17(2): 163-169.
- Kourtz, P.; Nozaki, P.; O'Regan, W. 1977. **Forest fires in the computer—A model to predict the perimeter location of a forest fire.** Fisheries and Environment Canada. Inf. Rep. FF-X-65.
- Richards, G.D. 1990. **An elliptical growth model of forest fire fronts and its numerical solution.** *Int. J. Numer. Meth. Eng.* 30: 1163-1179.
- Rothermel, R.C. 1972. **A mathematical model for predicting fire spread in wildland fuels.** USDA For. Serv. Res. Pap. INT-115.
- Rothermel, R.C. 1991. **Predicting behavior and size of crown fires in the northern Rocky Mountains.** USDA For. Serv. Res. Pap. INT-438.
- Sanderlin, J.C.; Sunderson, J.M. 1975. **A simulation for wildland fire management planning support (FIREMAN): Volume II. Prototype models for FIREMAN (PART II): Campaign Fire Evaluation.** Mission Research Corp. Contract No. 231-343, Spec. 222. 249 p.
- Sanderlin, J.C.; Van Gelder, R.J. 1977. **A simulation of fire behavior and suppression effectiveness for operation support in wildland fire management.** In: Proc. 1st Int. Conv. on mathematical modeling, St. Louis, MO; 619-630.
- Van Wagner, C.E. 1977. **Conditions for the start and spread of crownfire.** *Canadian Journal of Forest Research* 7: 23-24.
- Van Wagner, C.E. 1993. **Prediction of crown fire behavior in two stands of jack pine.** *Canadian Journal of Forest Research* 23: 442-449.
- Wallace, G. 1993. **A numerical fire simulation model.** *International Journal of Wildland Fire* 3(2): 111-116.