Understanding the Fire Program Analysis (FPA) Large Fire Module

Topic:

Understanding the Fire Planning Analysis (FPA) Large Fire Module (LFM).

Introduction

The Fire Program Analysis (FPA) project uses fire behavior modeling to help Budget Planners gain insights into tradeoffs, at a national level, of investing varying funding levels in different Fire Planning Units (FPUs) for preparedness and hazardous fuel activities. This modeling occurs within the FPA Initial Response Simulator (IRS) and Large Fire Module (LFM). IRS models the effectiveness of FPU fire resources, while LFM models the outcome of all fires[1] that exceed the simulation limits in terms of probability of burning and flame length distributions. The LFM does not model line-producing resources or other FPU personnel; instead, it provides a statistical predictor of large fire occurrence, expected suppression cost, and burn intensity.

This paper introduces the Large Fire Module concept, and explains how the module simulates the probability of burning across the landscape at different flame lengths.

Discussion

The FPA Interagency Science Team (IST) designed the Large Fire module as a two-stage modeling process in order to minimize computer run/wait time and FPU-Planner workload during their analysis. The FPU planners have two tasks in providing inputs to the Large Fire module. The first is to provide the FPA Project with simple typical fuel treatment prescriptions[2] (objectives). The second is to identify a weather station[3] that typifies the general weather conditions under which large fires spread in their FPU.

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[1] Including Wildland Fire Use (WFU) events. WFU events are not modeled in IRS; instead, they are passed to LFM for their final outcome.

[2] See Building a Fuels Treatment Prescription for Fire Program Analysis (FPA) Large Fire Module Simulation LF_002_TP…

[3] http://www.fpa.nifc.gov/Library/Papers/Docs/FPA_2/Tech_Single_Weather_Station_08_1_18_final.pdf

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The Large Fire model processes data through two stages:

Stage 1: Developing Statistical Models

FPA staff complete five FSPro[4] runs for each FPU before the planning season. Where significant changes in surface fuels or types of fuels treatments have occurred since the previous year, FPA will annually complete another five FSPro runs.

Stage 1 consists of five runs to generate an FPU's fire behavior profile:

1. **Standard** -- This simulation uses historic large fire occurrence data and landscape data to represent as accurately as possible the current state of the fuels, weather data, and large-fire suppression effect[4].

2. **No Large-Fire Suppression** – Includes information from the Standard simulation, but without any large fire suppression data. This simulation represents the spatial scale of large fires without suppression actions for use in Wildland Fire Use (WFU) fire size calculations.

3. **Constant Fuels** – Includes information from the Standard run, but the fuel model and topography are held constant across the FPU. FPA selected FM 10 with zero slope and no aspect to examine sensitivity of the simulation outputs to varying weather conditions. FPA could have selected any surface fuel model. The important point is that fuels and topography are held constant.

4. **Constant weather** – Includes information from the Standard run, but with a single set of burning conditions (wind speed, direction, and fuel moisture content) and burn duration. Holding the weather constant allows FPUs to examine sensitivity of the simulation outputs to the variability in the fuels and topography.

5. **Fuel Treatment** – Includes information from the Standard run, but with fuels treatment applied to 15%[5] of the landscape to test sensitivity of outputs to the general prescriptions provided by the FPUs.

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[4] The Large Fire module fire-behavior calculator is based on work done by Dr. Mark Finney at the USDA Forest Service's Rocky Mountain Research Station in Missoula, MT. Its core is the FSPro fire modeling application used by FPA and the Wildland Fire Decisions Support System (WFDSS). For a more technical description about fire generation and spread on the landscape, refer to Mark Finney's write-up on the large fire simulation at http://www.fpa.nifc.gov/Library/Docs/Science/FPA_SimulationPrototype_0705.pdf . Note that some of the information in this paper is specifically for the prototype run. A new paper that describes in detail how the Large Fire module works is currently in progress.

[5] 15% is a number chosen in collaboration with the IST. Experimentation found that 15% generates data needed for the statistical portion of LFM. One of the data elements needed to estimate the spatial burn probability is the percent of the area treated within a given radius of a point. 15% of the landscape treated generates enough treated

These five runs generate a fire behavior profile for each FPU based on the topography, weather, current fuels, and typical fuel treatments. These runs create all of the data needed to develop the statistical models. For fuel treatments, information about how the general prescriptions change the probability of burning at different flame lengths are captured here. FPA processes this information for specific Fire Workload Area (FWA)-level fuel treatment options generated from investment alternatives in Stage 2: Statistical Simulations.

The burn probabilities and flame lengths generated by the five FSPro runs are used to statistically model the unique relationships among the several variables including:

- Topography,
- Weather, and
- Existing fuel types and typical fuel treatments for each FPU.

LFM depicts these relationships in regression[6] models that are applied to specific investment alternatives in statistical simulations.

Stage 2: Statistical Simulations

FPUs run Stage 2 – FPA Statistical Simulations each year during their budget planning.

FPUs use the Stage 1 statistical models to predict the impact each of their candidate investment alternatives has on nationally defined performance measures in their FPU. Here, specific fuel treatment options (part of the FPU's investment alternatives) are applied to the landscape via percentages of fuel types treated in each FWA[7]. Fuel types have a probability of being treated based on the fuels treatment option defined for the FPU's Fire Workload Areas (FWAs). The statistical simulation retrieves information about the impact of "treating" a cell from information in Stage 1. FPA assumes the treatments applied here are the same types of prescriptions as were modeled in Stage 1. This analysis requires no FPU Planner data input other than defining investment alternatives for analysis and their associated IRS outputs (specifically, the number of

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cells so that LFM can model the entire range (from 0% to 100%) of the area treated within the radius. For example, a cell far from a treatment block has 0% of the area around it treated, while a cell located inside a treatment block may have 100% of the area around it treated. The actual 15% treated is not used anywhere in the module; it generates "enough" treatments in a statistical sense.

[6] In statistics, regression analysis is a technique that examines the relation of a dependent variable (for example, acres burned) to specified independent variables such as weather index, location, index, duration, and percent of the area treated. A regression equation represents the key relationship in a regression. Each regression equation contains regression parameters whose values are estimated using data from Step 1. The estimated parameters measure the relationship between the dependent variable and each of the independent variables.
http://en.wikipedia.org/wiki/Regression_analysis

[7] These are not the same as the general prescription required for Stage 1. These are specific application of the types of treatments described in Stage 1 for a given investment alternative. For example, if an FPU's general prescription is moving FM10 to a FM8, the specific application here might be moving 1,500 acres of FM10 to FM8 in this particular FWA and zero acres of treatments in the neighboring FWA.

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fires that exceed simulation limits). Based on experience with the prototype models, FPA staff estimate that it should take less than five hours of unsupervised computer run-time to complete the calculations for all Stage 2 investment alternatives. Stage 2 results are:

- Spatial maps of burn probability and flame lengths, and
- Expected annual acres burned and associated costs. FPA uses these costs to calculate FPU performance measures.

The Large Fire module derives expected suppression costs from the Stratified Cost Index (Gebert 2007, in press).

Review History:

Date	Initials	Change Summary
March 4, 2008	BE	Editorial and content review.
March 4, 2008	KSH	Editorial review.
March 3, 2008	AK	Review.
February 20, 2008	KSH	Edit for clarity and readability.
February 12, 2008	JH	Technical review (Jim Hutton).
February 8, 2008	AK	Technical review (Andy Kirsch).
February 5, 2008	DS	Initial draft.

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