Appendix E—White Paper on Pre-Fire Risk Assessment and Fuels Mapping

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Issues/Overview

In recent years, wildland fires and altered fire disturbance regimes have become a significant management and science problem affecting ecosystems and wildland/urban interface across the United States. This white paper describes some of the many pre-fire geospatial needs that should prove useful for conducting effective fire-management programs prior to a fire occurring.

- Remote-sensing mapping and characterization of vegetation and fire-fuels parameters and data sets are required by national fire management and science communities. These needs are clearly defined in strategic documents such as the National Fire Plan (NFP), the Joint Fire Science Program (JFSP), U.S. Congress General Accounting Office (GAO) reports, and the 10-Year Comprehensive Strategy of the USDA Forest Service and DOI. These documents stipulate that there is a consistent need to develop spatial technology and data about fires, fuels characteristics, and burns.

- There is a need for more mapped information on fire fuels within the Nation's wildland areas, particularly those in or near the urban interface, as well as to expand the capability of fire-behavior models such as BEHAVE and FARSITE. In addition, natural resource managers would like to have improved methods for monitoring the outcome of prescribed burns in terms of the objectives of the burn.

- Real-time data are needed in the form of nationwide, seamless, base-layer data (topography, roads, hydrography) integrated with fire data (perimeters, satellite data) to aid in making informed decisions. Geographic Area Coordination Centers (GACCs) are interested in Web-based technology to assist in creating maps for incident support, public briefings, and in prioritizing resource allocation; there is a need to pre-stage data to facilitate data acquisition by incidents.

- There is a need for improved methods of remote estimation of moisture content of wildland fire fuels. Ultimately, satellite-based information that provided real-time estimates of fire-fuel moisture content would be of great benefit to the fire-science community for both improved fire-danger monitoring and inputs to fuel-modeling systems such as BEHAVE and FARSITE.

- There is a need to look at fire-fuels mapping from a broader perspective (that is, beyond mapping vegetation to fit into the traditional fuel model schemes) that lends itself more effectively to state-of-the-art remote-sensing capabilities. Two areas of study in this direction might be (1) to compare burn-severity data with the corresponding imagery of the same area before burning to look for correlations between burning and spectral characteristics of the unburned vegetation; and (2) to build fuel characteristics from a combination of spectral characteristics and 3-D vegetation profiles as rendered with multiple return LIDAR (Light Detection And Ranging).

Current USGS Work

Web-Based Mapping for Fire Applications (GeoMAC)

Principal investigators:

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The USGS has developed and housed the National Interagency Fire Center's (NIFC) GeoMAC (Geospatial Multi-Agency Coordination Group) site for the past 3 years. GeoMAC is an Internet-based mapping application that allows the public and wildland firefighting coordination centers to access online maps of current wildland fire locations and values at risk using standard Web browsers. This technology provides users with a way to graphically visualize fire-related data that historically have been available only as database files or textual reports. Data layers are collected, processed, and integrated to provide seamless nationwide coverage. Viewing data such as fire location on the landscape and then accessing the associated textual information with a mouse click has vastly increased the public's and fire manager's access to data and information. Fire-perimeter data are updated several times a day based upon input from incident intelligence sources: field observation, global positioning system (GPS) data, and infrared (IR) imagery from fixed-wing and satellite platforms. The GeoMAC Web site allows users to manipulate map information displays, zoom in and out to display fire information at various scales and detail, and print hard-copy maps. The fire data are tied to relational databases in which the user can display information on individual fires such as the name of the fire, current burned acreage, and other fire status information.

Potential USGS collaborators: National Interagency Fire Center, Bureau of Land Mangement, USDA Forest Service

The LANDFIRE Project: Developing Critical Spatial Data and Modeling Tools for Implementing the USA National Fire Plan and the Cohesive Strategy

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The USDA Forest Service and Department of the Interior developed the National Fire Plan, the 10-Year Comprehensive Strategy, and the recent Implementation Plan to establish a national commitment to restore and maintain ecosystem health in fire-adapted ecosystems for priority areas across the interior West. As a new strategy to map fire risks, a series of maps for the lower 48 States was developed at 1-km^2 pixel resolution in 2000 that characterized vegetation cover, historical fire regimes, and departures from the historical regimes, known as fire regime condition classes (FRCC). This 1-km^2 project provided a basis for mapping and assessing fire risk and other valuable data for national prioritization and planning of fire management. It became apparent that finer scale information was critically needed nationally, regionally, and locally to effectively implement the National Fire Plan. In addition, the coarse scale data fell short in addressing fire risk on nonforested lands. The LANDFIRE (LANDscape and FIRE Management Planning System) project, funded jointly by the USDA Forest Service and Department of the Interior, is designed to provide scientifically credible, comprehensive, and critical mid-scale data for prioritization and planning to implement the National Fire Plan, both at the national and local level. Vegetation composition and structure are being mapped at the USGS EROS Data Center, and fuels, FRCC, and a myriad of other maps and tools are being developed at the USDA Forest Service Rocky Mountain Research Station Fire Sciences Laboratory.

Potential USGS collaborators: USDA Forest Service, Department of the Interior, Universities

Greenness Mapping and Fire-Danger Monitoring

Principal investigators:

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The requirements for analyzing and forecasting wildfire potential at a national scale necessitates that remote-sensing research and applications develop spatial information and technology to assess and forecast fire hazard over large areas. A Fire Potential Index (FPI) was initially developed in 1997 by scientists at the USDA Forest Service in collaboration with the USGS EROS Data Center as an augmentation to standard Forest Service fire-danger indices. The FPI uses both static and dynamic variables from three data sources—fuel type maps, satellite images, and meteorological data—to generate 1-km resolution fire-potential maps for the conterminous United States and Alaska. The FPI enables the local and regional fire planners to quantitatively measure fire-ignition risk. This allows the planners to pre-position the resources in specific geographic areas based on quantitative measurement of the FPI. The feedback from the fire community coupled with recent technological advances has suggested improvements to the FPI model. It is expected that the improvements in the type of meteorological data and the refined relative greenness information will enable the FPI to more accurately determine the influence of weather and climate variability on fire ignition, as well as improved modeling and mapping of dead-fuels moisture content. The ability to assess and provide long-term forecasts of fire hazard with the FPI will provide the USDA and DOI fire managers the use of new remote-sensing technology that is critically required in wildfire prevention.

Potential USGS collaborator: USDA Forest Service

Fuel and Fire-Hazard Mapping in the Mojave Desert

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This project uses existing vegetation, topography, lightning detection, and other spatial data to develop fuel and fire-hazard models and maps that focus on the Mojave National Preserve area of the Mojave Desert. To develop a fuel map, the existing vegetation map, which consisted of about 20 vegetative-cover categories, was qualitatively classified into categories by relative potential for fire spread and fire intensity (high, medium, low) and by fuel models 1 and 6 (the only ones that can be applied to this landscape). Digital-elevation-model data were then used to characterize effect of slope on fire spread rate and intensity. Finally, lightning-detection data (high, medium, low) were incorporated into the model to produce a fire-hazard map. In the future, it is planned to use thematic-mapper images to detect where the interspaces green up the most during spring, as an indication of where most of the interspace fine fuels are. This may allow the identification of areas that will be most sensitive to interannual variation in fuel continuity (for example, from annuals, especially alien annual grasses).

Potential USGS collaborator: National Park Service

The Use of Thematic Mapper and AVIRIS Data to Map Fuel Characteristic Classes in Western Ecosystems

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In order to plan, monitor, and implement fuels-management programs, improved methods of mapping fuels need to be developed. Landsat 7 Thematic Mapper (TM) imagery and Airborne Visible InfraRed Imaging Spectrometer (AVIRIS) hyperspectral data show promise for characterizing the condition of fuels and changes in those conditions over time. The objective of this research, sponsored by the Joint Fire Science Program, is to test the accuracy, efficiency, and cost-effectiveness of AVIRIS and ETM (Enhanced Thematic Mapper) PLUS remotely sensed data for developing fuel characterization classes based on field data collected at five different locations in forest, shrub, and grass ecosystems. Forest fuels and vegetation data necessary for characterizing fuel classes have been collected from more than 1,000 plots in Yosemite National Park. Collection of similar data from more than 360 plots in the Lassen Volcanic National Park has been completed, as has 1 year of data collection from 165 plots in Glacier National Park. Shrub fuels data from Great Basin National Park and grass fuels data from Theodore Roosevelt National Park will extend the analysis to nonforested ecosystems. Data from the plots will be used to establish relations between fuel characteristics and spectral signatures by using spectrum matching and end-member analysis of AVIRIS data. AVIRIS data obtained over Yosemite National Park in September 2001 were updated with a complete reflight in August 2002 to account for sensor malfunctions and cloud-covered areas from the 2001 data. Ground spectrometer data were collected 2 to 3 days after the 2002 flight for purposes of calibration to surface reflectance. Preliminary analysis of a selected portion of the 2001 AVIRIS data indicates the presence of at least 12 to 15 spectral end members, which may correlate to specific fuel models. The existence of 2 years of AVIRIS coverage for from one-third to one-half of the study area offers additional opportunities to study before-and-after fire effects for at least one fire that occurred in the 2002 growing season.

Potential USGS collaborator: National Park Service

Potential Research and Collaboration

- Continue working with the National Interagency Fire Center to produce a 5-year project plan for continued GeoMAC (Geospatial Multi-Agency Coordination Group) support. Develop strategies to improve speed and functionality of Web sites. Work closely with the GACC's to refine their requirements and mapping requirements.
- Suggested future research on fusion of fuels identified from electro-optical remote sensing (MSS [Multi-Spectral Scanner] and hyperspectral) with 3-D multiple-return LIDAR (Light Detection And Ranging) profiles to define canopy and subcanopy and possibly estimate vegetation density. USGS and Colorado State University School of Forestry could collaborate on this research.
- Wildland fires present many complex issues that bring with them challenging research needs. USGS remote-sensing scientists should conduct studies that are relevant to fire-management issues and compatible with USGS technical capabilities, long-term vision (such as the National Map), and research plans (for example, Geographic Analysis and Monitoring Five-Year Plan).
- Mapping fire fuels requires data and information about vegetation types, structure, and green biomass. How can we design mapping and modeling techniques to measure canopy height, stand size, and understory vegetation in an operational mode? Can we effectively integrate field data with satellite imagery to derive desired variables? Will ecological modeling be effective for deriving vegetation types and structure classes? Will the overall mapping strategy be repeatable? Can remeasured field-plot data drive updating of land and vegetation maps? There also is a critical need to incorporate LIDAR, IFSAR (Interferonmetric Synthetic Aperature Radar) technologies and expertise at EDC to applications of land and vegetation mapping and characterization.
- Improvement in monitoring and forecasting of factors associated with potential fire occurrence. Tools such as Fire Potential Index (FPI) could be improved through studies that lead to a better understanding of (1) vegetation conditions such as moisture content, percent green vegetation, and fuel models; and (2) the effect of climate and weather variability, spatially and temporally, on fire occurrence.

- Mapping of values at risk. In addition to fuel hazards, there are other factors that contribute to fire risk. In particular, the presence of population centers and access corridors contribute to the potential for a fire to start. Once ignited, values that need protection need to be identified such as communities, structures, watersheds, and sensitive species habitats. A method to categorize, weight, and map these values needs to be developed.

Actions Needed to Improve Pre-Fire Risk Assessment and Fuels Mapping

Fire-management issues, corresponding to different phases of a fire cycle, require different but related research approaches and technologies. For example, fuel reduction requires mapping of the spatial distribution of vegetation characteristics and fuel models, whereas the monitoring and forecasting of fire-ignition danger primarily depends upon coarse-resolution satellite data and weather models. In addition, the use of accurate fuel models will make fire-danger forecasting more consistent and accurate. The USGS should continue to pursue its efforts in these areas and encourage the involvement of multiple USGS disciplines, other DOI bureaus, and academia.

To accomplish these tasks, the following actions are needed:

- Reaffirm current science relationships with other agencies and bureaus
- Increase USGS fire-science roles in the DOI fire-management responsibilities
- Develop standard methods and procedures for using satellite imagery and field data for fire-management needs
- Continue developing and investigating Web-based mapping technology for relaying fire information to the public and wildland fire managers
- Convene a fire-science working group within USGS to identify potential research topics and coordinate efforts
- Participate in national and international conferences dealing with remote sensing and fire management