Chapter 1

Executive Summary

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Geospatial data describing wildland fuel and current as well as historical vegetation conditions are essential for planning, implementing, and monitoring projects supported by the National Fire Plan and the Healthy Forests Restoration Act. Scientifically credible, consistent, and standardized spatial data allow fire and land managers to accurately identify the amount and locations of lands or communities with hazardous fuel build-up or extreme departure from historical conditions. These data also facilitate the prioritization of ecosystem restoration and hazardous fuel reduction treatments to protect ecosystems, property, and people. Moreover, these data may be used during specific wildland fire incidents to maximize firefighter safety, pre-position resources, and evaluate fire behavior under a variety of weather conditions.

The Landscape Fire and Resource Management Planning Tools Prototype Project, or "LANDFIRE Prototype Project," was a three-year project that began April 1st, 2002 and ended April 1st, 2005. The project was funded by the United States Department of Agriculture Forest Service and United States Department of the Interior, with an annual cost of approximately $2 million. The objectives of the LANDFIRE Prototype Project were to develop the methods, tools, and protocols for producing consistent and comprehensive digital maps of current vegetation composition and condition, wildland fuel, historical fire regimes, and fire regime condition class (FRCC) for the entire U.S. at a 30-meter spatial resolution. The LANDFIRE Prototype Project was conducted in two large study areas: the first in the central Utah highlands and the second in the northern Rocky Mountains of Idaho and Montana.

The LANDFIRE Prototype Project involved various government agencies, universities, and private institutions. The two principal partners in the effort were the U.S. Department of Agriculture Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory (MFSL) in Missoula, Montana and the U.S. Department of the Interior Geological Survey, USGS Center for Earth Resources Observation and Science (EROS) in Sioux Falls, South Dakota. Additional partners included the University of Montana (Missoula) Numeric Terradynamic Simulation Group (NTSG) and Systems for Environmental Management (SEM), also in Missoula, Montana. MFSL mapped biophysical settings, wildland fuel, historical fire regimes, and historical vegetation composition and structure. MSFL also conducted most ecosystem and landscape modeling. EROS mapped existing vegetation composition and structure; developed a quality assurance, quality control, and accuracy assessment system; and developed the LANDFIRE data-dissemination system. NTSG developed the daily weather DAYMET database used as a foundation for mapping biophysical gradient layers, and SEM created the LANDFIRE reference database and provided valuable expertise on the classification, mapping, and modeling of vegetation and fuel.

As mentioned above, LANDFIRE methods were tested in the central Utah highlands and revised based on problems and limitations encountered. These revised methods were then tested on the second study area in the northern Rocky Mountains of Montana and Idaho. In April 2004, one year prior to completion of

the LANDFIRE Prototype Project, the Wildland Fire Leadership Council chartered the national implementation of the LANDFIRE Project (LANDFIRE National). It is important to emphasize here that the information presented in this report refers specifically to methods, procedures, and results from the LANDFIRE *Prototype* Project. LANDFIRE National is an ongoing effort involving most of the original collaborators and with the addition of The Nature Conservancy, NatureServe, and the Student Conservation Association to assist in vegetation modeling, vegetation map unit classification development, and field data collection, respectively. Lessons learned during the prototype process provide the foundation for the current mapping of vegetation, fuel, and fire regimes across the United States through LANDFIRE National. Visit www.landfire.gov for a detailed description of LANDFIRE National and to learn about and access the various LANDFIRE National data products.

The design criteria for the LANDFIRE Prototype Project resulted from several organizational meetings between the LANDFIRE team and USDA and USDOI fire management staffs. Agency fire management imposed abbreviated timelines and solid deadlines, required that LANDFIRE methodology be based on a strong scientific foundation, and required that the products be scalable to local applications with minimal modification. These conditions contributed to the following design criteria:

The LANDFIRE Prototype Project must be:

- based on the best available science,
- able to be implemented consistently across the nation,
- mapped at a 30-meter pixel size,
- reliant on no new field data collection,
- repeatable in time and space,
- scalable in application,
- developed within a three-year development timeline, and
- tested for accuracy.

Given these design specifications, we then developed a set of guiding principles that we used to direct the development of all LANDFIRE data layers. These principles allowed us to set boundaries for the development of every LANDFIRE product. These guidelines were as follows:

- Development should be targeted at mid-level map classifications.

- All themes must be identifiable, scalable, mappable, and model-able.
- Mapping applications must incorporate the biophysical gradients that determine the distribution of vegetation and disturbance regimes across landscapes.
- The primary development tool should be simulation modeling.
- The timespan for historical reference conditions would be 1600 AD to 1900 AD.

Many databases and computer models were developed to create the geospatial data layers describing vegetation and wildland fuel for the LANDFIRE Prototype Project to demonstrate that the methods and protocols could be applied nationwide. These products can be summarized by the following categories:

- **Databases**: LANDFIRE reference database, wildland fuel inventory database, vegetation development database, and map attribute tables
- **Computer models**: LANDFIRE-BGC, WXFIRE, LANDSUMv4, and HRVStat
- **Biophysical gradient maps**: 38 variables describing direct and indirect gradients affecting the distribution of vegetation and historical fire regimes
- **Vegetation maps**: existing vegetation, potential vegetation, canopy height, and canopy cover
- **Wildland fuel maps**: fire behavior fuel models, fire effects fuel models, and canopy fuel
- **Fire regime maps**: simulated historical fire return interval and severity, fire regime condition class, and indices of departure from historical conditions

The 24 core LANDFIRE Prototype Project spatial data layer products comprise a comprehensive set of data that may be implemented in broad- or mid-level prioritization of hazardous fuel mitigation efforts or in project-level planning of specific land and wildland fire management projects. See Chapter 2, table 1 for a detailed list of the LANDFIRE Prototype Project products.

The primary goal of the LANDFIRE Prototype Project was to develop a high-resolution map of FRCC for the entire nation. The computation of FRCC requires a comparison of current conditions with historical conditions to quantify departure. Current conditions are described using maps of vegetation composition (cover types) and structure (structural stages) derived from a supervised classification of Landsat imagery using continuous maps of biophysical gradients and an extensive collection of geo-referenced plot data called the LANDFIRE reference database. Historical conditions were described using a

spatially explicit landscape fire succession model called LANDSUMv4. Vegetation composition and structure were described using a cover type and structural stage classification developed specifically for LANDFIRE. The biophysical gradient layers were created from two ecosystem simulation models that compute variables describing the fundamental physical processes that govern vegetation dynamics. These models used the DAYMET national weather database, which has a 1-km^2 spatial resolution and daily temporal resolution spanning 18 years. Biophysical gradient layers created from these models were also used to construct a data layer describing biophysical settings (potential vegetation types) that was then used to facilitate Landsat imagery classification and as an input layer for simulating historical reference conditions.

Historical reference conditions were simulated over a timespan of thousands of years using a spatially explicit landscape fire succession model, called LANDSUMv4, which simulates vegetation development using deterministic succession pathways for different biophysical settings and simulates fire using a pixel-to-pixel cell percolation or spread approach. The time series of simulated historical vegetation conditions was compared with imagery-derived current conditions using the area occupied by biophysical setting/cover type/structural stage combinations within square (0.81 km^2) spatial reporting units. Fire regime condition class was mapped using methods consistent with the Interagency Fire Regime Condition Class Guidebook. In addition, we created a statistical program called HRVStat that computes another, more statistically robust index of departure with a corresponding measure of statistical significance. Fire severity and fire return interval information simulated over time was summarized over the entire simulation period to create simulated historical fire regime maps.

Several additional data layers were developed as part of the LANDFIRE Prototype Project to provide critical information to wildland fire management for planning and implementing hazardous fuel mitigation and ecosystem restoration projects. We developed a refined set of fire behavior fuel models specifically for LANDFIRE that was better suited for distinguishing subtle differences in fuel characteristics resulting from fuel treatments, and we mapped the original 13 fuel models in addition to the refined set based on an expert system and an integrated vegetation database describing cover type, structural stage, and biophysical settings. Maps of canopy fuel, including canopy height, canopy cover, canopy bulk density, and canopy base height, were mapped based on

statistical landscape modeling (specifically, regression trees) using Landsat imagery and the biophysical gradient layers. Fire effects fuel models were developed and mapped using the same approach as that used for fire behavior fuel model mapping. Maps of fire behavior fuel models and canopy fuel can be used in real-time wildfire applications, such as modeling fire growth or quantifying fire and fuel hazard using the suite of available fire behavior models, which include FARSITE, FlamMap, and NEXUS. Fire effects fuel models represent actual estimations of loading by fuel category for fire effects applications, such as estimating fuel consumption and smoke production using CONSUME or FOFEM.

The main strengths of the LANDFIRE Prototype Project included:

- a standardized, open source, repeatable method for developing consistent and comprehensive maps for use in wildland fire management;
- use of existing databases from government and non-government sources;
- the combination of remote sensing, ecosystem simulation, and biophysical gradient modeling to accurately map vegetation, fuel and fire regimes;
- a robust, straightforward, biophysically-driven statistical approach;
- a quantitative accuracy assessment;
- the automation of individual LANDIFRE tasks and processing steps;
- comprehensive coverage across all administrative boundaries and ownerships; and
- a seamless, Internet-based database dissemination tool.

The comprehensive, consistent, and automated methods developed through the LANDFIRE Prototype Project complement an integrated approach to wildland fire management and facilitate comparison of potential treatment areas using equivalent databases across the entire United States. The LANDFIRE system does not preclude the use of locally developed fire and fuel information in planning and management activities.

Please refer to the individual chapters of this report for a detailed description of each aspect of the LANDFIRE Prototype Project, information on the scientific background, and specific details regarding the individual procedures for creating the LANDFIRE data products.

For further project information, please visit the LANDFIRE website at www.landfire.gov.

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The Authors _____

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Robert E. Keane is a Research Ecologist with the USDA Forest Service, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory. Since 1985, Keane has developed various ecological computer models for the Fire Effects Project for research and management applications. His most recent research includes the development of a first-order fire effects model, construction of mechanistic ecosystem process models that integrate fire behavior and fire effects into succession simulation, restoration of whitebark pine in the Northern Rocky Mountains, spatial simulation of successional communities on landscapes using GIS and satellite imagery, and the mapping of fuel for fire behavior prediction. He received his B.S. degree in Forest Engineering in 1978 from the University of Maine, Orono, his M.S. degree in Forest Ecology in 1985 from the University of Montana, and his Ph.D. degree in Forest Ecology in 1994 from the University of Idaho.

Zhiliang Zhu is a Research Physical Scientist with the USDOI Geological Survey Center for Earth Resource Observation and Science (EROS). Zhu's research work focuses on mapping and characterizing large-area land and vegetation cover, studying land cover and land use change, and developing remote sensing methods for the characterization of fire fuel and burn severity. His role in the LANDFIRE Prototype Project has been to design and test a methodology for the mapping of existing vegetation cover types and vegetation structure and to direct research and problem-solving for all aspects of the methodology. He received his B.S. degree in Forestry in 1982 from the Nanjing Forestry University in China, his M.S. degree in Remote Sensing in 1985, and his Ph.D. degree in Natural Resources Management in 1989, both from the University of Michigan.