# J10D.4 A REPEATABLE AND CONSISTENT NATIONAL VEGETATION MAPPING STRATEGY

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**Abstract**

The 1999 1-km historical natural fire regime and fire regime condition class maps, developed by the Forest Service using baseline data produced by the USGS scientists for general applications, have been widely used for national fire management planning purposes. However, the use and misuse of the data since 2000 have also demonstrated the need for a dedicated vegetation mapping effort as a component of the LANDFIRE project at a mapping scale suitable for supporting multi-scale management applications from watershed management to national policy implementation. LANDFIRE requirements for the vegetation mapping methodology include consistency, repeatability, accuracy, and capability to map detailed (in terms of spatial and information depth) vegetation types and structure variables at 30-meter resolution. Such an effort, for national wall-to-wall coverage, is unprecedented. In this paper, we discuss a strategy for achieving the LANDFIRE vegetation mapping objectives within a five-year repeat cycle. The methodology is based on four essential design features: 1) reliance on Landsat data acquisition and processing by the USGS land cover program, 2) access to a large quantity of field reference data, 3) applications of environmental gradient layers and mapped potential vegetation types in the mapping process, and 4) the use of nontraditional and flexible classifiers that integrate field plot data with a large volume of predictor variable layers. Results from a prototype area will be shown as supporting evidence of the methodology.

**Vegetation Mapping Requirements**

Complex interactions of climate, topography, and vegetation characteristics contribute to spatial and temporal variations of fire fuels, risks from fire, burn severity, and succession pathways. Thus, fire community requirements for vegetation mapping are often stringent on temporal and spatial scales in order to ensure accurate, consistent and precise management applications. Spatially explicit fire effects and spread models (e.g., Finney 1998, Hargrove *et. al* 2000) depend on detailed vegetation types and structure classes as input layers. In developing a methodology for assessing fire risks over large areas, the U.S. Forest Service Missoula Fire Sciences Laboratory tested converting existing 1-km land and vegetation cover classifications to attributes of fire fuels and fire regimes (Schmidt *et. al* 2002). This research showed how mapped vegetation details could be converted to fire fuels classification, and demonstrated the need for vegetation mapping at finer spatial resolutions (e.g. 30-meter), with sufficient details in vegetation species composition and structure, and with regional and national coverage of forest, shrub, and herbaceous ecosystems. Vegetation parameters that have been frequently suggested as the most important data for contemporary scientific investigations are:

- Vegetation types or species composition defined by a national vegetation classification standard, such as the United States Federal Geographic Data Committee (FGDC) National Vegetation Classification Standard (Grossman *et. al* 1998). The alliance (community with multiple dominant species) or association (community with a single dominant species) levels of this standard have been found to correspond well with mapping efforts using satellite data.
- Percent vegetation cover per pixel (i.e. canopy density measured as a continuous variable) for forest, shrub, and herbaceous cover
- Average canopy height and aboveground green biomass estimates needed for fire fuels, carbon, and productivity studies.

Recent progress in land and vegetation mapping is evidenced by developments in the last decade of a number of successful datasets with scales from regional, 30m resolution (Vogelmann *et. al* 1998) to continental and global at 1km resolution (Loveland *et. al* 1999). The combined technical progress and availability of newly developed large-area datasets have led to increased applications by land management, science, and policy communities since the 1990s. However, to go beyond descriptions of general land cover labels and to meet the needs of more sophisticated applications (such as mapping biomass or fuels) require new research and development in vegetation mapping.

**Proposed Strategy**

Large-area, high-level vegetation map data play an increasingly important role for scientific, land management, and policy purposes within both national and international scopes. On the other hand, the existing literature together with experience in land and vegetation mapping research and development, suggests that technology progress has made such a mapping effort more feasible than ever before. Towards this end, we outline a broad strategy to produce accurate, repeatable, and consistent vegetation data at a spatial resolution suitable for multiple applications. We have developed this strategy as a part of a project being conducted at the U.S. Geological Survey and the U.S. Forest Service. The project, called LANDFIRE (Landscape and Fire Management System) is designed to produce nationwide vegetation and fire data for use by land management agencies in the U.S. (Keane *et al*. 2001). The vegetation-mapping portion of the project is conducted on the basis of four essential processes, which form the core design features of the vegetation mapping methodology:

1. First, the national vegetation mapping effort is stratified using a USGS mapping zone framework (Figure 1), which was developed by considering ecological variations, appropriate area per mapping zone for achieving mapping efficiency with current computing technology and effectiveness to join adjacent mapping areas to form a national map (Homer *et al.* 2002). Improved accuracy and scheduling convenience are expected as well by using the geospatial stratification tool.
2. Second, there exists a large amount of field reference data to overcome the traditional mapping problem of the lack of sufficient ground truth data to drive mapping models and validate mapping results.
3. Third, in addition to Landsat spectral data, digital elevation data, and field reference data, the mapping process also incorporates ecological information in terms of potential vegetation classification and a set of biophysical data layers that are closely related to ecosystem constituents or functions such as soil properties and potential and actual evaportranspiration (Menakis *et al*. 2000)
4. Fourth, suitable machine learning algorithms can be identified that are flexible enough to integrate a variety of predictor (spectral and environmental gradient) layers with variables collected on field sample plots.

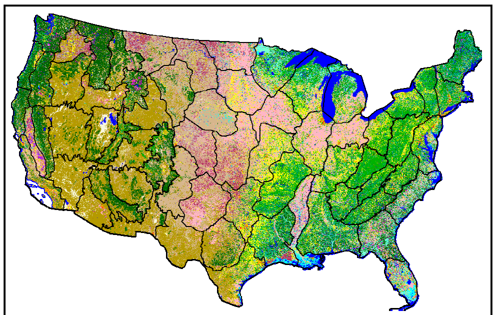

Figure 1. Overlay of the USGS land cover mapping zones on a USGS conterminous US land cover map. Mapping zones are also developed for the rest of the US.

The methodology designed for achieving vegetation-mapping objectives of the LANDFIRE project include these considerations and other technical design features. Central components of the methodology are described below and in Figure 2.

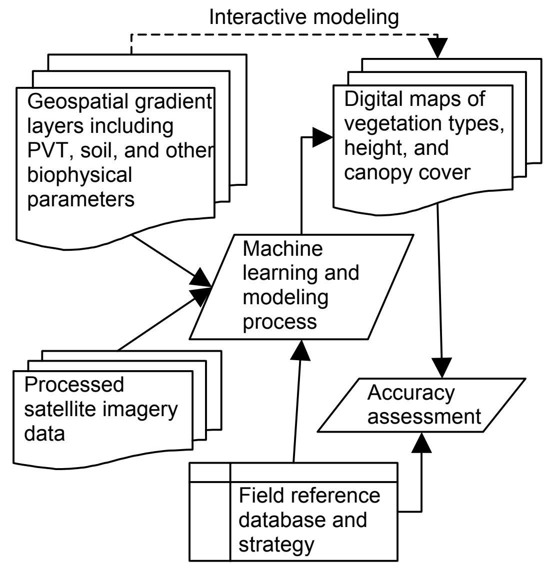


Figure 2. Flow chart of major methods used in the LANDFIRE process of mapping actual vegetation types and structure.

**Key Results**

In mapping these vegetation parameters, a question arises as whether the cover type and structure should be constrained by either forest, shrub, or herbaceous life form, i.e. whether a given pixel could be assigned more than one life forms on cover type, height, and canopy designations. Having multiple life form assignments provides flexibility to characterization of fire fuels and simulation of landscape complexities. It is also a consideration for many other potential applications, such as insect and disease and biomass studies that uses LANDFIRE vegetation data. Therefore, in the process of LANDFIRE vegetation mapping, cover type, height and canopy density are modeled independently for each of the three life forms without constraints (Figure 3).

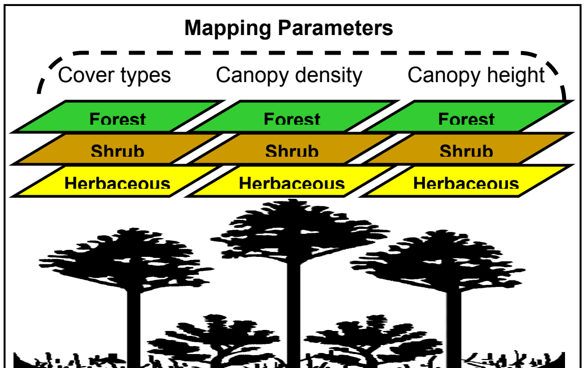


**Figure 3**. A hypothetical landscape formed by merging separate and independent mapping of cover type, canopy density (percent cover), and average canopy height of three life forms: tree, shrub, and herbaceous cover types.

Effects of the above-outlined vegetation mapping strategy are being evaluated over a prototype area in the central Utah Wasatch and Uinta mountains, where at least 28 modified FGDC alliance or association vegetation classes (12 forest, 10 shrub, and 6 herbaceous) can be found. Figure 4 shows the developed potential vegetation types, existing vegetation types, and existing vegetation structure stages of the central Utah mapping area.

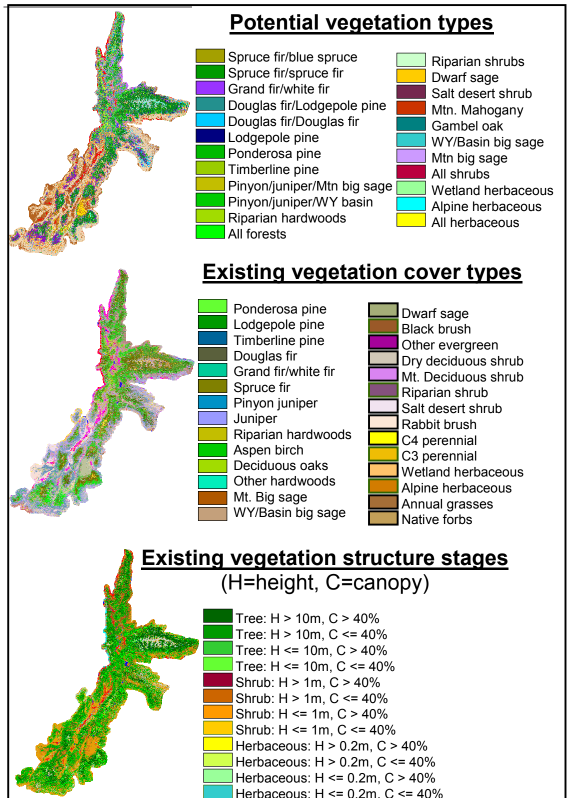


Figure 4. Potential vegetation type (top), existing vegetation type (middle), and existing vegetation structure stage (bottom) maps of the central Utah prototype mapping area. Existing vegetation type map is aggregated from forest, shrub, and herbaceous cover type maps, whereas the existing vegetation structure map is based on continuous maps of height and canopy of the three life forms.

Because of the size and complexity of this research effort, there are many questions still unanswered. The field data effort is still an expensive and limiting task and there is a pressing need to study how mapping performance is related to size and collecting methods of field reference data required. Relationships and successional distances between mapped potential vegetation and current vegetation need to be investigated. Methodology repeatability, both temporally and spatially, will also be a study focus. Furthermore, it is not clear whether the methodology used in this study would also work for other, perhaps related, vegetation variables.

The LANDFIRE project is designed to support national fire policy implementations and fire and land management practices at all scales by developing a suite of integrated vegetation, fire fuels, risks and ecosystem conditions data layers wall-to-wall nationwide. The science basis of this large-scale and challenging project is a 30m vegetation database that needs to be developed accurately and consistently. In addition to fire management uses, we anticipate the resulting database will provide very useful baseline information required for a broad range of science and land management applications.

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