Dynamic landscape mapping of fuels using the FCCS system and remote sensing

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Abstract

Understanding changing patterns of fuel succession on the landscape is necessary for dynamic modeling of fire behavior and fire effects. Fuel maps based on remote sensing and field data provide valuable information for modelers and managers, but are only snapshots in time. Quantitative fuel maps can become obsolete rather quickly, depending on the magnitude of either ecosystem productivity or disturbance; hence, some form of dynamic modeling is necessary in order to keep fuel maps current so that they will retain their value for users. A approach that combines changes in productivity and biomass over time with high-resolution empirical data is required for the most accurate prediction of fuel succession on the landscape.

In this paper we present examples of a method to classify and quantify fuels that is scaleindependent and can be updated as input data change. The Fuel Characteristic Classification System (Sandberg et al. 2001) (FCCS – Figure 1) quantifies live and dead fuel loadings for 16 types of fuels across 6 layers, from canopy to duff, for 150 fuelbed types defined for the continental USA. These fuelbed types are explicitly linked to ecosystem geography, potential natural vegetation, and current vegetation (both cover type and canopy cover), thereby enabling fuel types to be mapped across landscapes at the scale of resolution of existing GIS layers. We present a completed fuelbed classification for the continental USA at 1-km resolution, developed in a knowledge-based approach (Schmoldt and Rauscher 1996) from GIS layers of Bailey's ecoregions, Küchler potential vegetation, and remotely sensed vegetation layers. We also briefly present ongoing work on a national forest in the Pacific Northwest, using more quantitative methods that can be applied nationwide at the sub-regional scale.



Figure 1: Fuel configuration represented in the FCCS.

For the coarse-scale modeling, we compiled GIS data from sources on the internet, US Forest Service archives, and databases developed in previous collaborative efforts. Current cover types were taken from Schmidt *et al.* (2002), at http://www.fs.fed.us/fire/fuelman/. Potential natural vegetation was taken from a polygon coverage of the Küchler (1964) classification, in the possession of the senior author. Elevation data were taken from 1-km digital elevation models (DEM) provided by the US Geological Survey (http://edcdaac.usgs.gov/glcc/glcc.html). Land use (natural vs. agricultural or urban) was taken from the Land-Use, Land-Cover data at http://edcwww.cr.usgs.gov/pub/data/landcover/states/.

Decision rules were developed separately within each Bailey's section, within each province. All unique combinations of potential vegetation and current cover were entabulated and matched to FCC fuelbeds, using vegetation associated with fuelbeds, gradient variables (elevation, climate) and geographic location as additional criteria. Where more than one fuelbed

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was possible the most likely was assigned to that cell. A complex process ensued, relying on both a set of general rules (Schmoldt and Rauscher 1996) and the ecological and biogeographical knowledge of the authors and colleagues.

The strong linkage between fuelbed type and vegetation in the FCCS is both advantageous and limiting. On the one hand, we have captured specific arrays of fuel loadings that are uniquely associated with specific vegetation, and therefore cannot be captured by traditional fuel models. The classification procedure is limited by the taxonomic resolution of the GIS input layers, however. Local managers will always need to rely on fine-scale local information where it is available rather than the output of coarse-scale classifications such as ours.

The principal application of this fuelbed classification will be for coarse-scale modeling of fire effects. A key limitation in regional- and continental-scale models of both smoke emissions and dispersion is the lack of accurate estimates of fuel loadings (Sandberg *et al.* 2002, Ferguson *et al.* 2003). Emissions inventories and estimates of fire severity and crowning potential require an accurate representation of the vertical and horizontal arrangement of fuels, such as provided by the FCC fuelbeds.

The 1-km scale is appropriate for coarse-scale modeling, e.g., for US-wide fire emissions inventories and smoke dispersion, but too broad for local applications. We also present a brief example of work-in-progress mapping fuels on the Okanogan-Wenatchee national forest in the western US, using field-based inventories, classifications from LANDSAT imagery (30-m), and vegetation layers from aerial photography. A list of fuelbeds specific to the forest was developed in two workshops involving two of the authors and fire management officers on the forest. These fuelbeds were designed so that they could be matched to vegetation polygons in GIS

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layers and mapped to the landscape at 30-m resolution. Quantitative estimates of fuel loadings (means and ranges) within the fuelbeds will be derived from georeferenced stand-level data on the six ranger districts in the forest. This regional-scale classification demonstrates a methodology that is applicable US-wide at the scale of individual forests and national parks. Because our core methodology is scale-independent, it can be adapted to GIS layers at multiple spatial scales, and because it is dynamic it can be updated from new classifications from remote sensing as these become available.

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