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Using fine-scale fuel measurements to assess wildland fuels, potential fire behavior and hazard mitigation treatments in the southeastern USA

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ABSTRACT

The inherent spatial and temporal heterogeneity of fuelbeds in forests of the southeastern United States may require fine scale fuel measurements for providing reliable fire hazard and fuel treatment effectiveness estimates. In a series of five papers, an intensive, fine scale fuel inventory from the Savanna River Site in the southeastern United States is used for building fuelbeds and mapping fire behavior potential, evaluating fuel treatment options for effectiveness, and providing a comparative analysis of landscape modeled fire behavior using three different data sources including the Fuel Characteristic Classification System, LANDFIRE, and the Southern Wildfire Risk Assessment. The research demonstrates that fine scale fuel measurements associated with fuel inventories repeated over time can be used to assess broad scale wildland fire potential and hazard mitigation treatment effectiveness in the southeastern USA and similar fire prone regions. Additional investigations will be needed to modify and improve these processes and capture the true potential of these fine scale data sets for fire and fuel management planning.

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1. Introduction

Fuelbeds of the southeastern USA are structurally complex and vary greatly in their physical attributes and potential fire hazard due to shifting land use practices of agriculture, forestry, fuel treatments, and the expanding wildland-urban interface. Since long growing seasons and favorable climate contribute to high forest productivity (Tian et al., 2010), and prescribed fire is only applied to 10% of the southeastern United States annually (Haines et al., 2001), litter accumulation and dense understories of shrubs and hardwood trees can rapidly develop and result in hazardous fuel conditions. To reduce fire hazard, a variety of individual treatments and treatment combinations are available to modify fuelbed structure and composition including prescribed fire, mechanical thinning, mastication (chipping and shredding), and herbicide treatment (Marshall et al., 2008). The inherent spatial and temporal heterogeneity of fuel conditions in Southeastern forests makes it challenging to evaluate potential fire behavior and the effectiveness of fuels treatment at scales relevant to the land managers (10–1000 ha) (Hiers et al., 2003). Fine scale fuel measurements may be the only means for providing reliable fire hazard and fuel treatment effectiveness estimates.

Recent progress has been made in the use of remote sensing information to provide coarse scale assessments and mapping (Rollins et al., 2004; Arroyo et al., 2008; Reeves et al., 2009), and LiDAR may provide significant improvements in precision mapping of overstory structure (Reutebuch et al., 2005; Hiers et al., 2009). Where the primary management objective is to reduce overstory tree density, and forest vegetation changes slowly over time, remote sensing and aerial imagery are often adequate to identify treatment locations. However, if the aim is to reduce surface fuels, such as shrubs and small trees which also contribute to fire hazard (Agee and Skinner, 2005), or vegetation conditions are very dynamic, these tools are often inadequate. Less progress has been made mapping surface fuels and fire behavior over large landscapes at spatial and temporal resolutions compatible with designating specific mitigation treatments (Reich et al., 2004; Pierce et al., 2009). Improving fine-resolution fuel characterization at the scale of management units will depend on developing methods to measure the spatial and temporal variability of fuels. Because fine-scale fuel measurements are costly, the degree to which national, regional or local multi-resource inventories can be utilized to meet this challenge is critical (Fernandes et al., 2006; Westfall and Woodall, 2007).

To assess patterns and processes influencing wildland fuels, potential fire behavior, and hazard mitigation treatments, a study was conducted on the 80,000 ha Savannah River Site, located in South Carolina. The site represents an actively managed forest landscape typical of Southeastern forests (Kilgo and Blake, 2005) in which a high density multi-resource inventory (~1 plot per 100 ha) was modified to incorporate measurements of wildland fuels. In a series of five papers, the authors present the findings

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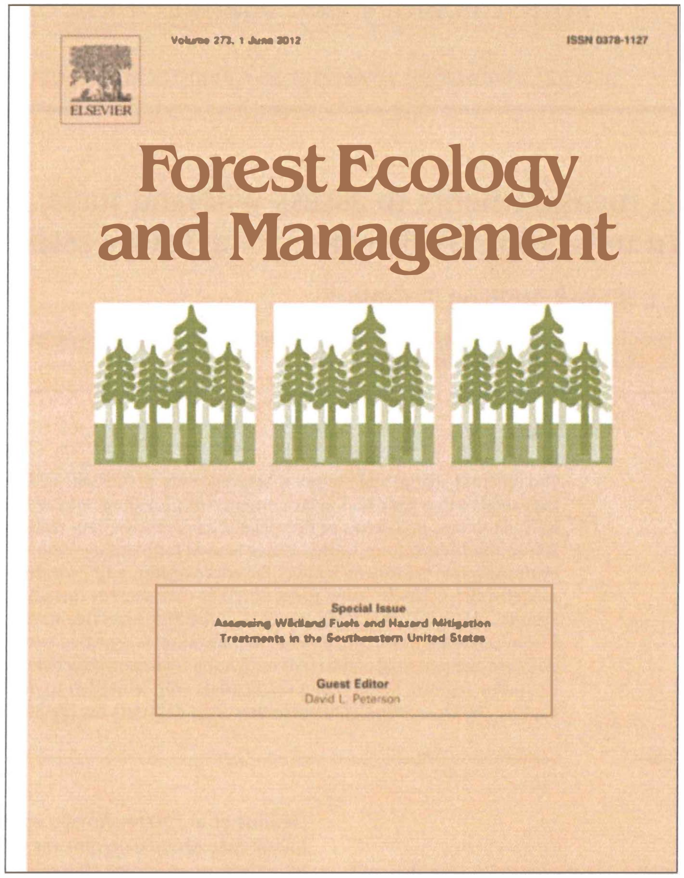
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of this study that uses the intensive fuel inventory, to build fuelbeds and map fire behavior potential, evaluate fuel treatment options for effectiveness, and provide a comparative analysis of landscape modeled fire behavior using three different data sources including the Fuel Characteristic Classification System (FCCS) (Ottmar et al., 2007; Sandberg et al., 2007), LANDFIRE (Rollins et al., 2006), and the Southern Wildfire Risk Assessment (Buckley et al., 2006).

2. Series overview

Parresol et al. (2012a) develop quantitative models of fuel loads for dead and live surface fuel components using vegetation type, stand age, basal area, site quality and recent fire history. These equations are used to understand influences of these factors and to stochastically impute fuel load components for each stand in order to spatially distribute fuelbeds. The authors observe that stand basal area and age have a greater influence on fuel loads than recent fire history, and that litter, duff, shrubs and grasses are predicted more precisely than dead fuels.

Andreu et al. (2012) demonstrate how fuel data from hundreds of sample plots can be converted to fuelbeds with associated fire behavior attributes using FCCS. The authors find that in most forest types, litter and shrub loading and the condition of the shrubs, account for the largest influence on surface fire behavior.

Parresol et al. (2012b) illustrate a solution to handling hundreds of complex fuelbeds derived from inventory data. By using cluster analysis based on FCCS parameters to create a small number of distinct groups, an equivalent number of custom fuel models can be constructed to interface with landscape fire assessment models.

Ottmar and Prichard (2012) present two case studies that use FCCS to provide examples of fuel treatments effectiveness and evaluate potential fire behavior across a managed forest at the Savannah River site. The FCCS can identify effective treatment benefits, and quantify the contribution of fuelbed categories to fire behavior. The study shows large disparities exist between spatially constrained estimates derived from surface fuels measurements and models based on remote sensing. In the final paper, Hollingsworth et al. (2012), map the custom fuel models derived from the study by Parresol et al. (2012b) and create a FCCS custom landscape from which the system FlamMap (Finney, 2006) is run. The authors then compare the FCCS model results with results from fuel model data from LANDFIRE and the Southern Wildfire Risk Assessment, using the same fuel moisture and wind conditions. When viewed over the landscape, mean values for flame length, surface spread rate and crown torching are similar, but values at small spatial scales, characteristic of fuel treatment planning, are not well correlated.

3. Conclusion and vision

Collectively, this research demonstrates that fine scale fuel measurements associated with fuel inventories repeated over time can be used to assess broad scale wildland fire potential and hazard mitigation treatment effectiveness in the southeastern USA and similar fire prone regions. Hundreds to thousands of complex fuel structures can be arrayed within a manageable framework and reduced to create dynamic fire behavior models. Furthermore, these kinds of measurements can help address scientific questions regarding the influence of temporal changes in hazardous fuels on wildfire occurrence (Malamud et al., 2005), and isolate coupled climate change-vegetation relationships (Meyn et al., 2009). They also provide insights into the factors influencing the spatial patterns and temporal processes of surface fuel components at a scale that integrates management decisions with ecological conditions (Reich et al., 2004; Poulos et al., 2007; Moreira et al., 2009; Finney, 2005). Additional investigations will be needed to modify and improve these processes and capture the true potential of these fine scale data sets for fire and fuel management planning.

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