Recreational Use Management and Wildfires in Southern California: Using GIS and Visual Landscape Simulation Models for Economic Assessment[1]

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Abstract

Recent advances in fire behavior are conforming strategies for forest management in non-industrial private and public forests in the western United States. The strategy developed should include identifying the most cost-effective ways for allocating fire management budgets. In recreational areas, visitors' opinion should be included in forest planning decisions and surveys have been useful tools to collect this information. However, it is difficult to assess fire prior to occurrence, particularly in areas where fire regime varies due to climate change. We merged geographic information system (GIS) applications and visual landscape simulation models to obtain visual information about predicted scenarios including different forest management programs, climate change predictions and future wildland fire risk. In our study, we represent both, forested landscapes and individual stands, after forest management activity and wildfires in the short, medium and long term. Our goal was to determine how recreational values are related to preservation (or not) of different parts of the landscape and how it is affected by wildfires through time. We used an online survey to determine recreationists' willingness-to-pay (WTP) for non-fire programs in the San Jacinto Wilderness, San Bernardino National Forest in Southern California. The computer visualization is a useful tool to gauge visitors' preferences and consider it in land management planning, including potential actions or disturbances based on landscape modeling. This type of tool can be used by forest managers and stakeholders to support their decision to demonstrate and evaluate tradeoffs of pursuing alternative fire management strategies to promote a more sustainable future wildland fire management program and its appropriate role in public land management.

***Keywords**: Fire-prone areas, forest management; non-market valuation*

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Introduction

Wildland fire risk assessment and fuel management activities have become a major activity because an increasing area burned related to global change, mainly in Mediterranean areas (Flannigan and others 2000). USDA Forest Service (FS) in western US promotes tools to reduce the growing financial and ecological losses from catastrophic wildfires (Calkin and others 2011). Fuel treatment activities includes a wide range of operations in forest management, such as thinning, mechanical treatments (e.g., mastication) or prescribed burning to reduce fuel and break continuity (both horizontal and vertical), which aims to reduce the frequency of large wildfires (Finney and others 2006). However, including fuel management in forest planning is complex and needs applications to be tested with fire behavior modeling software in both a research and operational context (Calkin and others 2011).

Scientists are modeling many aspects of complex natural ecosystems simultaneously and linking it to fire behavior models using as input factors weather conditions (Flannigan and others 2000). In practice, simulation models examine the potential effectiveness and ecological impacts of fuel treatment program in a static scenario, such as ArcFuels that is an ArcGIS interface for fuel treatment planning and wildfire risk assessment (Ager and others 2011). It includes extensions to several models, such as Forest Vegetation Simulator (FVS), FARSITE, BehavePlus and Stand Visualization System (SVS). SVS contributes with a visual output, which generates graphics depicting stand conditions, representing information obtained for homogeneous polygon from the dataset.

Public expectations from federal land management have expanded in recent years. Operational application concerns a quantitative of social and ecological values, and the design of fuel treatment projects in terms of where, how much, and how to treat surface and canopy fuel to meet wildland fire management objectives (Zimmerman and others 2006). Forest managers should include the public acceptance of their management strategies including landscape appearance through time. Traditional methods have not always provided enough information to understand what happened, mainly to non-specialists such as some stake holders, politicians or general public (González-Cabán and others 2011).

The aim of our study was to enhance public communication. To achieve it, we linked the Arcfuels interface, SVS outputs and a visual simulation model (Envision, McGaughey 1997) to obtain visual simulations for predicted scenarios. We applied the system to a wildland area enclosed in San Bernardino National Forest to obtain different visual simulation including forest management, severity of a hypothetical fire in the current conditions and the natural regeneration in different scenarios for the short-, medium- and long-term.

Methods

We selected a recreational area in the San Jacinto wilderness, San Jacinto Ranger District, San Bernardino National Forest and also part of California San Jacinto State park in southern California. The wilderness cover about 32,248 acres (13,055 ha), the altitudinal range varies from 6,000 to 10,000 feet (1,800-3,050 m) above sea level, and the climatic habitats goes from desert to alpine areas. Of the 16 trails crossing the recreational area we selected four of the most highly used for our work: Deer Springs, Devil´s Slide, South Ridge and Pacific Crest Trail.

The wilderness and surroundings contains several recreational grounds, campgrounds, villages and housings (high wildland-urban interface area) and is crossed by hiking trails so the social and recreation usefulness is very important. The fire history in the area indicates that in the last century several wildfires burned at lower altitudinal areas surrounding the wilderness; however, for the last 100 years no fire have been evidenced (Figure 1). In the area, the time since the last fire have exceed the fire recurrence period because the fire exclusion policies, special weather conditions and different ecosystems (Wohlgemuth and others 2009). In addition, the fuel load in the wilderness is very high (Figure 1). Therefore, the wildfire risk and hazard in the area is high.

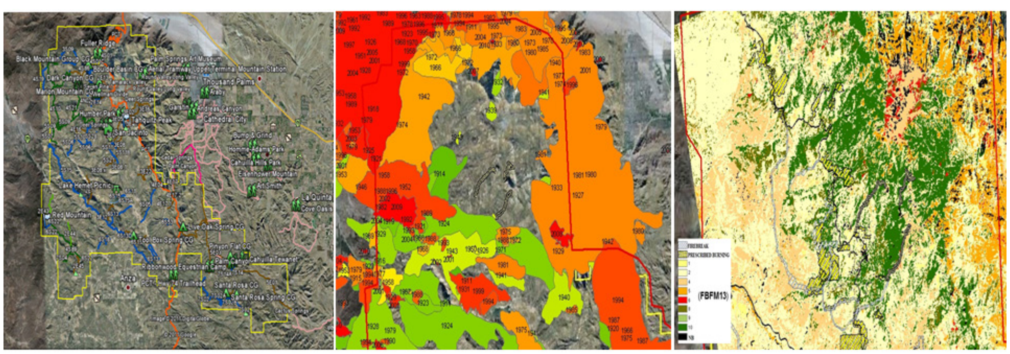

Figure 1— San Jacinto wilderness, located in the San Jacinto Ranger District in San Bernardino National Forest in southern California: high anthropic pressure (left), fire history (center) and fuel load (right).

According to the California wildlife habitat relationship system (2008), the predominant biotic communities in the study area are Sierran Mixed Conifer (Smc): Douglas Fir, Ponderosa pine, White Fir, Montane Chaparral (Mcp): Ceanothus Species, Manzanita Species, Bitter Cherry, Subalpine Conifer (SCN): Engelmann Spruce, Subalpine Fir, Mountain Hemlock, Montane Hardwood-Conifer (MHC): Ponderosa Pine, Incense Cedar, and California Black Oak.

We hiked the trails, digitalizing the routes using a DeLorme *PN-40 GPS*[4] *and converting to shape with Topo USA software. We recorded several images of the viewshed from different points and obtained several detailed images in three relevant* locations: the trailhead, midway trail, and end of trail (highest elevation).

To include the fuel management and forest planning in the study we developed a viewshed analysis technique to link the spatial allocation, the natural development of the ecosystem, and the incidence of wildfires depending on silvicultural treatments preventing large and sever wildfires and the visual state as time passes. For the four trails selected viewshed we obtained theior current conditions. After that, we assumed that a wildfire was going to burn the wilderness, but the incidence was dependent on fuel management treatments. Three different scenarios were examined: no treatment (*high severity* of fire), heavy silvicultural treatments *(low severity* fire) and a medium management (*medium severity* fire). In addition, we included time elapsed since the fire: burned in the *short-term* (0-5 years), burned in the *medium-term* (5-15 years) and burned in the *long-term* (more than 15 years). We obtained DEM (digital elevation model), a shape containing the fuel load in the area, general information of National Parks and forest management and vegetation information (USDA Forest Service Region 5 2011).

Using Arcfuels interface for ArcMaps v.9.1 (Ager and others 2011), we created a stand layer shape containing updated information of both abiotical (aspect, slope, elevation, etc.) and biotical (forest type, cover from above (CFA), size and tree density, wildlife habitat relationship (WHR) , etc.) factors. In the next stage, we simulated the three selected fire classes (low, medium and high severity) for the summer 2011 and the natural regeneration for the three time intervals (short-, medium- and long-term). The outputs were recorded in a SVS format. The SVS files for each scenario were copied and loaded in Envision to create a different project for ten possible scenarios (control and three severities of fire in three different intervals), replicated for each location for the four trails. For each point, we adjusted and focused light and background parameters to the moment in which the viewshed was photographed in the trail. Using DEM and coordinates recorded, we created a viewpoint to obtain the same perspective as in the photograph. Vegetation was recreated using SVS stand look up table and surface grid were created to recreate the soil surface according the simulated scenario. A background was built using the real image, separating visual simulation below the horizon and inserting a picture of the sky (from the real conditions) above the horizon. The rendering options were optimized to obtain the visual output most similar to the recorded picture.

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[4] Citing brand name products does not constitute an endorsement by the USDA Forest Service.

Results

In this first phase of the research we obtained several visual images to be used in studies assessing nonmarket resources valuation. Conducting surveys in the San Jacinto Wilderness will allow us to replicate the experiment in other Mediterranean regions, such as southeastern Spain. Once the survey data is collected, it will provide information to determine recreation values including forest planning and fuel management under hypothetical fire scenarios (Table 1). It will also allow linking management, forest regeneration and recovering of recreation values.

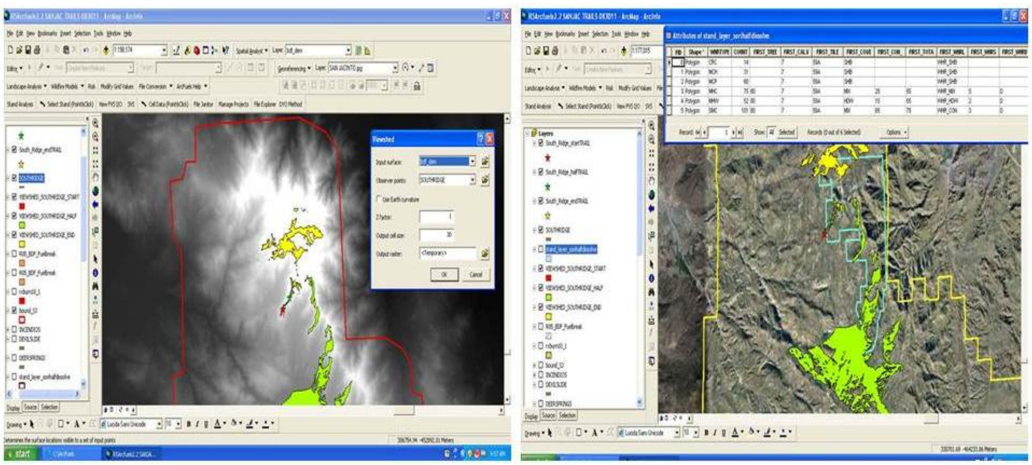

Figure 2—ArcFuels: ArcGIS interface for fuel treatment planning and wildfire risk assessment; creating basic information for the stand layer of studied area in San Jacinto wilderness, San Bernardino National Forest in southern California.

The fire scenarios developed will place recreationist on a particular trail, in a characteristic point and the viewshed would change depending on the fire severity and time since fire. Based on our experimental design, we obtained 108 images (Figure 3). The viewshed surface visible to a recreationist depends on where in the trail is; the highest elevation produces the greatest viewshed area. Four tree coverage losses (related to fire severity) were evaluated: less than 25%, 25-50%, 50-75% and 75%-100% in CFA (related to low, medium and high severity). The visualization outputs will help respondents understand the hypothetical fire scenarios as well as the landscapes preserved using resources derived from the wilderness permit fees invested in preservation efforts.

Discussion

Sustainable forest management should meet stand-level objectives while maintaining or enhancing the aesthetic and biological quality of a landscape. Englin and others (2001) found that there is an increase in visitation during recent fires, but then decreases for several years. Visualization tools provide feedbacks to design a stand treatment, helping in the communication and understanding of future effects and possible scenarios in a landscape context.


EnVision

Figure 3— Visual simulations obtained for the Sky tram Trail to San Jacinto peak. The viewshed represented here was located in the midway trail point; we took a photo and recreated the same image as control (upper image). In addition, we recreated three fire severity fires (lower images) for an hypothetical wildfire occurring during the summer of 2011: low (top), medium (middle) and high (bottom).

The public acceptance of forest management activities are usually linked to the appearance of forested landscapes and individual stands, depending on the viewshed.

By using visualization tools, alternatives and disturbances can be simulated within a landscape context, which remains constant. Fire exclusion policies increases fuels, resulting in high-intensity and sometimes catastrophic large fires. Visualization can be used to communicate the high fire risk and show options for reducing the amount of fuel present, to decrease the impact of the disturbance. Depending on the accuracy of dataset, the output images can depict forest scenes that appear realistic. However, viewers must be able to distinguish rendered images from photographs, and presenters need to determine thoughtfully the appropriate level of realism for each application, thus preventing the risk of loss of credibility. It could help for identification of the most cost-effective ways for allocating fire management budgets, implementing the most appropriate management response to wildfires, including alternative science-based scenarios.

Table 1—*Basic survey to be held. The header will be describing how in a fire-prone area, resources can be used for fire prevention. The respondent could be presented as randomly multiple choices for possible conditions facing in future scenarios depending on investments in fire prevention.*

Viewshed destroyed	25-50%	50-75%	75-100%
Location	Trailhead (lowest elevation)	Midway Trail (medium elevation)	End (highest elevation)
Time elapsed since burn	Short term 0-5 years	Medium term: 5-15 years	Long term: >15 years
Wilderness Permit fee	$25	$20	$15
RESPONDENT CHOOSE			

Summary

This study reported the opportunity given by landscape simulation model to improve forest management and the forest economic assessment, mainly in simulated scenarios. Computer-based landscape simulations have become a recognized tool for previewing the visual impacts of land use decisions if they are based in reliable models and predictions.

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