Title	Evaluating alternative fuel treatments in the South Shore wildland urban interface area
Theme	Effects of wildfire and fuel treatments
Subtheme	Evaluating alternatives for fuel treatments
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Funding requested:	$68,340
Total cost share (value of financial and in-kind contributions):	$77,000

II. Proposal Narrative

a. Project abstract

We will develop the fuels data and management alternatives needed to reduce fire hazard in the South Shore Project of the Lake Tahoe Management Unit, Tahoe National Forest. Using an integrated approach that links two commonly used tools-the Fire and Fuels Extension to the Forest Vegetation Simulator (FFE-FVS) and the Fuel Characteristic Classification System (FCCS)-we will develop a range of management alternatives appropriate for application in the wildland-urban interface. Alternatives will include various combinations of forest thinning and surface fuel treatments, including the effect of treatments over time. This project builds on the TSC-funded project "Developing FCCS Fuelbeds for the Angora Fire Region" (PIs: R. Ottmar, H. Safford) for which fuelbeds are already developed, many of which will be directly applicable to the South Shore Project. Reducing fire hazard in the WUI is a high priority in the Lake Tahoe Basin. By developing a comprehensive fuels map and documenting effective alternatives for reducing fuels, we will provide the scientific basis for hazardous fuels reduction, vegetation management, and restoration in the WUI. Our approach will also provide a clear, visual means of communicating WUI management alternatives to resource managers, local residents, and decision makers. This approach will be applicable for other planning areas in the Lake Tahoe Basin WUI areas such as the Incline Hazardous Fuels Reduction and Forest Health Restoration Project.

b. Justification Statement

The Tahoe Science Consortium (TSC) review committee recognizes the significance of using the best available new science for managing and understanding complex environmental issues. In 2007, the TSC funded the project "Developing FCCS Fuelbeds for the Angora Fire Region" (PIs: R. Ottmar, H. Safford). This project has developed FCCS (Fuel Characteristic Classification System) fuelbeds for the Angora Fire area to better plan the restoration projects and communicate to managers, decision makers, and the public about levels of fire risk, and smoke/pollutant production. We will expand on this project by building FCCS fuelbeds for other areas and developing management alternatives for the wildland-urban interface in the Lake Tahoe region. We will integrate FCCS with the Fire and Fuels Extension to the Forest Vegetation Simulator (FFE-FVS).

The South Shore Fuel Reduction and Healthy Forest Restoration Project (known hereafter as South Shore Project) area provides a diversity of recreation opportunities to the public, in both private and National Forest settings. The South Shore Project includes the communities of South Lake Tahoe, Meyers, Tahoe Paradise, and Christmas Valley, as well as historic sites, resorts, and developed recreation facilities. A portion of the South Shore Project is within the 2007 Angora Fire area which burned 750 hectares of proposed South Shore Project fuel treatment units. We will develop fuelbeds for this project area which will give forest and fire managers the ability to rapidly build new fuelbeds, evaluate the effects of alternative thinning and surface fuel treatment effects on fire hazard, and estimate effectiveness of treatments over time.

Unlike traditional fuelbed classification methods, the Fuel Characteristics Classification System provides a scientifically robust, peer-reviewed approach for quantifying the structural complexity and geographical diversity of real fuels across landscapes (McKenzie et al. 2007, Ottmar et al. 2007, Riccardi et al. 2007a, Riccardi et al. 2007b, Sandberg et al. 2007a, Sandberg 2007b, Schaaf et al. 2007,). The FCCS fuelbeds represent measured or averaged physical characteristics of a relatively uniform unit on the landscape that represents a distinct fire environment. FCCS is designed to account for almost all fuel components that have a potential to consume (Riccardi et al. 2007). This system is currently linked to LANDFIRE, fuel consumption tools, and smoke emissions tools. FFE-FVS is a growth-and-yield distance-independent model that predicts forest stand dynamics and the effects of a variety of forest management actions such as thinning from below and prescribed fire (Dixon 2002). Linking FFE-FVS and FCCS is a logical step in the development of more robust fuels component.

c. Concise background and problem statement

Fuel treatments to reduce wildfire behavior and severity are major concerns for fire and forest managers throughout the western United States (Johnson et al. 2007, Peterson et al. 2005). Such treatments are generally not intended to stop wildfires (Finney and Cohen 2003), but to increase the resilience of the stand to subsequent wildfires by reducing fireline intensity (i.e., rate of heat energy released) and crown fire initiation (Agee 1996). Common treatment strategies for changing stand structure are thinning from below (removing trees from the lower canopy first), mechanical/physical removal of surface fuels, and prescribed fire (Agee 1996, Graham et al. 1999). Natural resource practitioners commonly use computer simulation models such as Behave (Andrews 1986), BehavePlus (Andrews et al. 2005), Fire Area Simulator (FARSITE) (Finney 1988), Nexus (Scott 1999), and FFE-FVS (Reinhardt and Crookston 2003) to evaluate the effects of thinning and surface fuel treatments on potential fire behavior and severity. A notable weakness of these models is their failure to represent or use realistic fuels (e.g.. stand examination data, Brown’s transects), relying instead on stylized fuel models (Albini 1976, Anderson 1982) to estimate fire behavior and effects. Fuel models do not represent the complexity and variability of fuels typically found in the field and were designed not to represent real fuels but to provide standardized fuelbed input for the Rothermel fire spread modeling approach (Sandberg et al. 2001).

The Healthy Forest Restoration Act of 2003 (HFRA) authorizes projects on federal lands to reduce fuel loads and increase or maintain healthy forest conditions and requires federal agencies to consider recommendations made by at-risk communities. The Lake Tahoe Basin Management Unit (LTBMU) proposes fuel treatments to reduce fire behavior in the South Shore Project. The South Shore Project contains a number of management areas that reflect the complexity of the resource values and major concerns within the Lake Tahoe Basin. A critical concern are the areas classified as WUI which includes all land ownerships where there is a juxtaposition of urban/suburban development and undeveloped wildland. The WUI land allocation contains the sub-classifications: urban core, defense zone, and threat zone. The urban core includes urban or suburban development, with the defense zone extending approximately ¼ mile from the urban core, and the threat zone extending approximately 1¼ miles beyond the defense zone. The South Shore Project proposes thinning treatments to reduce fire hazard only on National Forest ownership in the WUI area. Fuel treatments would be implemented in all three zones of the

WUI. The South Shore Project includes objectives for tree spacing and basal area to increase forest health while retaining larger trees, especially, Jeffrey pine, ponderosa pine, and sugar pine.

FCCS offers consistently organized fuels data, along with numerical inputs to fire behavior, fire effects, and dynamic vegetation models. It is the most comprehensive fuel classification system available, with highly detailed fuelbeds available for calculating fire effects. FCCS stratifies fuelbeds into six horizontal strata to represent every fuel element that has the potential to combust, and to better assess potential fire effects from each combustion phase of a fire. Strata are divided into one or more fuelbed categories and subcategories. FCCS offers a set of fuelbeds that are designed to be modified, if necessary, to create customized fuelbeds unique to a particular area of interest or research question. These fuelbeds have been mapped across the contiguous United States at a 1-km scale and are currently being used by the US Environmental Protection Agency to calculate and track emissions produced from wildland fire. FCCS calculates a surface fire behavior, crown fire, and available fuel potential index for all fuelbeds. Fire potentials facilitate communication among users and provide an index representation of the intrinsic capacity of each fuelbed for surface fire behavior, crown fire and available consumption of fuels (Sandberg et al. 2007).

The Forest Vegetation Simulator (FVS) is the US Forest Service's nationally supported framework for forest growth and yield modeling. FVS represents a family of forest growth simulation models that have been calibrated to different geographic areas across the United States. FVS has become a system of integrated analytical tools based on a body of scientific knowledge developed from decades of natural resources research (Dixon 2002). FVS is the standard model used by various government agencies including the Forest Service, Bureau of Land Management, and Bureau of Indian Affairs (Dixon 2002). Forest managers have used FVS extensively to summarize current stand conditions, predict future stand conditions under various management alternatives, and update inventory statistics. Model output has been exported to forest planning models and other analysis tools. In addition, FVS has been linked to other Forest Service corporate software such as databases and geographic information systems. Recently, the Fire and Fuels Extension (FFE) was added to FVS. This extension simulates fuel accumulation from stand dynamics and management activities, fuel decomposition, mechanical treatments, and prescribed or wildfire effects (Reinhardt and Crookston 2003).

FFE-FVS combined with FCCS has the potential to model fire effects and succession more realistically and with higher resolution than FFE-FVS alone. An interface between FFE-FVS and FCCS will give fire and forest managers the ability to (1) select from the existing library of 210 fuelbeds, or (2) quickly build comprehensive, site-specific fuelbeds. This will allow users to evaluate and simulate silvicultural treatments (e.g., thin from below) and surface fuel treatment (e.g., prescribed fire, lop/scatter) alternatives, and model forest and fuel succession based on realistic fuelbeds. This integration will also allow managers to estimate fire behavior using the FCCS or traditional fuel model approach. FFE-FVS output variables (e.g., torching index, crowning index, and fire type) can be generated to make comparisons.

Problem Statement: Develop fuelbeds and fuel reduction alternatives for the South Shore Project.

d. Goals, objectives, and hypotheses to be tested

This project will expand on the TSC-funded Ottmar/Safford project by using an integrated approach to evaluating the effects of alternative fuel treatments on fire hazard over time in the South Shore Project.

Project Objectives

- Build site-specific, comprehensive fuelbeds for the South Shore Project
- Collaborate with fire and forest managers on designing a potential fuel treatment matrix of alternative thinning and surface fuel treatments
- Develop an interface between FFE-FVS and FCCS. Create a post-processing program for FVS that will take output values generated from model projections and save them to a database in XML format that can be recognized by FCCS
- Evaluate the effects of alternative fuel treatments and project FCCS fuelbeds 30 years to evaluate treatment longevity
- Map fire hazard in South Shore planning area using FCCS fire potentials and FFE-FVS fire indices
- Conduct a beta test with Lake Tahoe Basin managers and scientists to ensure that the new integration work and provide accurate results and is simple to use
- Conduct a workshop to demonstrate and train selected managers on how to use the integrated system
- Prepare and present one or more progress reports to the Forest Service Pacific Southwest Region and other stakeholders

e. Approach, methodology and location of research

The South Shore Project extends from Cascade Lake on the northwest to the Heavenly Mountain Resort Special Use Permit boundary and the Nevada State line on the northeast, and from Lake Tahoe on the north to the LTBMU boundary on the south. The analysis area for this project totals 38,000 hectares.

1. Obtain fuelbed data

We will acquire stand examination data (e.g., tree list, woody fuel inventory) that are currently available in the South Shore Project from local fire and forest managers. We have already met with LTBMU Vegetation, Urban Lots, and Fire & Fuels staff and have acquired most of the stand examination data available in the South Shore project area. We will convert these data into an FFE-FVS portfolio and begin building FCCS fuelbeds. We have discussed with the project manager the study design and proposed alternative thinning and surface fuel treatments. Stands will be delineated into four age groups. Treatment will be implemented in each group and both FFE-FVS and FCCS outputs will be obtained to evaluate the effect of the thinning and surface fuel treatments. FFE-FVS outputs will include flame length, rate of spread, torching index, crowning index, and fire type. FCCS outputs will include fire behavior potential (reaction potential, spread potential, flame length potential), crown fire potential (torching potential, active crown fire potential), and available fuel potential (flame available fuel, smoldering available, residual available).

2. Develop FFE-FVS-FCCS interface

We will work with the FFE-FVS programmers at the Forest Management Service Center in Fort Collins, CO, to develop an interface (e.g., post-processing program) for the FFE-FVS that will export output values generated from model projections and save them to a database in XML format that can be recognized by the FCCS program (Fig. 1). The development of the XML file routine that links the two systems will be critical but straightforward task. This interface will convert FFE-FVS output data and user FCCS assumptions for populating into FCCS XML code. For example, FFE-FVS does not track or project shrub and herbaceous vegetation even though this type of vegetation can exacerbate fire behavior and severity, especially during extreme weather conditions. Species and percentage cover of shrub and herbaceous material for each fuelbed will be estimated by managers or derived from a relational database stored with the FVS system. We will use the "Guide to Forest Communities of the Upper Montane in the Central and Southern Nevada" to populate each fuel with shrub and herb vegetation. The initial percentage cover will be based on FFE-FVS structural classification (e.g., stand initiation, stem exclusion, old growth), expert opinion, and information from areas with similar vegetation types that have had shrub and herbaceous vegetation measured.

FCCS will process the FFE-FVS data from each output year and prepare a new tabular file reporting all estimated fuel loadings, fire parameters, and fire potentials. Every time treatments are performed in FFE-FVS, output will be automatically exported to the FCCS XML format which will calculate new FCCS fire potentials. This integration will give fire managers the ability to simulate the effects of thinning and surface fuel treatments and estimate when follow-up treatments are necessary.

3. Develop treatment matrix and evaluate and map output

Agee and Skinner (2005) published "principles of a fire-safe forest" to help forest managers develop effective treatments to reduce crown fire hazard and to understand treatment consequences. Based on current knowledge of crown fire and intended to increase forest resilience to wildfires, the principles include: (1) reduce surface fuels, (2) increase canopy base height, (3) decrease canopy bulk density, and (4) retain large fire-resistant trees. Application of these principles will facilitate reduction of wildfire hazard in dry forest type across the western United States.

In collaboration with the South Shore project manager, we have developed an initial treatment matrix to test the effects of various thinning and surface fuel treatments (Fig. 2). The treatment matrix is consistent with the principles of a fire-safe forest. For example, thinning to 130 tph will have a different affect on canopy base height and canopy bulk density compared to thinning to 750 tph. Similarly, "leave slash untreated" compared to "extraction" will have different effects on fireline intensity. Fire behavior output for each FCCS fuelbed will be calculated and mapped in the watershed. The treatment matrix illustrates potential thinning and surface fuel treatment options that can be used to analyze the efficacy of fuel treatments and fire hazard.

We will evaluate treatment effects on several fire behavior variables from both FFE-FVS and FCCS: (1) FCCS reaction potential (kW m^{-2}), (2) FCCS spread potential (m min^{-1}) (3) FCCS flame length potential (m), (4) FFE-FVS canopy base height (m), (5) FFE-FVS canopy bulk density, and (6) FFE-FVS fire type (e.g., surface fire, conditional crown fire, passive crown fire, and active crown fire). Reaction potential represent reaction intensity and is a function of the reactive volume of fuels per unit ground surface, depth of surface fuelbed strata, heat of combustion, and a scaling factor. Spread potential is proportional to the rate of spread in surface fuels is a function of reaction intensity, propagating energy flux, the heat sink calculated for the unburned fuels in advance of the spreading flame, and a scaling factor. Flame length potential is proportional to the predicted flame length and is derived from the product of reaction intensity, rate of spread, and flame residence time.

f. Relationship of the research to previous relevant research, monitoring, and/or environmental improvement efforts

Proposed research will expand upon Roger Ottmar and Hugh Safford's TSC-funded project "Developing FCCS Fuelbeds for the Angora Fire Region" by applying and building a comprehensive coverage of fuelbeds for the South Shore Project, then evaluating the effectiveness of various fuel treatment strategies over time.

g. Strategy for engaging with managers

We will continue to collaborate with the forest managers on the South Shore project, including active discussions on specific fuel treatment projections and recommendations for tailoring the study design to better meet local objectives. For example, the thinning densities and surface fuel treatments in the treatment matrix can be changed as needed. Project managers will also play an important role in quantifying the initial the shrub and herbaceous vegetation composition within each fuelbed. We will also seek project manager's advice on populating all strata in the fuelbeds. Finally, local managers will serve as beta testers for the final tools produced as part of this project, and will review all results and manuscript that we produce. We anticipate several site visits and conference calls to facilitate ongoing communication.

h. Description of deliverables/products

The primary products of the proposed research will be:

- Comprehensive coverage of FFE-FVS-FCCS fuelbeds for the South Shore project
- Fire hazard map of FCCS potentials and FFE-FVS fire hazard indices and fire type
- FFE-FVS-FCCS interface (post-processing program)
- Presentation of the results to US Forest Service Pacific Southwest Region managers
- Quarterly progress reports and invoicing
- Final report describing approach to developing FFE-FVS-FCCS interface
- Manuscript to peer review journal (e.g., Ecological Application, International Journal of Wildland Fire) and common-language outlet (e.g., Fire Management Today).

III. Schedule of major milestones/deliverables in a table with estimated start and end dates (note progress reports are required each quarter)

The study is designed with a two year duration from the receipt of funding (assumed to be June 30, 2009).

Activity/Deliverable	Start Date	End Date	Description
Data collection	July 1, 2009	November 1, 2009	Collect stand exam data and build FCCS fuelbeds
Quarterly report	September 1, 2009	October 1, 2009	Update of project status
Build interface	November 1, 2009	May 1, 2010	Computer programming to link FFE-FVS to FCCS
Quarterly report	December 1, 2010	January 1, 2010	Update of project status
Quarterly report	May 1, 2010	April 1, 2010	Update of project status
Build treatment matrix	May 1, 2010	August 1, 2010	Develop thinning and surface fuel treatments to be tested
Quarterly report	June 1, 2010	July 1, 2010	Update of project status
Make projections	August 1, 2010	December 1, 2010	Implement treatments in FFE-FVS-FCCS
Quarterly report	September 1, 2010	October 1, 2010	Update of project status
Test interface	December 1, 2010	March 1, 2011	Testing treatment effects and assumptions
Quarterly report	December 1, 2010	January 1, 2011	Update of project status
Final report	March 1, 2011	June 1, 2011	Project results
Prepare journal article	June 1, 2011	August 1, 2011	

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V. Figures

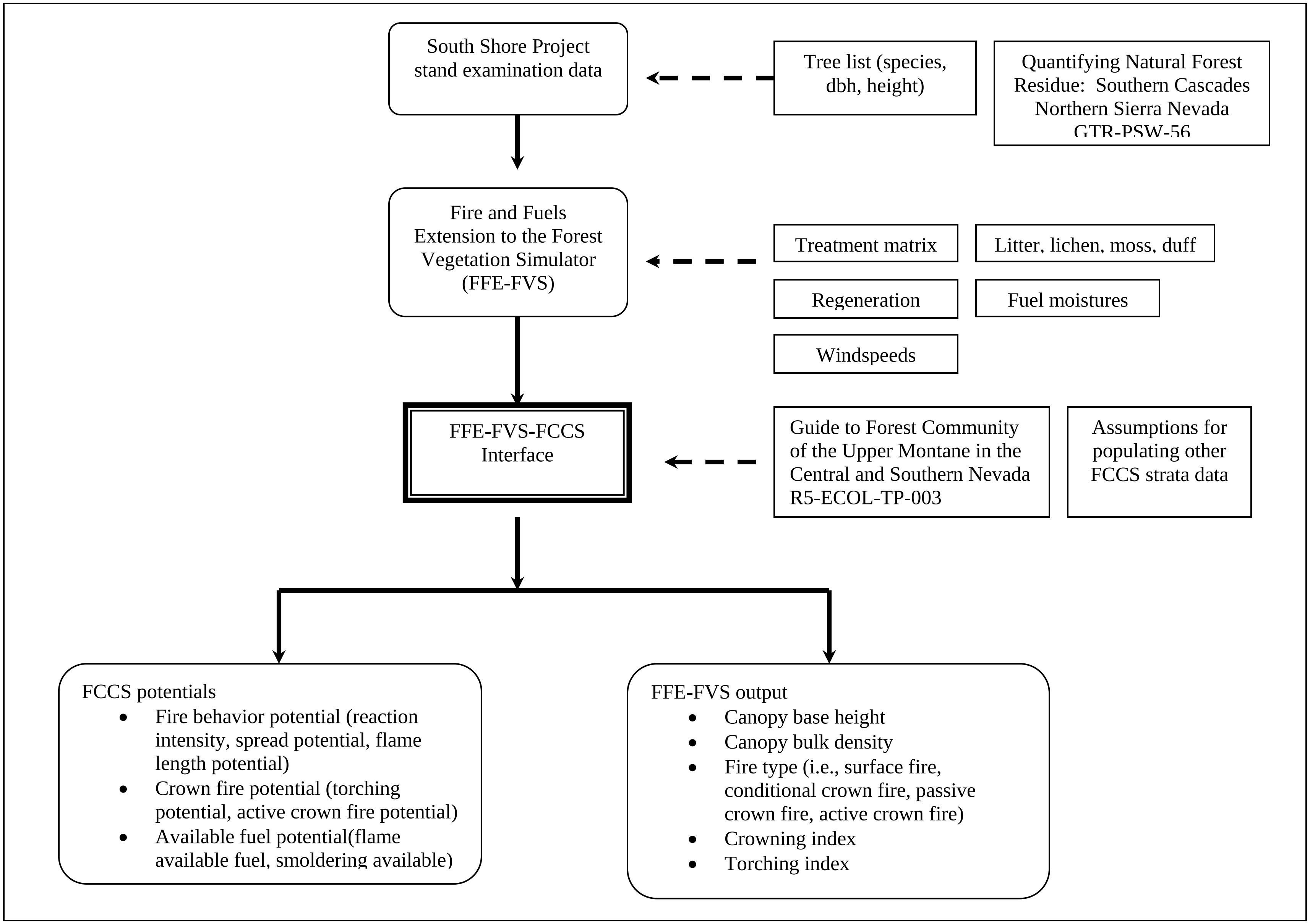

Fig. 1. FFE-FVS FCCS interface represents the flow of information between the FFE-FVS and FCCS.

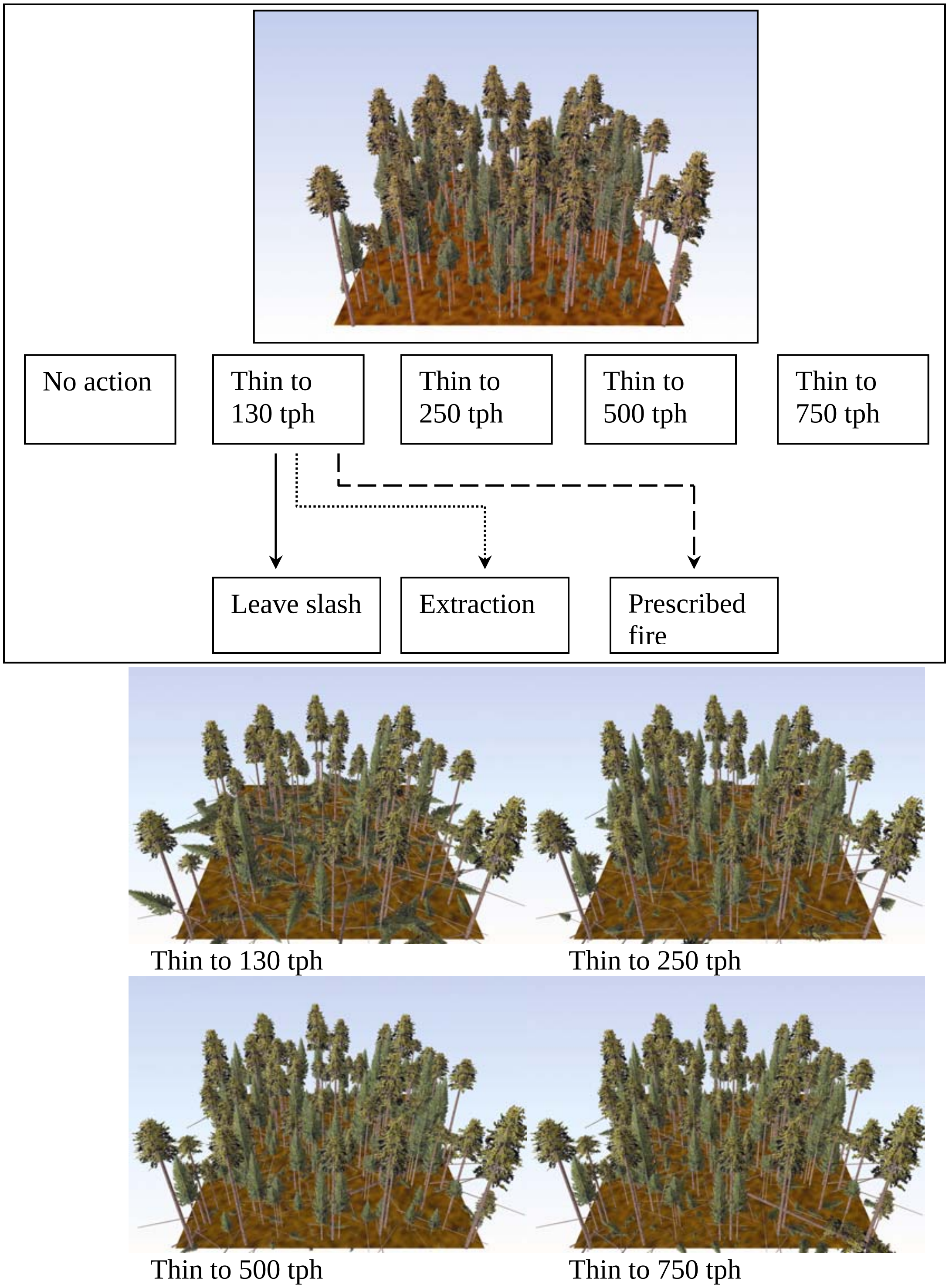

Fig. 2. Example of thinning and surface fuel treatment matrix. Each South Shore FCCS fuelbed can be projected through a series of thinning and surface fuel treatments in order to evaluate the effects on FCCS fire potentials and FFE-FVS fire behavior outputs. This matrix represents a combination of 13 treatment options for determining the relation between forest structure and fire hazard.