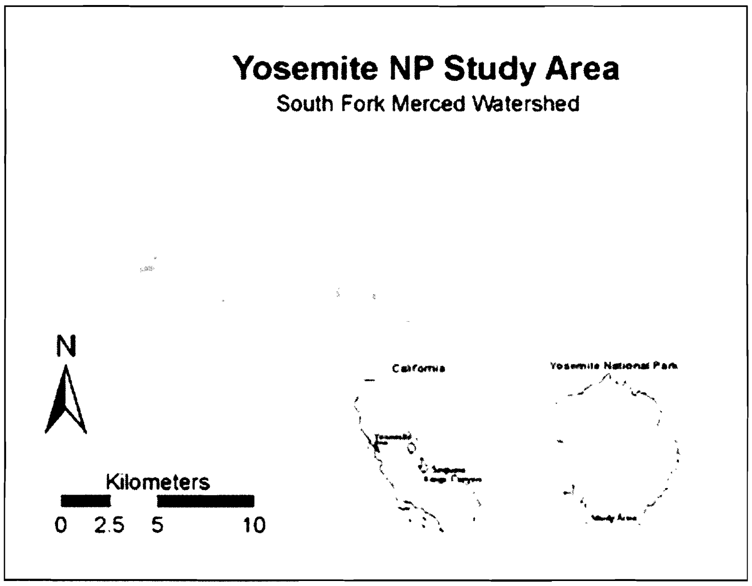
Learning From the Past: Retrospective Analyses of Fire Behavior in Yosemite and Sequoia-Kings Canyon National Parks

PROJECT DETAILS

STUDY AREAS

The project focused on one watershed in each park: the 31,400 ha South Fork Merced watershed in Yosemite National Park and the 90,696 ha Kaweah watershed in Sequoia-Kings Canyon National Park.

The South Fork Merced watershed is in the southern portion of Yosemite NP. Areas of concern for fire and fuels management include the townsite of Wawona, and the Mariposa grove of giant sequoias. As a result, fires are typically suppressed in this area, which has led to accumulation of heavy fuels.



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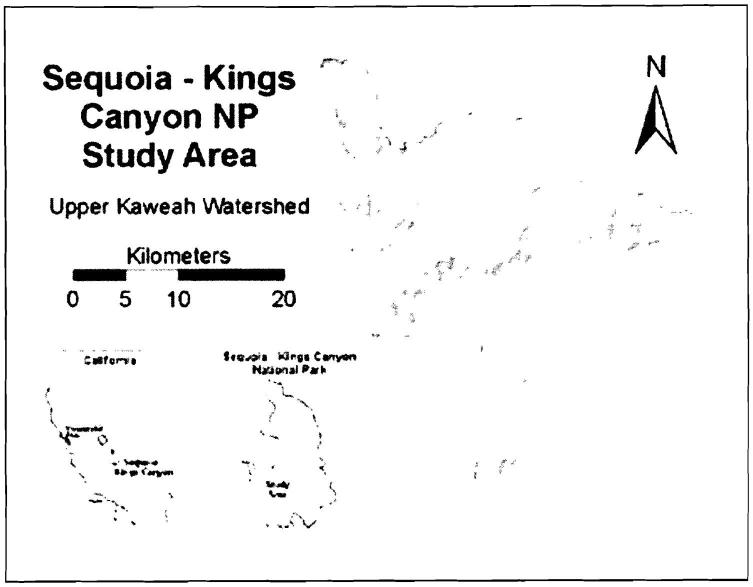
The Kaweah watershed in Sequoia-Kings Canyon NP contains most of the park's infrastructure, all of its giant sequoia groves and has the greatest diversity of boundary interface issues. Due to its proximity to developed areas, heavy fuels, and topography that faces the San Joaquin Valley, smoke and its impacts on air quality are a primary concern.



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SPECIFIC PROJECT OBJECTIVES

This project had two main objectives:

Objective 1: Build an extensive GIS data library that can be used to support decision-making on future fire incidents. Support can take the form of defining Maximum Manageable Areas (MMAs) in Wildland Fire Implementation Plan (WFIP) Stage III, determining appropriate management response for suppression and/or communicating tradeoffs with the public and air quality regulatory agencies. The library was built from detailed fire spread and behavior modeling conducted under average and severe weather conditions (see Materials and Methods). A minimum of 20 ignitions in each of the two study areas were used to develop the GIS data library. [Completed]

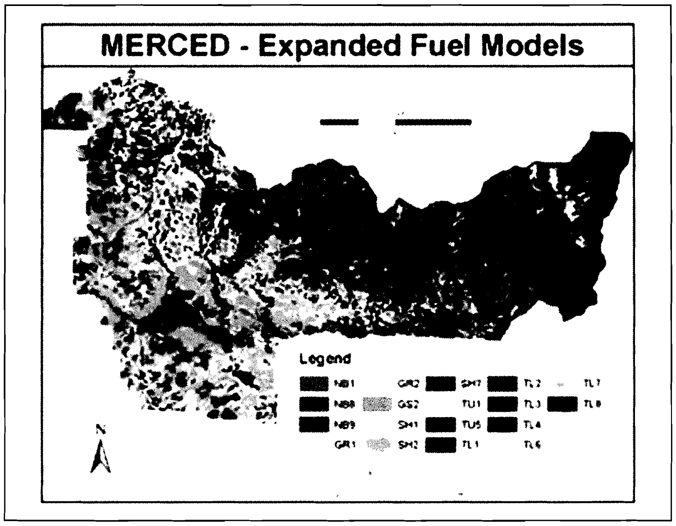
Objective 2: Evaluate the cumulative effects of fire suppression decisions on Fire Return Interval Departure (FRID), the measure both parks currently use to describe deviation from natural conditions. This was achieved by chronologically modeling all suppressed lightning ignitions using the environmental conditions present at the time of ignition and updating FRID data with the results. [Completed]

MATERIALS AND METHODS

The two main objectives of this project were met using two sets of retrospective analyses. The first is concerned with the development of a 'Map Library' of the risks, benefits and costs of potential fires in the study area (Objective 1 above). These potential fires were modeled from differing ignition locations throughout the study area using current fuel conditions and a variety of weather conditions. The second set of analyses is aimed at measuring the 'Cumulative Effects' of fire suppression on FRID over a ten-year period from 1994 to 2004 (Objective 2 above).

Data Requirements

The data required for both of these sets of analyses is much the same. Both required spatial information about fuels, topography and ignition locations and both required weather and wind data. The major differences being that the Cumulative Effects analyses used a new, expanded set of surface fuel models (Scott & Burgan, 2005), actual weather conditions and actual ignition locations, whereas the Map Library analyses used the standard NFFL surface fuel models (Burgan & Rothermel, 1984) historical average and extreme weather conditions and ignition points stratified by historic ignition patterns.



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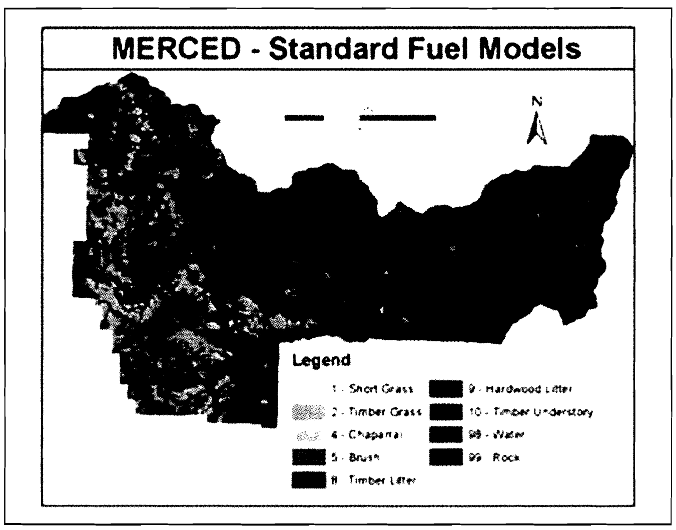

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Analysis

Objective 1: Map Library

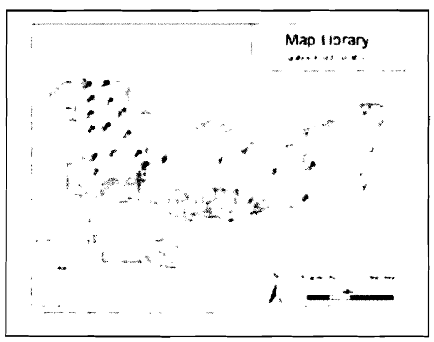
For the generation of the map libraries we used 20 ignitions for each study area. These ignitions were stratified across the landscape based on historical ignition patterns. We modeled an additional 5 ignitions in Sequoia-Kings Canyon National Park. These ignitions were requested and located by park personnel. FARSITE was used to model the spread of fire across the landscape. FARSITE is a fire growth simulation model that uses spatial information on topography and fuels along with weather and wind data to simulate the spread and behavior of wildland fire (Finney, 1998).

Each ignition was modeled under average and severe weather scenarios as calculated from historical weather data. For Yosemite National Park we used 50th and 98th percentile ERC (Energy Release Component*) weather conditions coupled with wind speeds of 5 and 10mph respectively. For Sequoia-Kings Canyon National Park we used 50th, 75th and 98th percentile ERC coupled with wind speeds of 6, 8 and 14mph respectively. The 75th percentile condition runs were made at the request of park personnel. For each of the weather scenarios, predicted flame length, crown fire activity and fire perimeter GIS layers were created for each ignition. In addition, an analysis of potential acres burned stratified by FRID was performed for both parks and potential acres by treatment priority for Sequoia-Kings-Canyon National Park. For Yosemite National Park FARSITE's post-frontal combustion option was used to estimate total amount of smoke emissions (PM 2.5 and PM 10) that would have been produced by the fire under each weather scenario. The same smoke emission estimates were made for Sequoia-Kings Canyon National Park using their custom estimation tool. Estimates of cost per acre for WFU and prescribed fire were used to provide a coarse comparison of the costs of managing the fire for resource benefits and the costs of burning the same area using prescribed fire.

* Energy Release Component: The Energy Release Component is a number related to the available energy (BTU) per unit area (square foot) within the flaming front at the head of a fire. Daily variations in ERC are due to changes in moisture content of the various fuels present, both live and dead. ERC may be considered a composite fuel moisture value as it reflects the contribution that all live and dead fuels have to potential fire intensity. The ERC is a cumulative or 'build-up' type of index. As live fuels cure and dead fuels dry, the ERC values get higher thus providing a good reflection of drought conditions. The scale is open-ended or unlimited and is relative. Conditions producing an ERC value of 24 represent a potential heat release twice that of conditions resulting in an ERC value of 12. (NWCG, 2002).

EXAMPLE

Yosemite Ignition Point Locations Map



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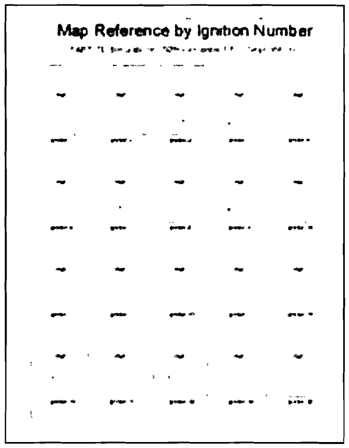
Fire Reference Maps

50th ERC Weather Conditions **98th ERC Weather Conditions**



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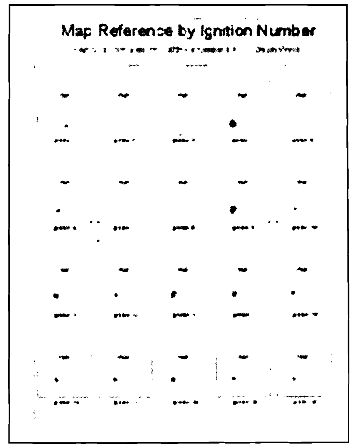

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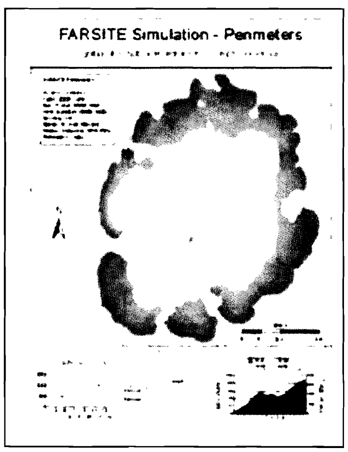
Ignition #6

50th Percentile ERC, 5mph SW Winds **98th Percentile ERC, 10mph SW Winds**

Progression



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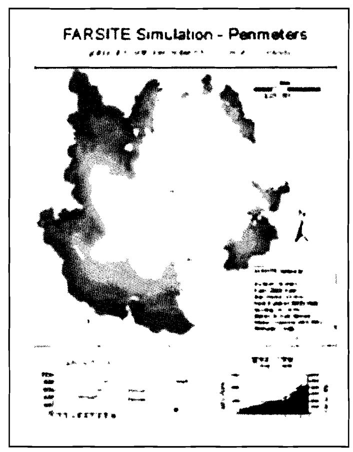

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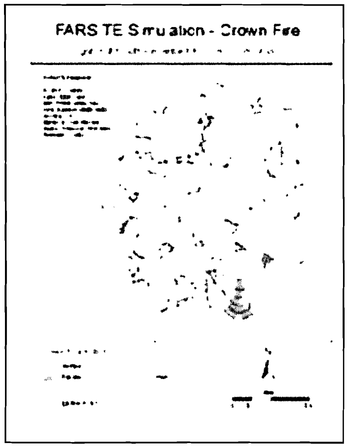
Crown Fire Activity



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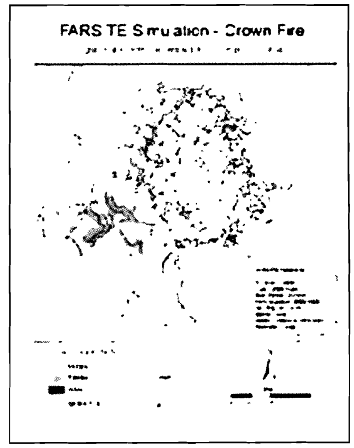

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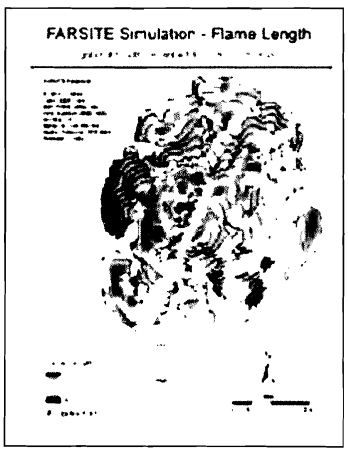
Flame Length



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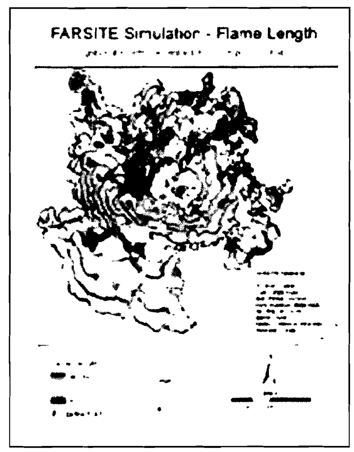

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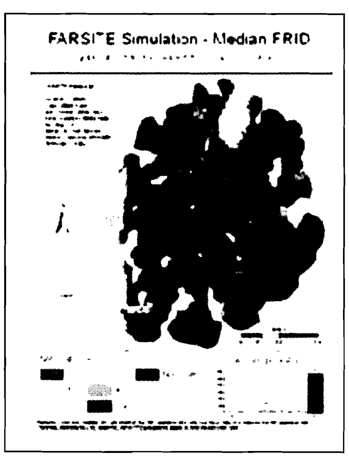
Fire Return Interval Departure



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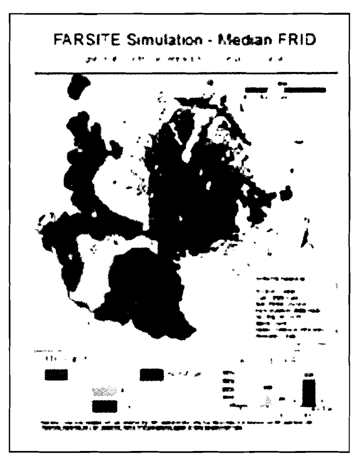

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Cost Estimates

WFU: $300-500/acre

Prescribed Fire: $500-1,000/acre

Acres 50th - 677

- **WFU:** $200,000-350,000
- **Prescribed:** $350,000-675,000

Acres 98th - 5,418

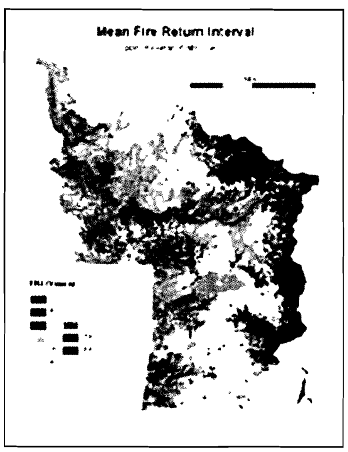
- **WFU:** $1,625.000-2,700,000
- **Prescribed:** $2,700,000-5,425.000

Costs are based on estimates made by park personnel and may be influenced by a number of factors including economies of scale and fire location. They should be considered educated guesses until further study is complete.

Objective 2: Cumulative Effects

As stated above, the second objective of this project was to evaluate the cumulative effects of fire suppression decisions on Fire Return Interval Departure (FRID), the measure both parks currently use to describe deviation from natural conditions. Fire Return Interval (FRI) represents the mean time interval between successive fire events. FRI is based on fire history studies and stratified by vegetation types. For example the mean FRI for Giant Sequoia Forest has been calculated to be 10 years (Caprio and Lineback, 1997). FRID represents the number of intervals missed. For example, after 50 years without fire Giant Sequoia Forest would have a FRID of five.

Mean FRI



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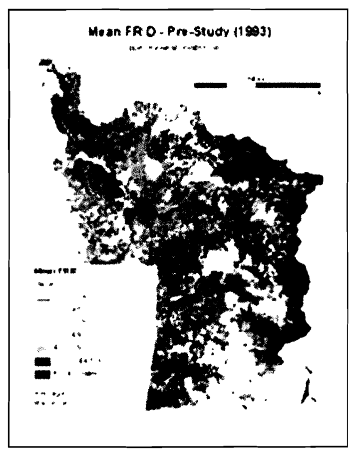
Mean FRID Pre-Study



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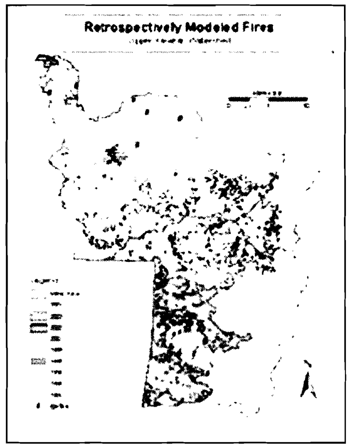
A total of 34 lightning ignitions in the Kaweah study area and 72 lightning ignitions in the South fork of the Merced study area were suppressed between 1994 and 2004. Fire spread was modeled from a subset of these ignitions using FARSITE and the weather and fuel conditions that existed at the time of the ignition. The subset was defined by the selection of those ignitions that had the greatest likelihood of significant spread had they not been suppressed. This subset was further modified during the simulation process when a simulated fire impacted a subsequent ignitions location. This methodology resulted in 20 modeled ignitions in the South fork of the Merced study area and 6 in the Kaweah study area.

These ignitions were modeled sequentially beginning with the first ignition suppressed in 1994 and ending with the last ignition suppressed in 2004. After each year's simulation, fuels data was updated based on the extent of the area burned by the simulated fire and any 'real world' fires that occurred in the intervening time period. These updates were based on fuel consumption and fire behavior. In addition 'real world' fire perimeters were set to unburnable within the simulation year they occurred. Outputs from each of the FARSITE runs will include the extent of the fire, flame length, crown fire activity, and smoke emissions.

Retrospectively Modeled Fires



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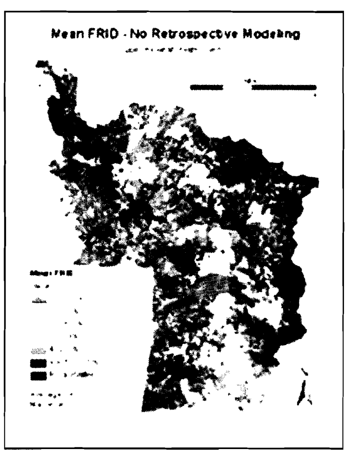
Next, the 2004 FRID that would have resulted had these ignitions been allowed to burn was calculated and compared to what actually resulted as a consequence of their suppression.

Mean_FRID_No_Retro



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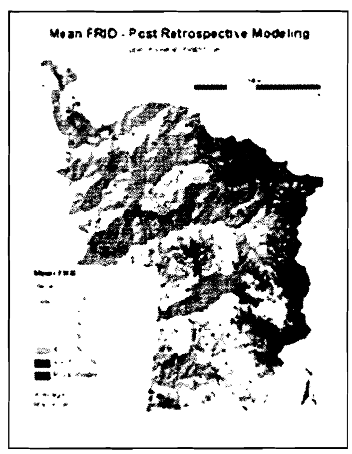
Mean_FRID_Post_Retro



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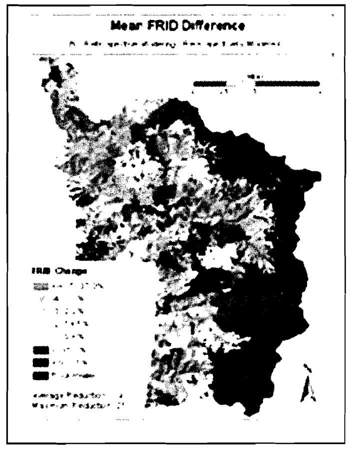
The impacts of suppression on FRID are substantial. In the absence of the simulated fires nearly 40%

of the burnable area falls in the extreme departure category (>/= 5), with the simulated fires that percentage drops to 2. The addition of the simulated fires drops the average FRID for the study area from 4.3 to 0.3. The map below depicts the difference in 2004 FRID between the two scenarios.

Mean FRID Difference



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The decrease in FRID values is one way to quantify the ecological benefits of not suppressing lightning ignitions. Other benefits are realized through future reductions in the number of ignitions requiring initial attack and the creation of natural firebreaks. There are a number of risks and limitations to allowing these ignitions to burn, including escape from park boundaries and threats to other valuable resources. These risks are well known and studied. Our purpose was to demonstrate that along with potential risk comes potential benefit.

APPLICATION

This project addresses the research needs in Task 1 as described in the Joint Fire Science Program's Request for Proposals (RFP), 2004-2 to:

" ... *directly address locally important knowledge or data gaps associated with planning and implementation of wildland fire, fuels treatment, or post-fire treatment actions*..."

The information produced will provide:

" ... *valuable information on local treatment effects to guide wildland fire management, fuels treatment or post-treatment effects.*"

The information and understanding generated by this research will improve the prioritization and planning of fuels management activities by supplementing the FRID analysis that is routinely done by both parks. The results of our analyses will allow park managers to frame future decisions and cost-benefit analyses in the context of past experiences, to track the cumulative effects of suppression, and to communicate tradeoffs to the public and other governmental entities.

The Map Library will provide a quick and easy reference for fire managers during the fire season when making the decision whether or not to suppress an ignition, when preparing Stage III Wildland Fire Implementation Plan (WFIP) analyses and when developing appropriate response on suppression incidents. The Cumulative Effects retrospective analyses will provide a measure of the ecological impact of the decision to suppress wildfire via the impact on FRID.

TIMELINE

This three-year project began on October 1st, 2004 and will be completed by December 31th, 2007.

Delivered Products:

1. Website: http://leopold.wilderness.net/research/fprojects/F006.htm
2. Invited Paper/Presentation: Davis, B. and C. Miller. 2006. Research to Support Wildland Fire Use Decisions in Yosemite National Park. Yosemite Fire Science Symposium, May 9-10, 2006, Yosemite National Park, CA.
3. Poster: Davis, B. 2006. Retrospective fire modeling to quantify the cumulative effects of suppression. Joint Fire Science Program Governing Board visit, Lubrecht Experimental Forest, Montana, September 14, 2006.
4. Dataset: GIS map library of potential fire spread for South Fork of the Merced River, Yosemite NP. Delivered June 2006.
5. Dataset: GIS map library of potential fire spread for Kaweah watershed, Sequoia-Kings Canyon NP. Delivered June 2006.
6. Poster: Retrospective fire modeling to quantify the cumulative effects of suppression. 2nd Fire Behavior and Fuels Management Conference, Destin, FL, March 26-30, 2007

For more information please see the following:

- **Project Proposal**
- **Research Update**
- **2005 JFSP Progress Report**
- **Presentation: Yosemite Fire Science Symposium- May 9th, 2006**
- **2006 JFSP Progress Report**
- **2006 JFSPProject Accomplishment 04-2-1-110** (Excel)
- **Poster: 2nd Fire Behavior and Fuels Management Conference, Destin, FL, March 26-30, 2007**
- **Poster: JFSP Governing Board Field Trip, September 14th, 2006**

Black, A.E., Miller, C., Landres, P.B. 2003. Evaluating opportunities and risks of wildland fuels management. Extended abstract (P1.5) in Proceedings of the Second International Wildland Fire Ecology and Fire Management Congress Nov 16-20,2003 Orlando, FL. CD available from the American Meteorological Society, Boston, MA.

Caprio, A.C. and P. Lineback. Pre-Twentieth Century Fire History of Sequoia and Kings Canyon National Parks: A Review and Evaluation of Our Knowledge. In: Proceedings of the Conference on Fire in California Ecosystems: Integrating Ecology, Prevention and Management. Nov. 17-20, 1997, San Diego, CA.

Burgan, R.E., Rothermel, R.C. 1984. BEHAVE: Fire behavior prediction and fuel modeling system-FUEL subsystem. USDA Forest Service General Technical Report INT-167.

Finney, M.A. 1998. FARSITE: Fire Area Simulator - model development and evaluation. Ogden, UT, USDA Forest Service Rocky Mountain Research Station.

NWCG, 2002. Gaining an Understanding of the National Fire Danger Rating System. National Wildfire Coordinating Group Report NFES 2665, P. Schlobohm and J. Brian (Eds.), 71p.

Scott, Joe H.; Burgan, Robert E. 2005. Standard fire behavior fuel models: a comprehensive set for use with Rothermel's surface fire spread model. Gen. Tech. Rep. RMRS-GTR-153. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 72 p.

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