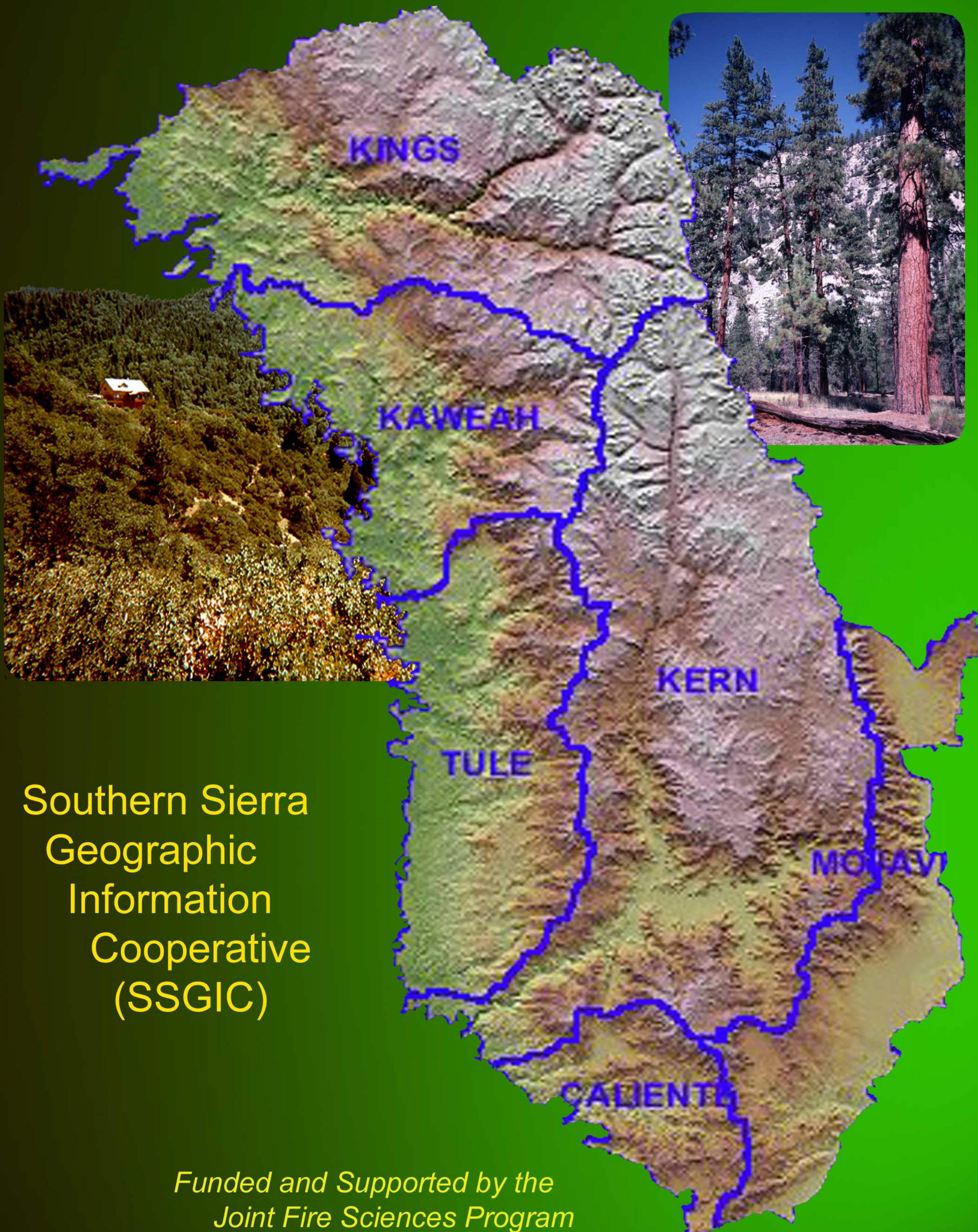
Develop a Landscape Scale Framework for Interagency Wildland Fuels Management Planning



Southern Sierra Geographic Information Cooperative (SSGIC)

Funded and Supported by the Joint Fire Sciences Program

September 2003

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For Interagency Wildland Fuels Management Planning

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Executive Summary and Recommendations

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Due to worsening hazardous fuels conditions in many areas and increasing urban encroachment into former wildlands, optimizing selection of critical areas most in need of fuels treatment has become increasingly important. Generally, managers have inadequate spatial information and analysis tools to effectively plan and implement wildland fuels treatments across agency boundaries using an ecosystem approach.

Starting in 1999, southern Sierra Nevada fire and technical staffs from federal and local agencies began systematically designing and developing an interagency collaborative framework for identifying and treating fuels across landscapes. The project area included six major watersheds and an astonishing diversity of vegetation and fuel types covering an area of about 4.8 million acres in the southern Sierra Nevada Range of California. Funded through the Joint Fire Sciences Program, this initiative focused on the long-term goals of improving firefighter and public safety, reducing fiscal costs to both government agencies and the public, and achieving both ecological and hazard reduction goals across jurisdictional boundaries.

Project Results

After three years of diligent efforts by interdisciplinary multi-agency staffs, most of the original project goals were met and much was learned about building and maintaining successful interagency collaborative relationships. Some specific project accomplishments include the following.

- Seamless geospatial datasets were developed across the entire project area with fully compliant metadata.
- Continuous 24/7 access to data and analyses are now available via the internet using a web-based mapping delivery system (ssgic.cr.usgs.gov).
- Collaborative analytical procedures and methods were developed to define and assess risk, hazard and values across the project's entire 4.8 million acres.
- A Geographic Information Systems software tool called Asset Analyzer was developed to efficiently compare, analyze, and prioritize fuels needing treatment.
- Highest priority areas needing fuels treatment were collaboratively identified across the entire project area using best available science and technology.

- Written protocols and guidelines were completed to facilitate replication by other areas of the technical and analytical processes.

Project Challenges

The principal investigators concluded that widespread organizational, cultural, and technical issues have created significant obstacles to interagency fuels planning and treatments. These obstacles continue to hinder effective interagency cooperation and collaboration and will adversely impact many ongoing and new fire initiatives such as the Fire Program Analysis System. This project's participants experienced many of these obstacles and were frustrated by issues that were impractical to resolve at the local level. Further, it appears that these obstacles are common throughout the wildland fire community.

A basic project assumption was that integration of high quality spatial data, and development of a *seamless* geospatial information framework would bridge many of the barriers hampering collaborative fuels management and fire use planning. A *seamless* geospatial information framework is an information system that delivers data and analyses to users across agency boundaries regardless of jurisdictions. This project successfully developed a *seamless* local geospatial information delivery system that delivers data and analyses through a web interface in both data and mapped forms (ssgic.cr.usgs.gov). However, the cost of developing and maintaining this spatial information framework was high. This endeavor would be more effective if coordinated at a national scale with widespread benefits throughout the nation. Other areas could then "plug into" and use this standardized geospatial information framework to meet their local fire planning and management needs.

Methods for collecting, managing, and analyzing geospatial fire and fuels data continue to be inconsistent across agencies. Each agency has established their own data practices including proprietary data standards. This presents challenges and barriers that hamper interagency data integration efforts. This often results in integrated, but "lowest common denominator" data that has reduced overall data quality. Lower quality data results in less reliable analysis and reduced value to fire personnel. A Southern Sierra Nevada fire and fuels data workshop in 2002 concluded that the business practices for developing and managing fire data could be, and should be, the same for most, if not all wildland fire agencies.

Southern Sierra Nevada fire managers found that trying to use existing personnel by adding new collateral duties for interagency planning added significant and excessive new workload and stresses. While the contributions of existing personnel are essential to the success of any interagency initiative, the added workload for coordinating interagency fuels planning and treatments will require additional fiscal and personnel resources.

Increasing interagency fuels planning and treatment requires more funding, but funding alone will not guarantee effective and efficient cross boundary fuels treatments. The technical, management, and political complexities of interagency collaborative fuels planning and treatments are one of the most difficult tasks facing fire managers, yet there is no clear and specific guidance or set expectations on how agency personnel should collaborate or even how their performance should be measured.

Much of the data and analyses produced through this initiative may be considered sensitive information and should be considered within the larger context of U.S. Homeland Security. Much of the fire analyses information and results could be used by malicious individuals or hostile countries to wreak havoc by igniting fires in areas that have highest potential for causing catastrophic loss. There is no guidance or policies relating to distribution and availability of potentially sensitive fire and fuels information.

Project Recommendations

The principal investigators believe that there is a need for increased national leadership on important issues presented in this report. The National Fire and Aviation Executive Board (NFAEB) should consider spearheading radical change to many existing fire and fuels information business practices. These recommendations spotlight the immediate need for developing a national strategy for developing, managing, and delivering fire and fuels-related geospatial information. Section 4 of the accompanying report presents important findings and recommendations and is based on three years of focused interagency fuels planning, geospatial data development, and deployment of a web-based mapping and data delivery system. Some of these recommendations include the following.

- The NFAEB should direct the development and implementation of a comprehensive national strategy and framework for developing, managing, and delivering fire and fuels data and analyses. The development and implementation of a comprehensive national strategy will promote significant benefits including: comprehensive data standards, rational data security policies and practices, standardized business practices for conducting geospatial analyses, and many other benefits. This national strategy would benefit most wildland fire agencies through long-term reduction in costs and provide contemporary best available information. An example of a potential national fire and fuels data framework strategy is presented in Section 4.1.6.

- The NFAEB should develop clear guidance and metrics for measuring interagency fuels treatment accomplishments outside of traditional intra-agency fuels planning and treatments. These new metrics should foster and reward cooperation between agencies over competition between them.

- To effectively and efficiently collaborate, local, regional, and national agency personnel should be educated on the mechanics of collaboration as well as how to foster a work environment and culture where collaborative fuels treatment planning and treatment becomes a standard business practice, rather than the exception.

- Interagency fire and fuels planning in complex multi-agency landscapes will require full-time dedicated positions. The NFAEB should consider new personnel and organizational strategies for implementing interagency fuel treatment practices across increasingly complex and hazardous fuel landscapes. An example organizational configuration for the Southern Sierra Nevada is presented in Section 4.1.1.

- The principal investigators recommend that a full-time, dedicated interagency federal wildland fire Geographic Information Systems (GIS) Coordinator position be established to coordinate interagency federal, state, and local geospatial fire activities.

- The NFAEB should consider directing the development of standardized geospatial planning analyses including technical software tools with standard data input requirements and well-defined protocols and business workflows. These analyses should focus on measuring and ordinating risk, hazard, and values across landscapes, rather than agency-centric traditional approaches.

- The NFAEB should provide direction in establishing policies governing the identification, publication and distribution of sensitive fire and fuels data and analyses.

- The NFAEB should direct the development of a common set of terminology and language to define the terms “risk”, “hazard”, “values” and other appropriate terminology in concert with the state and local wildland fire community.

- The NFAEB should re-define the mission, authority, and responsibilities of the National Wildfire Coordinating Group's Geospatial Task Group (GTG). It is recommended that the group expand its scope to include non-spatial data coordination, and re-name the GTG to better reflect a revised mission. The GTG membership should have equal representation from both fire management and the GIS community. Further, the GTG should have membership and input that includes local and state fire communities.

A few final words

In 2003, there has been a noted increase in cooperative fire activities between agencies in the Southern Sierra. This includes cooperatively managing lightning caused fires (> 5,000 acres) managed as Fire Use fires by the US Forest Service and National Park Service. Historically, such fires would have been suppressed or not allowed to cross agency boundaries. This Joint Fire Science Funded project has served as a catalyst for this improved cooperation, and has resulted in strengthened personal relationships and trust, fostering a stronger ecosystem approach to treating fuels.

We thank the Joint Fire Sciences Program for their support on this project and hope this project will help other areas transition toward landscape-level interagency treatment of fuels.

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Table of Contents

1 Introduction

1.1 Description of Need

Due to the widespread and urgent nature of hazardous wildland fuel conditions across the United States, optimizing selection of critical areas most in need of fuels treatment is increasingly important. Managers lack consistent high-resolution spatial information and analytical processes to accomplish wildland fuels management planning and activities on a large ecosystem-scale. Compounding this problem is the divided, multi-jurisdictional nature of most large ecosystems. Wildland fire and fuels management is usually fragmented and uses arbitrary jurisdictional boundaries rather than natural ecosystem boundaries. Historically, each agency has approached fire management including data management and analysis based on their particular fire management needs that are specifically related to the agency's mission. However, there is growing recognition that agencies have many common issues and that a new level of interagency coordination is needed, and mandated, to manage increasingly hazardous fuel conditions. The Conference Report for the Fiscal Year 2001 Interior and Related Agencies Appropriation Act (PL 106-291) states the following:

> *"The Secretaries should also work with the Governors on a long-term strategy to deal with the wildland fire and hazardous fuels situation, as well as the needs for habitat restoration and rehabilitation in the Nation. The managers expect that a collaborative structure, with the States and local governments as full partners, will be the most efficient and effective way of implementing a long-term program.*
>
> *The managers are very concerned that the agencies need to work closely with the affected States, including Governors, county officials, and other citizens. Successful implementation of this program will require close collaboration among citizens and governments at all levels. The managers direct the Secretaries to engage Governors in a collaborative structure to cooperatively develop a coordinated, National ten-year comprehensive strategy with the States as full partners in the planning, decision-making, and implementation of the plan."*

In August 2001, the Secretaries of Agriculture and Interior joined the Western Governors Association, National Association of State Foresters, National Association of Counties, and the Intertribal Timber Council to endorse *A Collaborative Approach for Reducing Wildland Fire Risks to Communities and the Environment: A 10-year Comprehensive Strategy* (Western Governors Association, 2002). Some basic goals include reducing hazardous fuels and restoring fire-adapted ecosystems with several important guiding principles:

1. Priority setting that emphasizes the protection of communities and other high-priority watersheds at-risk.
2. Collaboration among governments and broadly representative stakeholders.
3. Accountability through performance measures and monitoring for results.

There has also been a demographic shift in America towards living “close to nature” This has resulted in a growing Wildland Urban Interface (WUI), where human lives and property are in close proximity to increasingly hazardous fuels. Together, these two factors have created an environment in which fire and fuels management is very complex and the stakes very high.

There is a widespread perception that the integration of high quality spatial information, including a seamless spatial information framework can serve as a catalyst and bridge many of the social and institutional barriers inhibiting integrated fuels management and fire use planning. A seamless framework is one that provides consistent spatial information across boundaries regardless of agency jurisdictions. It is beyond the means of any single agency to bridge this information gap and facilitate the development of an ecosystem-wide, wildland fuels-based spatial information management system.

An interagency initiative is needed that focuses on building seamless spatial information datasets (including fuels) and a management system that provides agencies with valuable incentives for partnering with other agencies. This initiative includes the gradual institutionalization of an ecosystem-based collaborative spatial information management system. Additionally, it includes joint analyses and spatial data distribution systems across ecosystem landscapes. Data development and analysis strategies should include activities focused on regularly updating and improving data and analyses. Fire and fuels related information is dynamic and changes through both natural and anthropogenic means. Much of these data become outdated each year and can result in decisions that may not optimize fuels management and treatment decisions. Sound fuels management and associated analysis requires complex and time-consuming coordination that can be accomplished by focusing human, organizational, and fiscal resources on creating a multi-agency spatial information framework. The development of an integrated Geographic Information System (GIS) framework will provide updated, spatially-explicit information for planning and implementing fuels management strategies in a consistent and effective manner. This seamless GIS framework will be usable for many other management applications such as exotic species and wildlife management planning. Finally, regional and national agency staff will be able to evaluate the potential for applying similar methods across other large geographic areas.

Based on a well-defined need, the Southern Sierra Geographic Information Cooperative (SSGIC) was established. The SSGIC involved eight principal investigators (Appendix A) from five agencies:

- Bureau of Land Management – Bakersfield Field Office
- California Department of Forestry and Fire Protection – Tulare Ranger District
- Kern County Fire Department
- Sequoia and Kings Canyon National Parks
- Sequoia National Forest

The General Agreement establishing the SSGIC among the five agencies is provided in Appendix B.

1.2 Goals and Objectives

The SSGIC program focused on landscape-level fire and fuels planning, and development of standardized business processes to facilitate fire analyses across agencies.

The primary goals include improved firefighter and public safety, reduced fiscal costs to both government agencies and the public, and attainment of ecological and hazard reduction goals across jurisdictional boundaries.

To meet these goals SSGIC implemented an innovative technical, analytical process for fire and fuels planning across jurisdictional boundaries. This process required cooperative data development and distribution. SSGIC has emphasized using GIS and Information Technologies (IT) to support fire and fuels planning. Further, the nature of the interagency planning effort necessitated development of new business models for collaboration. Thus, the objectives for meeting these goals are grouped into three categories: data collection and distribution, technical/analytical process, and business process.

Data collection and distribution objectives:

1) Develop seamless datasets across the SSGIC analysis area with fully compliant metadata.

2) Provide continuous access to data and analyses via the internet using web based mapping technology.

3) Develop a web based collaborative system.

Technical/analytical process objectives:

4) Develop and implement collaborative analytical procedures and methods to integrate risk, hazard and value models to assess landscape-level wildland fuels.

5) Develop written protocols and guidelines to facilitate replication of technical and analytical processes.

6) Use fuels analysis to identify high priority treatment areas across the entire SSGIC area.

Business processes objectives:

7) Implement business processes that optimize long-term collaboration.

8) Manage a dynamic project plan that serves as a meaningful guide to meeting SSGIC goals.

9) Develop written protocols and guidelines to facilitate replication of business processes.

10) Meet Joint Fire Science Program requirements.

A Cooperative Agreement was developed and signed by the five stakeholder agencies (Appendix B). The SSGIC entered a 14-month contract with the United States Geological Survey (USGS) Rocky Mountain Mapping Center in Denver, Colorado to house the SSGIC web server and provide administrative support to this website from their office (Appendix C).

1.3 SSGIC Analysis Area

The project area (Figure 1-1) includes six major watersheds (Kaweah, Kings, Kern, Caliente, Tulare, and Mojave) covering an area of about 4.8 million acres in the southern Sierra Nevada Range of California. Most of the land (67%) is under federal ownership (Table 1-1). The second largest ownership category is local/private ownership (31%).

Table 1-1 -- SSGIC project area by land ownership.

Ownership	Area (acres)
Local / Private	1,502,257
Sequoia National Forest	1,134,961
National Park Service	819,260
Bureau of Land Management	626,449
Sierra National Forest	382,455
Inyo National Forest	199,322
Tule River Indian Reservation	53,982
Military	40,750
Calif. State Lands Commission	9,080
Calif. Dept. of Forestry	4,990
Calif. Dept. of Parks & Recreation	3,145
Calif. Dept. of Fish & Game	1,920
US Fish & Wildlife Service	903
Total	*4,779,475*

The project area topography varies from flat to rolling hills at the western edge to precipitous slopes on the eastern scarp of the Sierra Nevada, with the highest elevation at Mt. Whitney (4,417m; 14,494 ft). The regional climate provides wet winters and dry summers with the mountain snowpack providing significant spring runoff to lower elevations. The area encompasses numerous designated wilderness areas managed by the Bureau of Land Management, US Forest Service, and National Park Service. On the west side, it abuts the southern San Joaquin Valley urban areas of Fresno, Visalia, and Bakersfield. The valley and adjacent mountain slopes experience significant air pollution in the summer from ozone and smoke. Smoke from wildland fire use, prescribed fire, and wildfires is often controversial and problematic. The project area encompasses diverse ecosystems (Table 1-2) – from lowland agricultural, through chaparral and forested mountainous landscapes, and to high-elevation nearly-barren alpine. On the east side of the Sierran crest, semi-arid woodlands and arid shrublands are prominent. Coniferous forests dominate the mid-elevations of the west slope of the Sierra. These fire-adapted vegetation types have a history of fire-suppression activities that have impacted forest structure in recent decades.

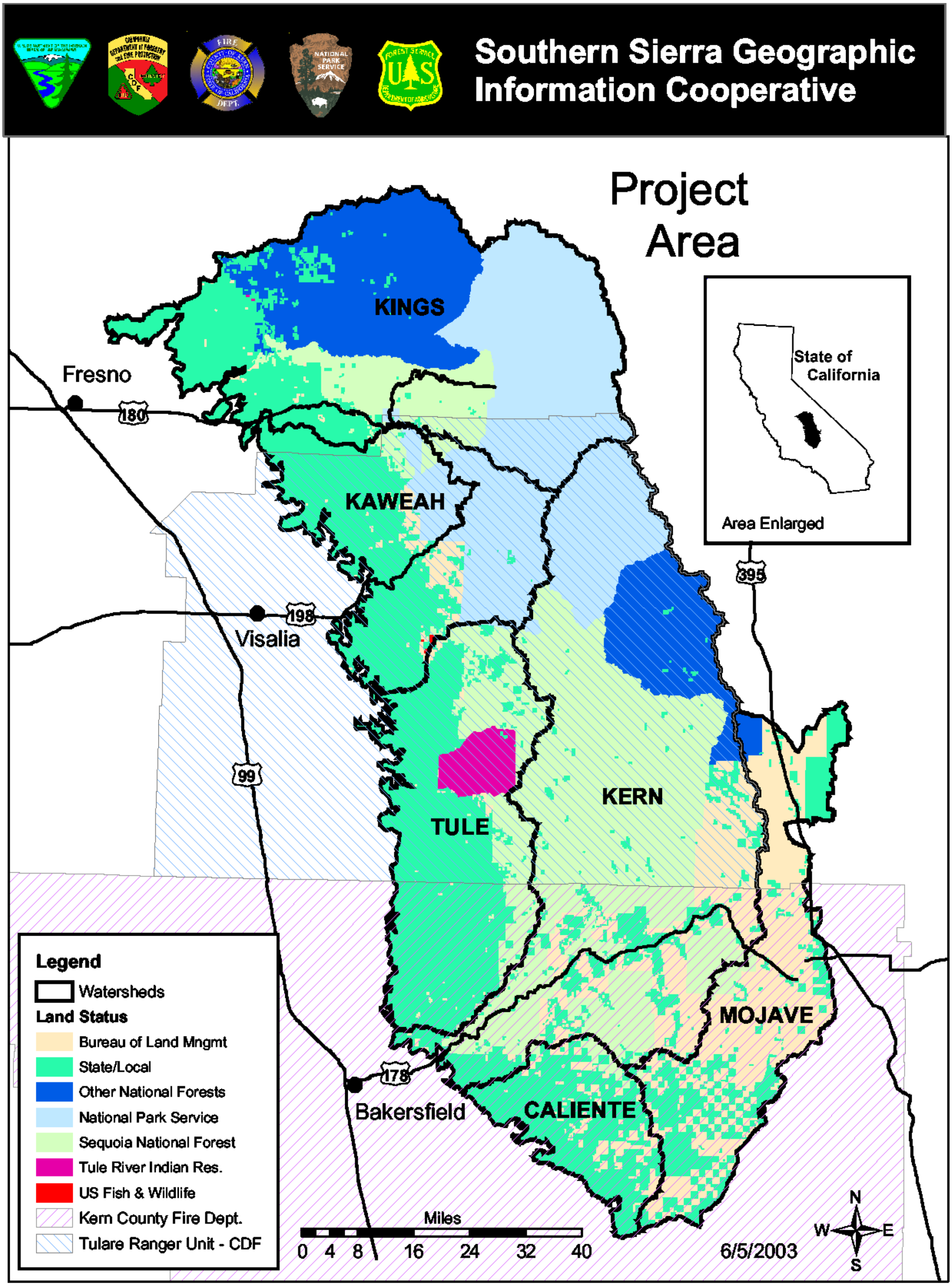

Figure 1-1 Map of SSGIC Project Area showing major watersheds and land ownership status.

Table 1-2 -- SSGIC project area by land cover type. Wildlife Habitat Relationship (WHR) codes are from California Dept. of Fish and Game (Mayer and Laudenslayer, 1988). See also http://www.dfg.ca.gov/whdab/html/wildlife_habitats.html for more information.

WHR Code	Name	Area (acres)	Percent	Cumulative Percent
BOW	Blue-Oak Woodland	797,347	16.7	16.7
SMC	Sierra Mixed-Conifer (white fir)	477,795	10.0	26.7
BAR	Barren	439,310	9.2	35.9
DSC	Desert Scrub	430,120	9.0	44.9
AGS	Annual Grasses	344,089	7.2	52.1
PJN	Pinyon Juniper	316,904	6.6	58.7
RFR	Red Fir	249,869	5.2	63.9
SCN	Subalpine Conifer	217,700	4.6	68.5
MHW	Montane Hardwood Conifer	212,738	4.5	73.0
MCH	Mixed Chaparral	208,117	4.4	77.3
JPN	Jeffrey Pine	163,127	3.4	80.7
PPN	Ponderosa Pine	156,304	3.3	84.0
LPN	Lodgepole Pine	153,542	3.2	87.2
BOP	Blue-Oak Foothill Pine	137,899	2.9	90.1
MCP	Montane Chaparral	137,681	2.9	93.0
SGB	Sagebrush	104,891	2.2	95.2
WTM	Wet Meadow	32,330	0.7	95.8
ASC	Alkali Desert Scrub	30,916	0.6	96.5
CRP	Cropland	30,897	0.6	97.1
WAT	Water	27,842	0.6	97.7
MHC	Montane Hardwood	26,164	0.5	98.3
VOW	Valley Oak-Woodland	18,233	0.4	98.6
JST	Joshua Tree	18,035	0.4	99.0
CRC	Chamise-Redshank Chaparral	14,093	0.3	99.3
JUN	Western Juniper	13,516	0.3	99.6
LAC	Lacustrine	4,865	0.1	99.7
MRI	Montane Riparian	4,381	0.1	99.8
OVN	Orchard and Vineyard	3,183	0.1	99.9
VRI	Valley Foothill Riparian	3,015	0.1	99.9
VIN	Vineyard	1,504	<0.1	100.0
ADS	Alpine/Dwarf Shrub	1,218	<0.1	100.0
URB	Urban	591	<0.1	100.0
IRF	Irrigated Farmland	409	<0.1	100.0
DRI	Desert Riparian	398	<0.1	100.0
BBR	Bitterbrush	370	<0.1	100.0
None		131	<0.1	100.0
WFR	White Fir	38	<0.1	100.0
	Total	*4,779,565*	*100%*	

2 SSGIC Fire and Fuels Planning Process

2.1 Overview of Process

The process for identifying high-priority fuels treatment areas involved significant efforts in data development, as well as the development of a common analysis framework. An interagency workshop was conducted May 23-24, 2000 in Visalia, California to develop a process that used the best available data and analytical processes. This workshop employed a consensus process to develop an analytical roadmap for identification of high priority treatment areas.

The analysis framework employed the concepts of **Risk**, **Hazard**, and **Value** as often used in fire and fuels management. However, these terms were defined differently by each stakeholder agency – no common terminology or definitions for these concepts could be found even though they are frequently used terms. Thus, the SSGIC cooperators agreed on common definitions for the SSGIC analysis. **Risk** is defined as the probability of a fire starting -- the fire ignition probability. **Hazard** relates to fire behavior characteristics, specifically resistance to control. **Values** are social, natural, or cultural resources subject to change (negatively or positively) due to a fire event or fire suppression.

Prior to the Analysis process many data development activities occurred (see Section 2.2). To support the GIS analyses, data had to be integrated from the best available sources. Data needs were prioritized and each agency provided their best available data. The quality and resolution of the data varied significantly across geographic areas and among agency sources. These source datasets were integrated into seamless, SSGIC area-wide GIS themes of "best available" data. Metadata were developed to meet Federal Geographic Data Committee (FGDC) standards. In some cases, data had already been integrated by the California Department of Forestry Fire and Resource Assessment Program (FRAP).

The SSGIC developed a website (http://ssgic.cr.usgs.gov) to provide web-based mapping functionality. Interactive, web-based mapping was implemented using the commercially available software ArcIMS, distributed by Environmental Systems Research Institute, Inc. (ESRI). Developed datasets were incorporated into map services accessible through a web browser to provide interactive viewing and printing of data and analysis. Data and metadata are also available for download by watershed area.

Agency fire and fuels personnel collaboratively developed the analytical process used to identify high priority fuels treatment areas. The processes, models, and methods developed were used to assign ordinated risk, hazard, and value measures from the analyses. Subsequent integrated GIS analyses were used to produce a range of alternative scenarios that prioritized risk, hazard, and values across a range of alternatives. From these alternative scenarios, a preferred alternative was selected by local fire managers to identify interagency, high-priority fuel treatment areas. A graphical overview of the process is shown in Figure 2-1.

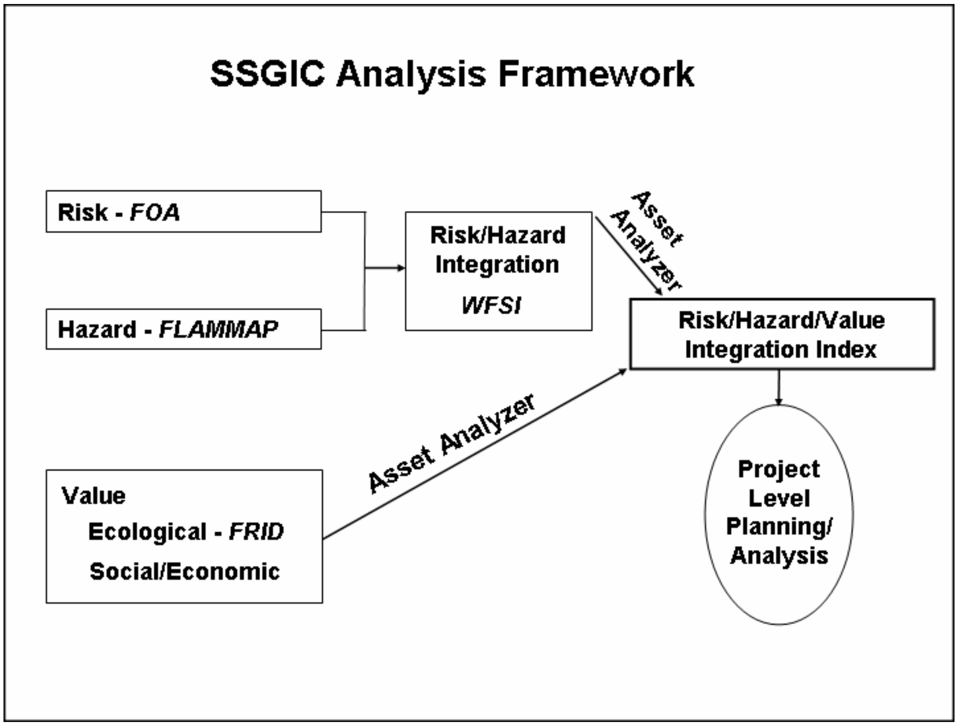

Figure 2-1 SSGIC analytical process used to identify high-priority project-level fuels treatment areas.

Risk was represented by a Fire Occurrence Areas (FOA) model that calculates the risk of an ignition occurring based on historical ignition data. Hazard was depicted using FlamMap (http://fire.org/) developed by Mark Finney (Fire Sciences Lab, Rocky Mountain Research Station, Missoula, MT). FlamMap is a spatial fire behavior predictor that uses fuel, terrain, and weather data to predict fire behavior for every grid cell. The results for hazard and risk were combined to derive a Wildland Fire Susceptibility Index (WFSI) using the methods of Carlton (1999). Ecological values were represented by Fire Return Interval Departure (FRID), a measure of deviation of an area from its historical fire regime (Keifer et al., 2000). The Asset Analyzer software tool was developed by SSGIC to provide a convenient means for weighting various economic, social, and ecological values to assign a single value class to each grid cell. The Asset Analyzer was an enhancement to the original Asset Analyzer developed by the California Department of Forestry (http://www.fire.ca.gov/FireEmergencyResponse/FirePlan/FirePlan.asp). The integration of the indices for risk, hazard, and value produced the basis for selecting areas for project level fuels treatment. Asset Analyzer was used to calculate weighted averages of seven datasets (FOA, FRID, FRID confidence, Threatened Wildland Urban Interfaces, Firefighter Risk, Flame Length, and Crown Fire Activity). Ten alternative scenarios were evaluated and one was chosen by expert analysis for use in planning fuel treatment areas. Five target areas were identified for fuel treatment. The decision rules for selecting these areas are outlined in section 2.6. Detailed discussion of each of these analyses is described later in this report.

2.2 Data Development

2.2.1 Overview

New data development and compilation of existing geospatial data resulted in more than 50 available GIS layers. Data development activities included the acquisition of data from stakeholder agencies, integration of seamless spatial data layers from these existing datasets, "crosswalking" different classifications to a common classification, and assuring a "best available" dataset for SSGIC analyses.

Data acquired from collaborating agencies for use in the SSGIC analysis process were often collected with differing, agency-specific standards. Thus, datasets were not always readily integrated into SSGIC-wide datasets. This situation required much effort to crosswalk datasets to ensure that information was the "best available."

Assembling seamless spatial data layers from numerous sources presented technical challenges. For example, vegetation data, derived from diverse sources, were used to derive fuels data. Because vegetation data layers were not explicitly intended to be used to derive fuels data they lacked a consistent interpretation when assigning fuel types. Another example, using fire ignition source data shows that even when similar data were collected, crosswalking was not straightforward. Different sources used different attribute codes for ignition causes, had differing database structures, and sometimes spatially overlapped with adjacent agencies. These issues with source datasets are discussed in more detail for each analysis.

2.2.2 Data Themes

The SSGIC acquired or developed numerous datasets. Some of these datasets are listed below in Table 2-1 for three categories of datasets: base data, fire data, and resource data. More information for each data theme (e.g., data sources, timeframes, processing, validity, URL for access) is available at http://ssgic.cr.usgs.gov.

Table 2-1 – Example datasets acquired or developed by the SSGIC.

SSGIC Datasets	
Base Data	
	Roads
	Cities
	Streams (Hydrography)
	Public Land Survey (PLS)
	Land Status (Ownership)
	Digital Raster Graphics (DRG)
	Digital Orthophoto Quads (DOQ)
	National Elevation Dataset (30m)
	Hydroelectric Power Plants
Fire Data	
	Ignitions
	Historic Perimeters
	Fuel Type
	Direct Protection Areas
	State Responsibility Areas
	Weather Stations, Remote Automatic Weather System (RAWS)
	Threatened Wildland Urban Interfaces (WUI)
Resource Data	
	Vegetation Classification (WHR)
	Soils
	Range Value
	Soil Erosion Potential
	Sequoia Groves
	Watersheds

2.3 Description of Components of the SSGIC Analysis Framework

2.3.1 RISK: Fire Occurrence Areas (FOA) Analysis

2.3.1.1 Overview

The FOA model calculated the risk of an ignition occurring based on historical ignition data. This approach used source ignition data from collaborating agencies for the years 1981-2000. Maps of ignition point data and ignition databases were processed to create a map for the entire SSGIC analysis area. The probability of ignition was then calculated for 30m grid cells. The grid cells were then classified and converted to polygons to display the historic number of fires per 1000 acres per year.

2.3.1.2 Data sources

Ignition datasets available from all agencies covered the period 1981-2000, except for Kern Co., which covered 1982-1989 and 2001. Datasets from different agencies used tables with different fire causes. A crosswalk between each dataset and a standardized table of cause codes was developed (see fire cause code tables in Appendix D). The frequency of fire causes for each of the 10 cause codes is summarized for each agency in Table 2-2.

Table 2-2 -- Fire causes summarized by agency.

		BLM	CDF	USFS	Kern	NPS	For all agencies	
	Cause			**Percent**			**Pct**	**Count**
0	Unknown	51.34	16.14	8.93	19.23	0.00	13.57	1061
1	Natural	47.45	3.95	61.35	15.11	66.42	36.85	2880
2	Campfire	0.00	3.40	1.63	2.20	16.74	4.02	314
3	Smoking	0.00	4.21	3.55	8.79	3.54	4.08	319
4	Debris Burning	0.00	9.48	2.66	2.75	2.04	4.84	378
5	Incendiary	0.00	23.09	0.17	5.77	3.33	9.07	709
6	Equipment Use	0.00	29.89	6.71	28.02	0.00	15.65	1223
7	Railroad	0.00	0.00	3.62	2.75	0.00	1.65	129
8	Children	0.00	3.88	2.52	10.71	0.11	3.34	261
9	Miscellaneous	1.22	5.96	8.86	4.67	7.83	6.93	542
For all	***Total***	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
causes	**Count**	411	2,733	3,012	728	932		7816

Several data quality issues became apparent when integrating the ignition datasets. One of these was the expected relationship between the location of an ignition and the Direct Protection Area (a DPA is the area for which an agency has primary protection responsibility; see Table 2-3) of the agency that responds to the ignition. The expectation was that an ignition would only be entered in the national database by the agency in whose DPA the ignition occurred. However, about 30% of the SSGIC ignition points fell outside of the DPA of the agency recording the ignition. The validity of these ignition data points was unclear though they were thought to be duplicates. Thus, they were removed from the dataset by spatially clipping each agency's data to the boundary of that agency's DPA. Also, any prescribed fires or other management-ignited fires were eliminated from the datasets.

Table 2-3 – Area of Direct Protection Area (DPA) by agency.

Agency		DPA (acres)
US Forest Service		1,773,573
California Department of Forestry		852,760
National Park Service		821,654
Bureau of Land Management		754,900
Contract		505,480
Local		37,805
Military		33,284
	Total	*4,779,456*

2.3.1.3 Processing

A raster map of ignition density (ignitions / 1000 acres / year) was created from the point coverage of ignition data (Figure 2-2) using ESRI ArcView 3.3 Spatial Analyst software and the function *Calculate Density*. This procedure results in each cell being assigned the average of all cells within a specified radius. The radius used was 2200 m. This radius was used for two reasons. First, it is the same as that used in previous analyses (Lake Tahoe, see Carlton 1999). The other reason is that both the reporting and precision of some older, historic ignition locations was limited to township/range/section for some agencies. The 2200 m radius was sufficient to encompass the center of any adjacent sections which also had data recorded at the center point. The output data are no longer discrete ignition points (as seen in Figure 2-2 of the point data), but a probability of ignition distributed across the landscape. One of the benefits of using the *Calculate Density* function is that it assigns values which can be used computationally as input into other models. It also allows a visual display of multiple ignition points at a given location that would not be spatially visible as ignition point data.

2.3.1.4 Results

The map of FOA (ignitions / 1000 acres / year) is shown in Figure 2-3. The highest density of ignitions occurred along road corridors and populated areas (e.g. near Lake Isabella and Three Rivers). The map shows significant areas calculated to have zero ignition density. These areas of zero values partly result from the limited temporal extent of the ignition data (20 years) and the spatial extent (2200 m) of the density calculation. The areas of zero ignition density had a significant impact on the results of WFSI (see below section 2.3.4) since WFSI is the product of Risk (FOA) values multiplied by Hazard (FlamMap) values.

2.3.1.5 Recommendations

If FOA results are to be used as input into the calculation of WFSI, the zero ignition class of FOA should be eliminated or reduced. Reclassification of FOA values would be one approach to eliminating the zero FOA class and the resulting zero WFSI values. Calculating density with a radius larger than 2200 m would also decrease the extent of areas with zero FOA values. Finally, it would be useful to calculate FOA based on different fire causes, specifically human-caused vs. lightning-caused.

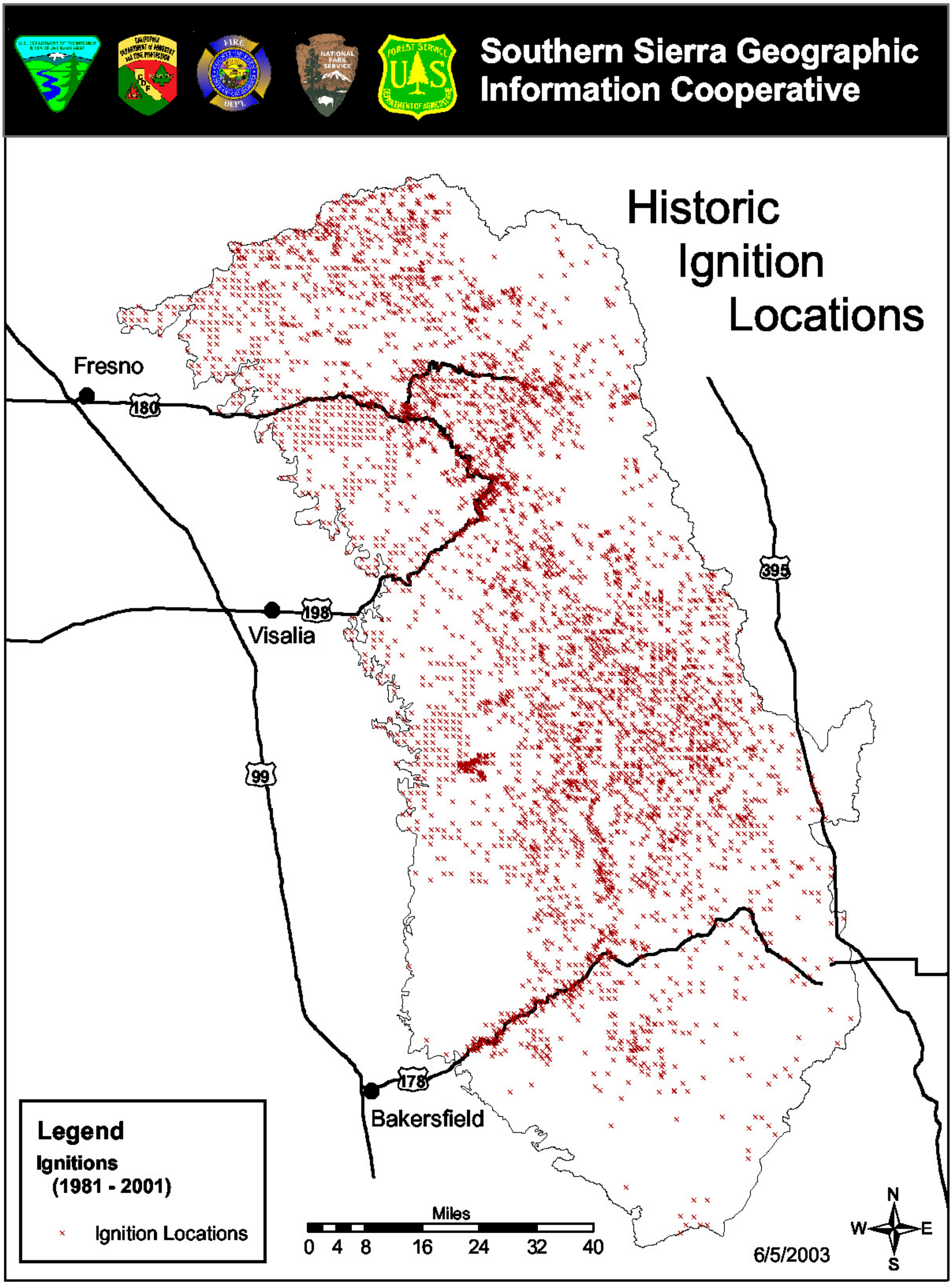

Figure 2-2 Map of ignitions in the SSGIC area used for FOA analysis

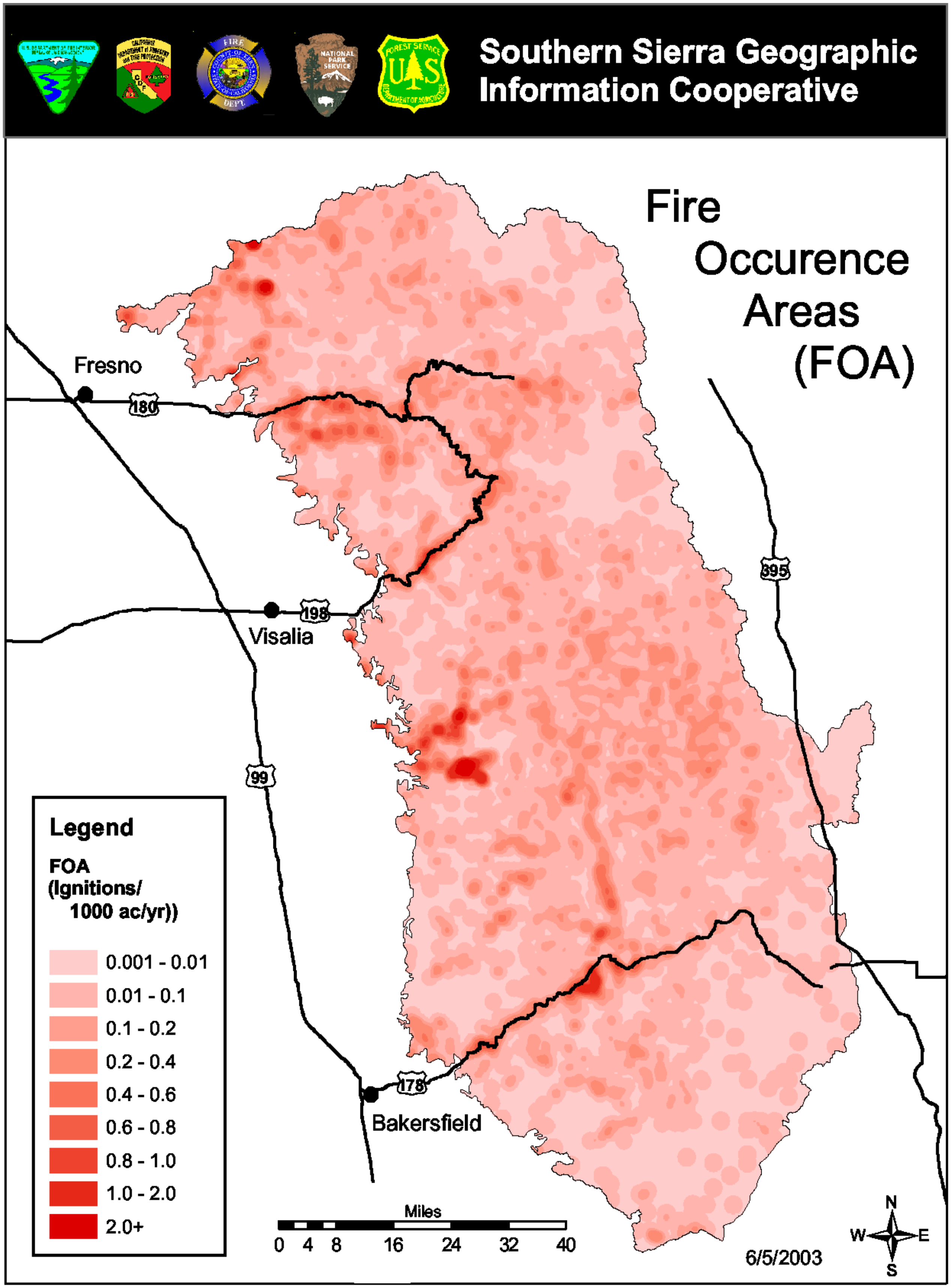

Figure 2-3 FOA (Fire Occurrence Area) map for the SSGIC analysis area

2.3.1.6 Overview

Within the SSGIC analysis framework, the means to assign a value for "Hazard" or predicted fire behavior on a piece of ground was the FlamMap model (http://fire.org/) of potential fire behavior. FlamMap analysis represents the hazard potential for a fire at each location across the landscape. FlamMap was used to provide a value for several fire behavior characteristics (i.e., fire rate of spread (ROS), flame length, crown fire activity) for each grid cell. FlamMap depends heavily on data inputs of terrain, fuel, and canopy cover, as well as user-specified weather, fuel moisture, and wind, to produce estimates of these fire parameters for each cell. Additional data describing canopy characteristics enables FlamMap to significantly improve predictions of crown fire activity. After initially evaluating FlamMap outputs produced without using these additional canopy data, we determined that developing these canopy datasets was essential.

FlamMap has its origins in the fire model Behave (http://fire.org/) and the spatial model Farsite (http://fire.org/). FlamMap uses the same algorithms as these models for ground fire, crown fire, and dead fuel moisture. It models fire behavior for each cell in the landscape but, unlike Farsite, does not model fire spread across cells. In FlamMap each cell on the landscape is an independent calculation.

2.3.1.1 Data Sources

FlamMap required spatial data for topography, canopy cover, and fuels, and non-spatial data for wind and fuel moisture. Topographic parameters needed were elevation, slope, and aspect. These inputs were derived from the National Elevation Database (NED). Fuels were characterized by canopy cover and fuel type (described below). Inputs necessary for improved predictions of Crown Fire Activity were tree height, crown bulk density, and crown base height.

Fuels

The default data source for fuels was CDF fuels data (Surface Fuels 2000 from FRAP), except in areas where better data were available. In these cases, fuels data were provided directly (SEKI, Sequoia NF, Sierra NF), or based on crosswalks from new vegetation data (BLM Case Mountain, BIA). These source fuels data enhancements were significant improvements to the original CDF source data and the resultant model outputs.

In addition to the 13 National Fire Danger Rating System (NFDRS) fuel models (programmed into FlamMap), five additional custom fuel models were used. Three were developed by CDF and two by SEKI. Table 2-4 describes these fuel models.

Table 2-4 -- Fuel models used for FlamMap analysis and the land area covered by each within the SSGIC analysis area.

Fuel Code	Name	Area (acres)
1	Grass	863,595
2	Pine/Grass (1 foot)	561,006
4	Tall Chaparral (6 feet)	223,498
5	Light Brush (2 feet)	328,525
6	Intermediate Brush	299,838
8	Hardwood/Conifer Light	438,833
9	Medium Conifer	189,519
10	Heavy Conifer	189,203
11	Light Slash/Treated Conifer	388,309
12	Medium Slash	132,534
13	Heavy Slash	43,162
14	Conifer, short-needle, low-elevation (SEKI custom code)	15,377
15	Desert (CDF custom code)	458,312
18	Conifer, short-needle, high-elevation, very low rate-of-spread (SEKI custom code)	79,570
28	Urban; wood frame structures (CDF custom code)	5,959
97	Agriculture (CDF custom code)	11,664
98	Water	33,128
99	Rock/Barren	517,424
	Total	*4,779,456*

The canopy cover dataset was derived from GAP data except where better data were already available (SEKI, USFS, CDF FRAP). FlamMap allows cover data to be in ten categories between 0% and 100%. Each source dataset that used fewer categories was crosswalked to “fit” the FlamMap categories. This resulted in implied precision in the resulting dataset not warranted by the coarse categories used in the source data (see Figure 2-4).

To provide weather input data into FlamMap, data from 23 meteorological stations (RAWS and manual) within the SSGIC area were considered. Stations with lower quality data, particularly missing data, were rejected. The remaining eight meteorological stations within the SSGIC analysis area were examined with FireFamily Plus software (Fire Sciences Lab, Rocky Mountain Research Station, Missoula, MT, http://fire.org/). The stations were Ash Mountain, Park Ridge, Pinehurst, Oak Opening, Blackrock, Hot Springs, Kernville, and Democrat. Comparisons of these eight stations with respect to temperature, relative humidity, and windspeed for extreme weather showed insufficient variation to justify using multiple weather influence zones for FlamMap analysis. One station (Ash Mountain) was chosen to best represent the SSGIC area as a single zone because it well-represented extreme weather and there was a complete dataset necessary to link to ignition dates for the WFSI analysis (see below). Thus, only one station and one weather influence zone was used in the FlamMap analysis. Data from the Ash Mountain station spanned the years 1981-2000 and included 3162 daily weather records. Windspeed and fuel moisture values were produced using FireFamily Plus software.

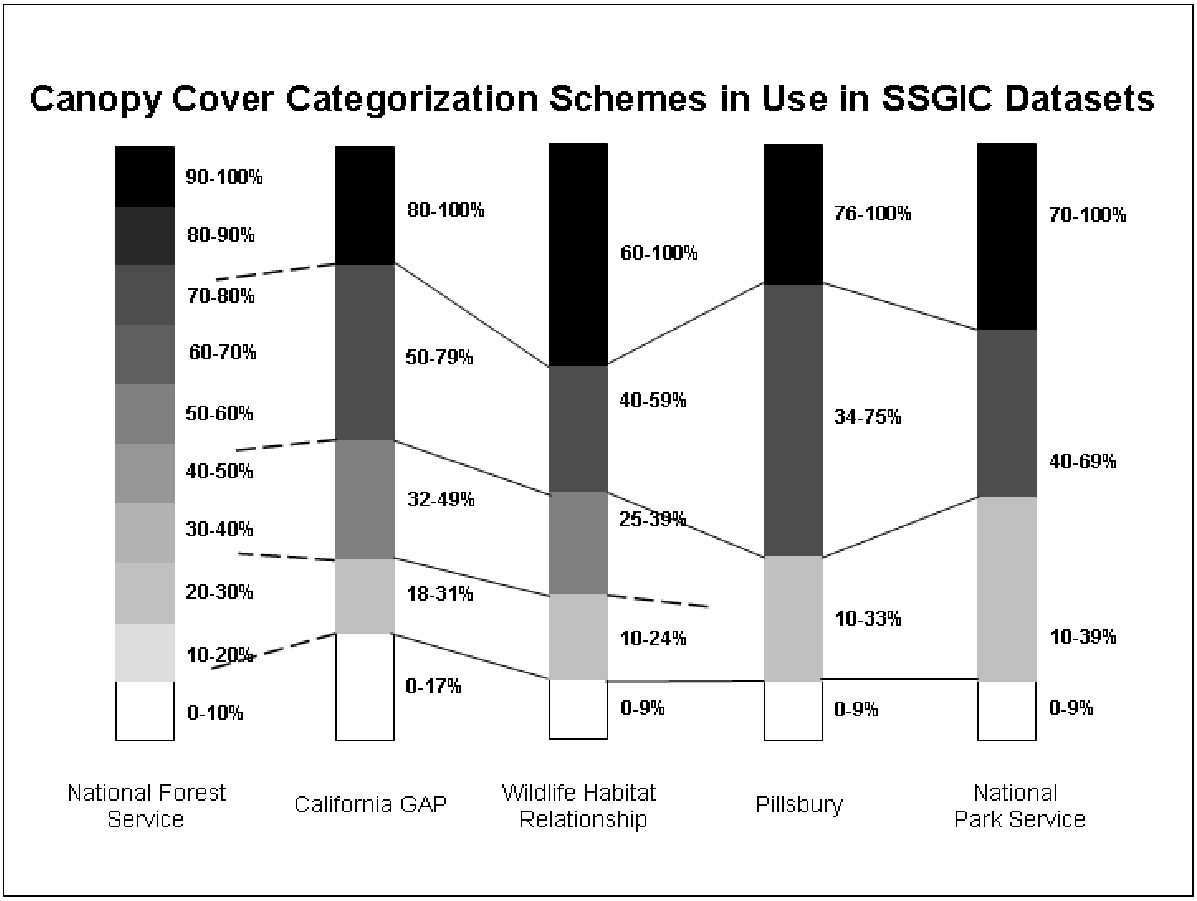

Figure 2-4 Canopy cover categories and crosswalks to FlamMap categories.

FireFamily Plus was used to produce weather data for four ranked, weather categories from the daily weather records input. The definition of these categories was consistent with that used by the fire community. These categories were Low (0-15 percentile), Moderate (16-89 percentile), High (90-97 percentile) and Extreme (98-100 percentile). After ranking the daily weather records by spread component, FireFamily Plus calculated average windspeed and fuel moisture values for each weather category.

For the calculation of Crown Fire Activity (CFR), FlamMap requires parameters for *crown base height, tree height, and crown bulk density* either as constant values (program defaults or user-supplied) or as spatial coverages. We constructed spatial coverages of these parameters from existing datasets.

Crown bulk density (kg/m^3) was estimated using a crosswalk table that predicted crown bulk density from stand density codes. This was based on research by Berni Bahro (Unpublished data, personal communication June 2, 2003) that supports predicting crown bulk density from stand density independent of vegetation type or size class. Local fuels specialists within the SSGIC assisted in building crosswalks based on canopy cover classifications.

Inputs for tree height and crown base height were derived from several sources. For USFS, we used USFS Forest Inventory and Analysis (FIA) data linked to CalVeg strata for tree height and crown base height values. For Sequoia and Kings Canyon National Parks we used existing spatial tree height data and height to understory data for crown base height determination. For BIA, BLM, and Kern County we used a crosswalk table based on extrapolation of forest FIA data, GAP density codes and agency vegetation assignments.

There are important differences among these datasets for crown base height. SEKI data was developed by a fuels specialist and data for the understory, middlestory, and overstory were recorded. However, only understory was incorporated into a spatial coverage and therefore that is what was used. FIA data was not collected from a fuels viewpoint. The crown base height was calculated from tree height and percent canopy ratio and more likely represents the height of live canopy (not dead branches). Only one vegetation layer is represented, equivalent to the overstory.

2.3.1.2 Results

Example outputs from FlamMap are shown below for low and extreme weather inputs for flame length (Figures 2-5 and 2-6), rate of spread (Figures 2-7 and 2-8), and crown fire activity (Figures 2-9 and 2-10).

2.3.1.3 Recommendations

Examination of output from initial runs with FlamMap that suppressed crown fire activity resulted in the consensus that modeling crown fire activity was important. Initially, FlamMap was run without the three optional canopy layers. Constant values were used for tree height (constant at 25m), crown base height (constant at 24m), and crown bulk density (constant at 0.01 kg/ m^3). Thus, the crowns were small, high, and very low density. Using these values had the effect of suppressing crown fire activity in the simulations. Subsequently, the necessary datasets were developed to enable modeling of crown fire activity.

The desert fuels code (15) produced very limited fire activity because it describes vegetation with few, widely-spaced plants. This code might be updated to describe a more flammable fuel type for desert ecosystems due to the incursion of cheatgrass which provides a more continuous flammable layer.

FlamMap is still currently under development by Mark Finney of the Missoula Fire Lab. It may be worth re-running FlamMap using the more current version of FlamMap (version 2).

Evaluation of the FlamMap outputs, especially crown fire activity, shows some unusual horizontal (east to west) striping. This was not in the source datasets and appears to be an artifact of processing. It did not appear to be the result of processing capacity or disc space available. After significant trouble shooting, we believe the condition creating the artifact is that the program creates static arrays for canopy characteristics in RAM, and does not expect non-tree fuel types like chaparral. To determine if this is the case, we could assign non-tree vegetation types crown parameters of 0 and rerun FlamMap. Another possibility is that the striping is an artifact in the DEM that resulted from the original photogrammetric processing (see Gesch et al. 2002).

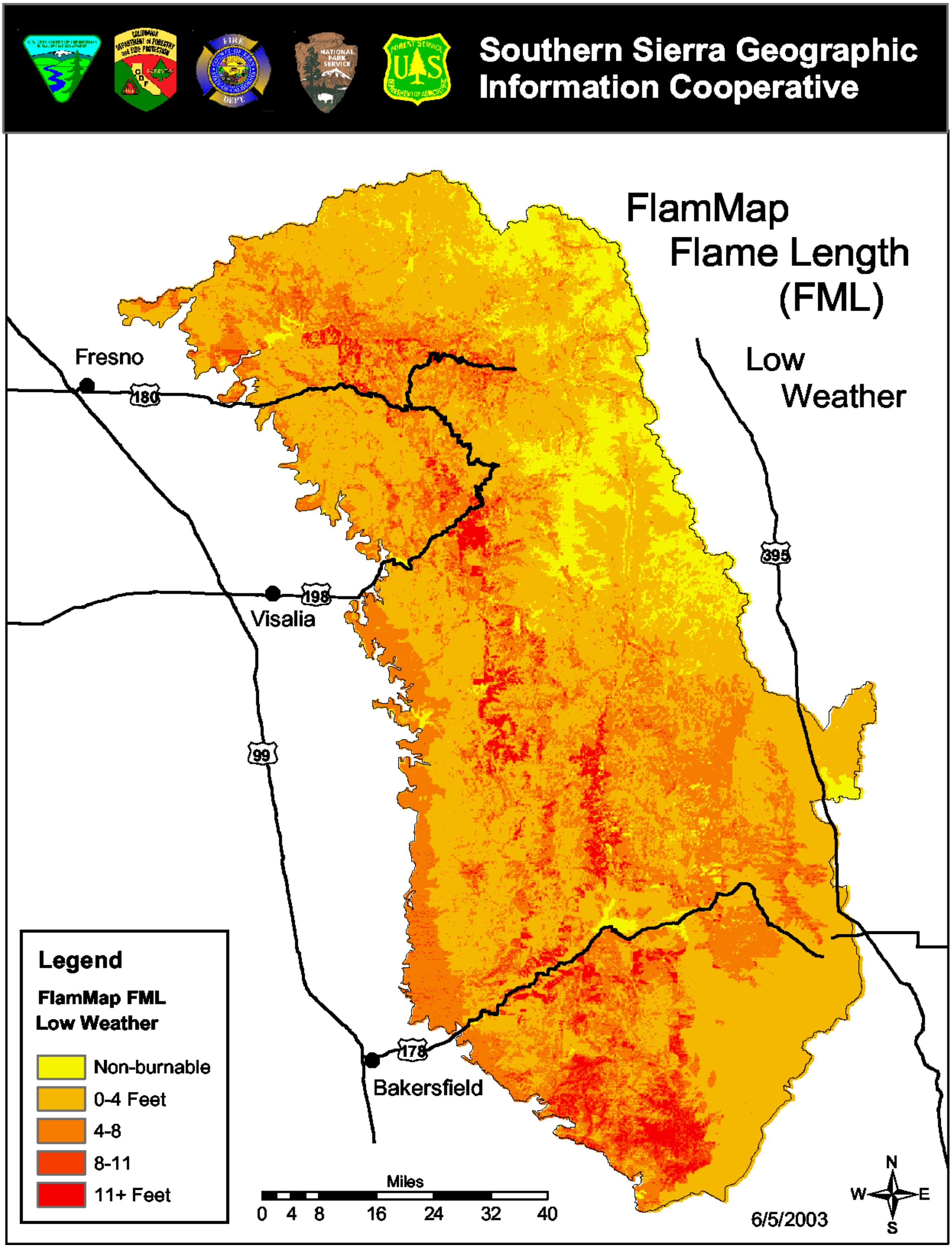

Figure 2-5 FlamMap results for flame length, low weather percentile category

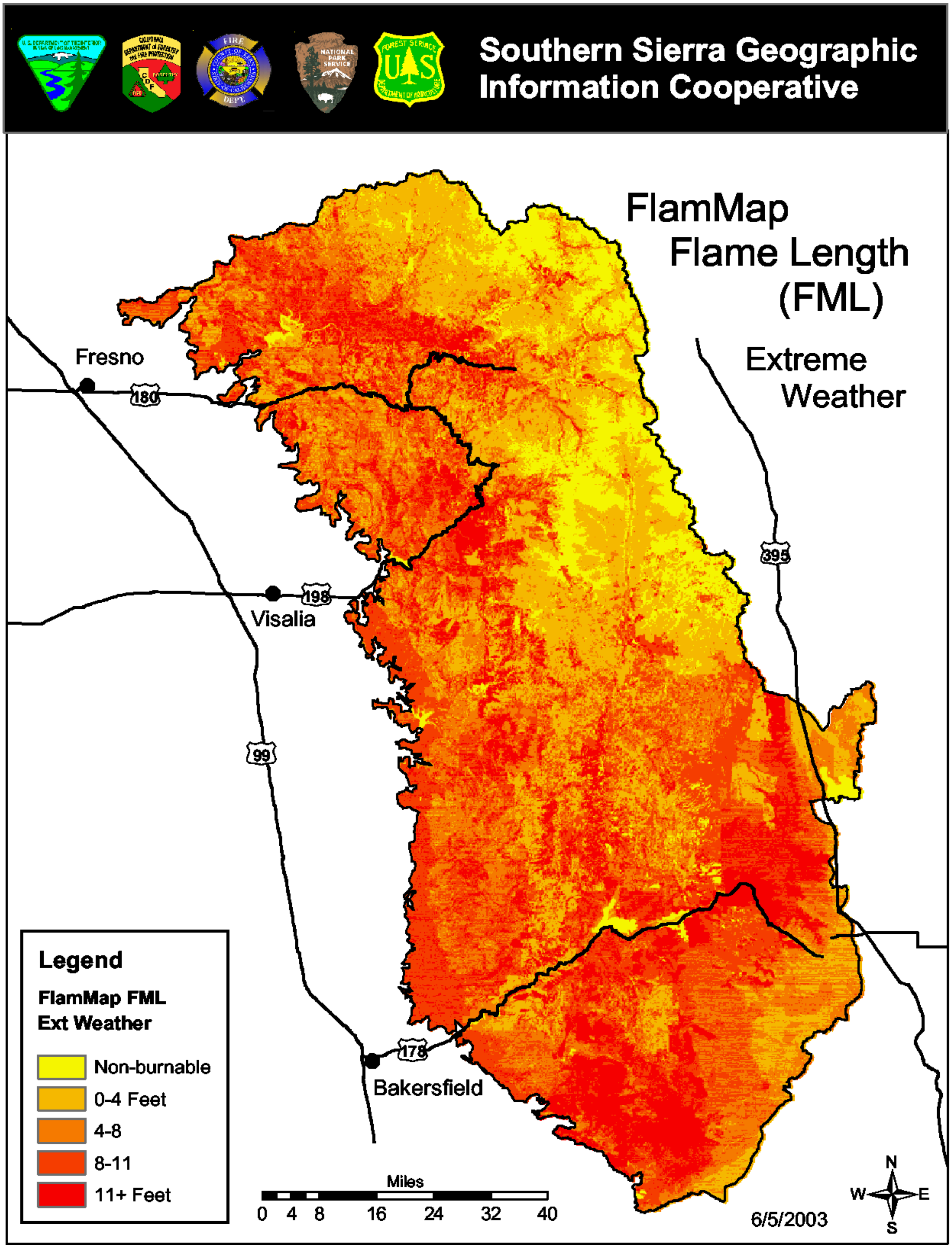

Figure 2-6 FlamMap results for flame length, extreme weather percentile category

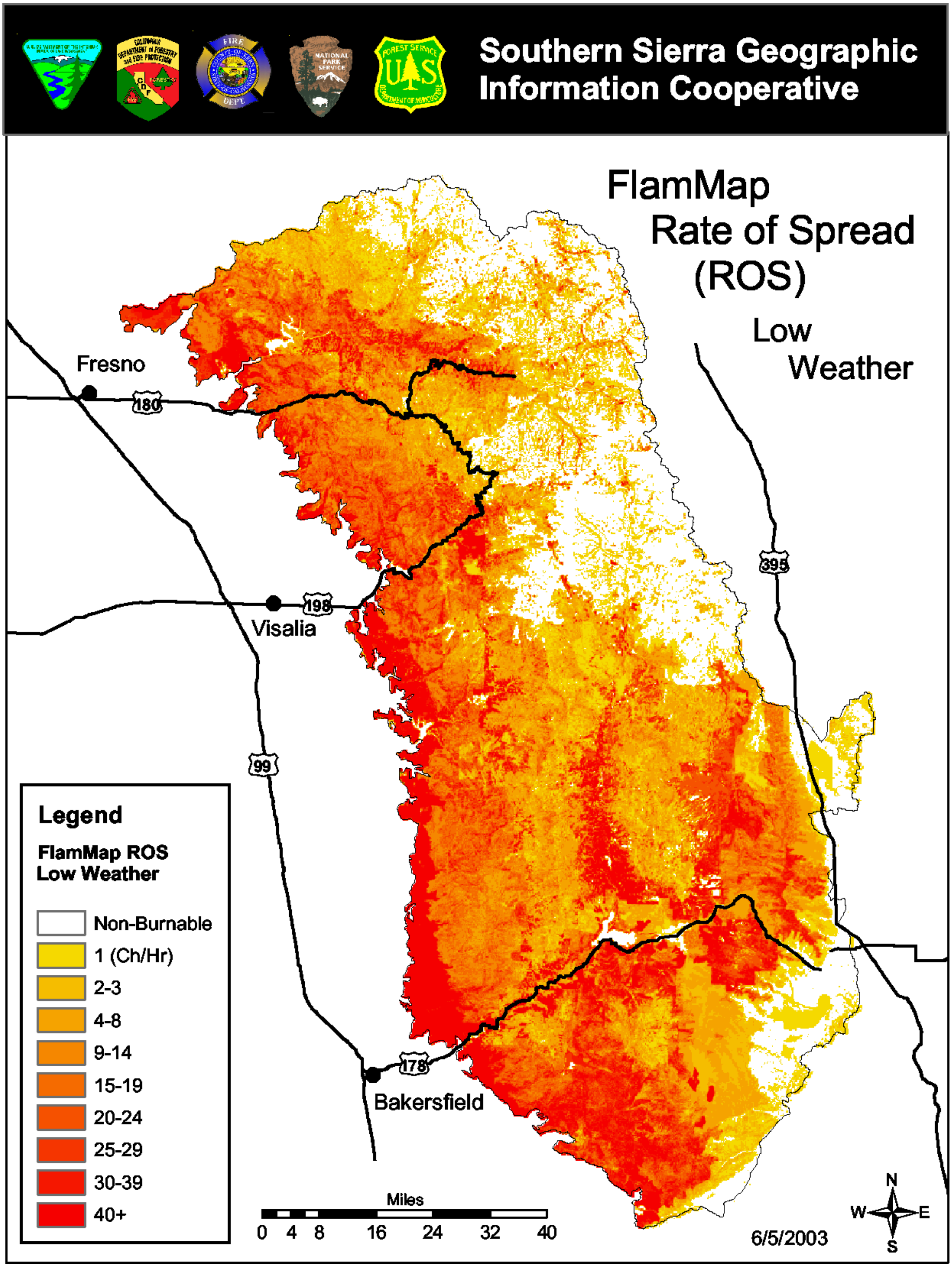

Figure 2-7 FlamMap results for rate of spread, low percentile weather category

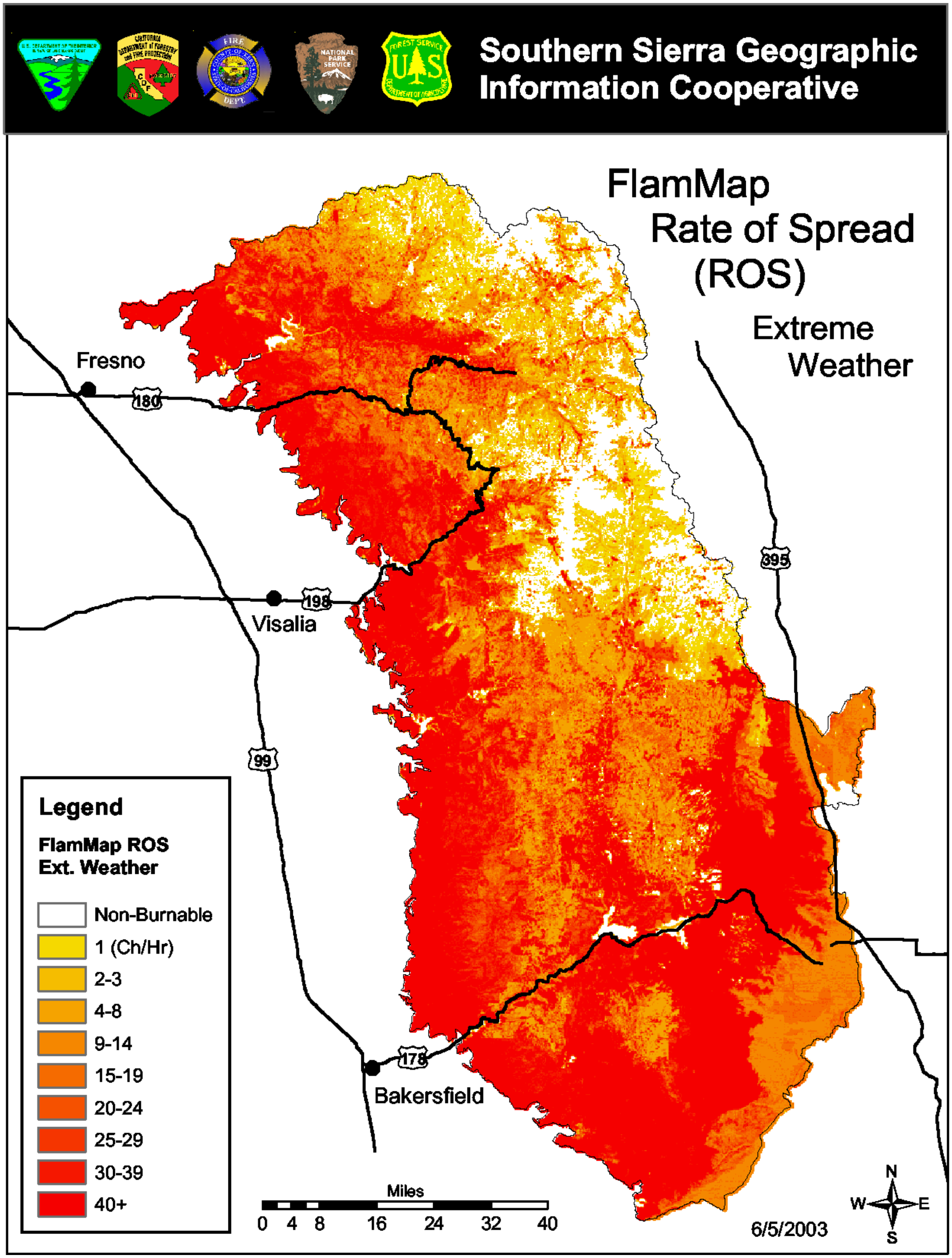

Figure 2-8 FlamMap results for rate of spread, extreme weather percentile category

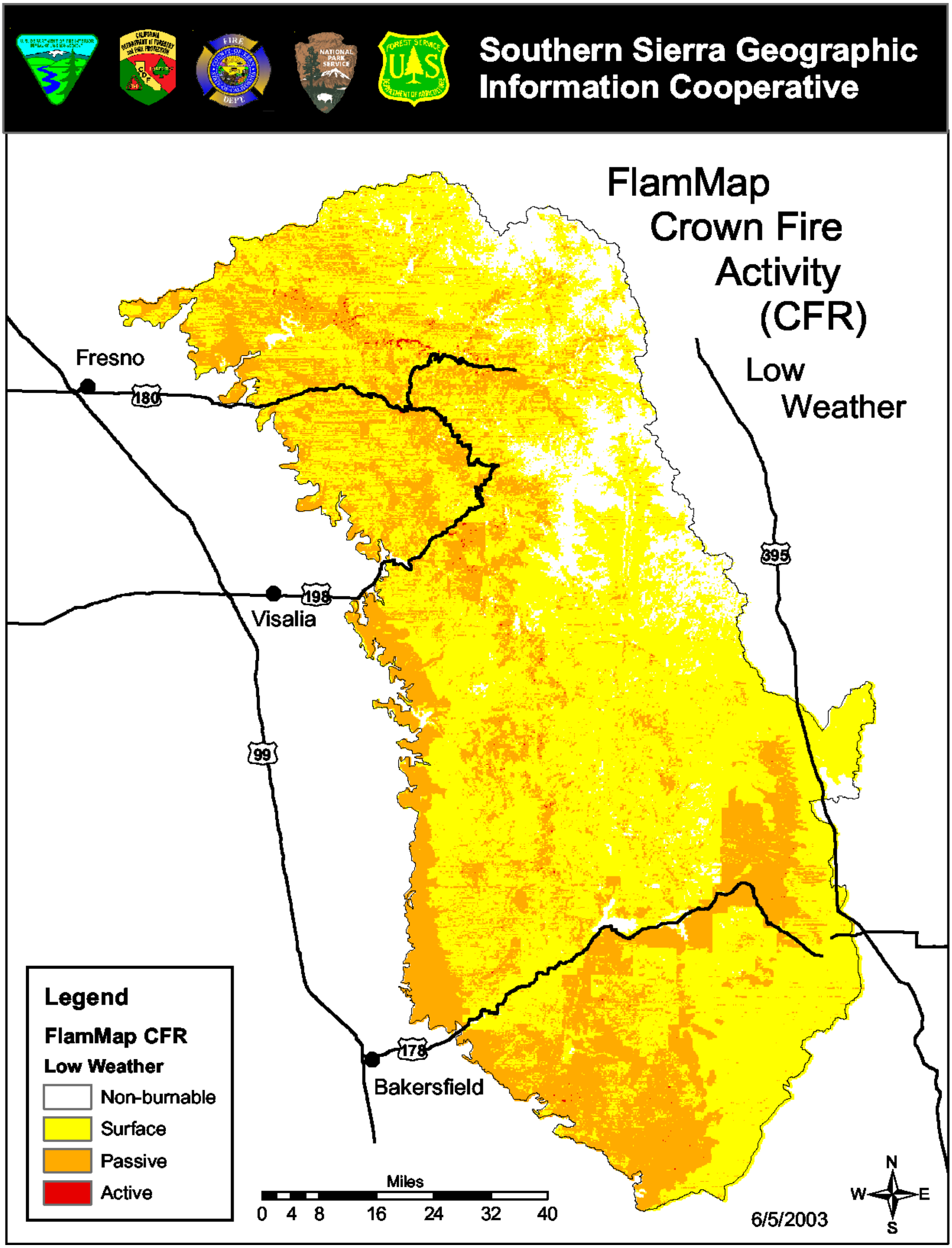

Figure 2-9 FlamMap results for crown fire activity, low percentile weather category

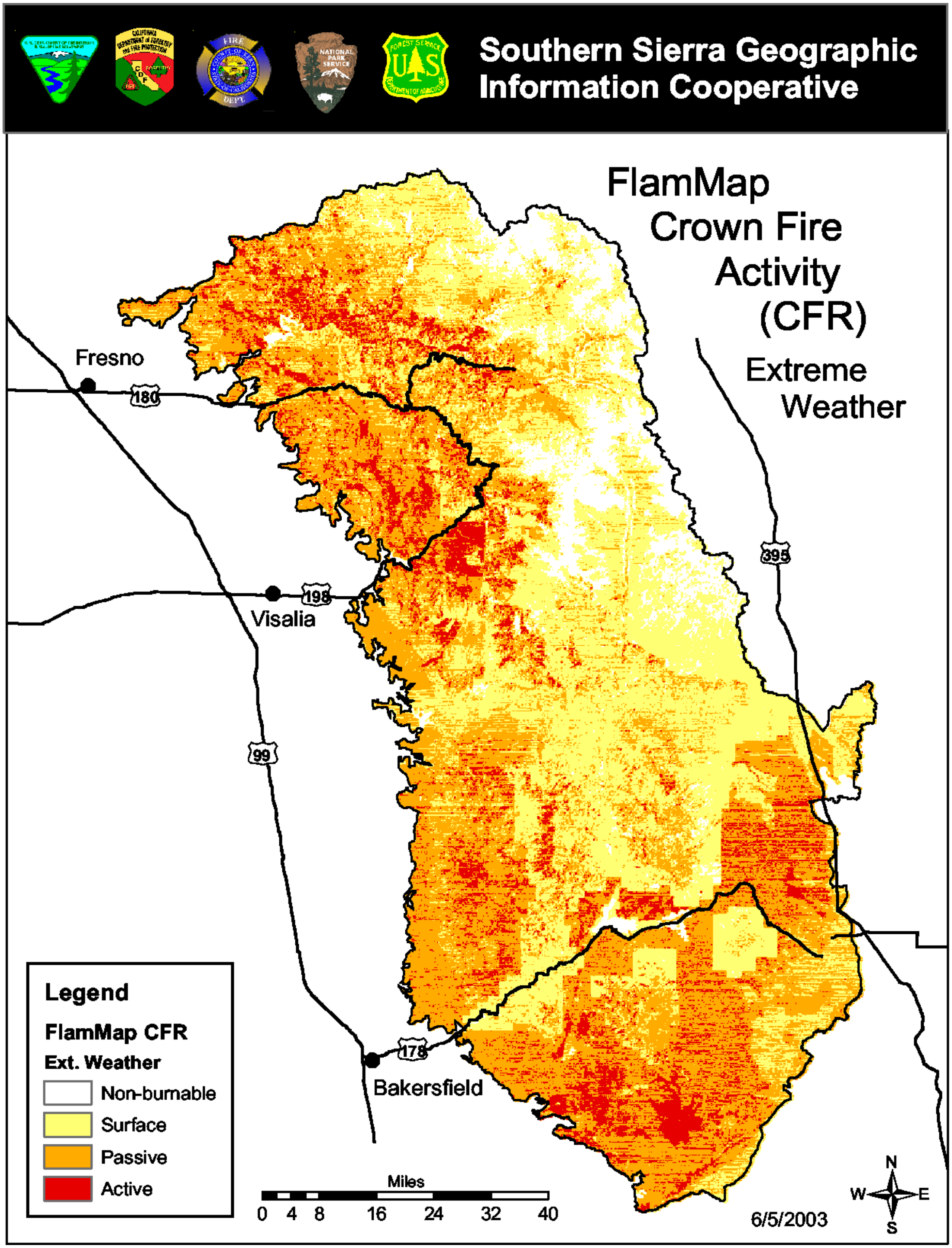

Figure 2-10 FlamMap results for crown fire activity, extreme weather percentile category

2.3.2 VALUE: Ecological Values, Fire Return Interval Departure, FRID

2.3.2.1 Overview

Fire is a keystone ecological process in the southern Sierra Nevada (Kilgore, 1973). Fire regimes changed dramatically with Euroamerican settlement in the Sierra Nevada and effective fire suppression practices, resulting in decreased fire and increased fuel accumulations. Departure from pre-Euroamerican settlement fire frequency or fire return interval indicates an ecological need to restore historic fire regimes.

To quantify this need, the Fire Return Interval Departure (FRID) was developed (Keifer et al. 2000). The calculation of FRID required inputs of vegetation class, historic Fire Return Intervals (FRI) for each vegetation class, and fire perimeters from known fires. Fire perimeters were used to produce a map of the Time Since Last Fire (TSLF). FRID index values were then calculated [FRID = (TSLF – FRI) / FRI] that represented the number of fire return intervals missed since the last fire.

2.3.2.2 Data Sources

The base GIS layers required for FRID analysis are vegetation and fire history. Sources of vegetation data that were merged to create a single vegetation layer were Sequoia and Kings Canyon NP, Sequoia NF, Tule River Indian Reservation, BLM (Case Mountain area), and California GAP data. GAP data, with a 300 acre minimum polygon size, were only used where other coverages were unavailable. Because each vegetation data source used a different classification each was crosswalked to WHR vegetation codes.

Fire history data were obtained from a CDF-compiled dataset with contributions from different agencies. Each agency had different minimum mapping standards and years of record. Also, prescribed burns were not included in the dataset.

Table 2-5 – Sources of fire history data

Agency	Years	Number of Records	Minimum Unit (acres)
Kern County	1982-2000	27	300
CDF	1950-2000	145	300 (or less)
NPS	1921-2000	515	10 (or less)
USFS	1910-2000	783	10
BLM		(not represented in the database)	

A table of fire return intervals for each vegetation class was constructed using best available information (see Appendix E). We used the "maximum average" fire return interval in order to provide conservative values for FRID. Fire return intervals were largely based on fire scar analyses (Figure 2-11) for tree-dominated vegetation types (see Appendix E). Because data for fire return intervals are limited, we assigned a level of confidence to the fire return interval given to each vegetation class. The four categories of level of confidence were good, poor, very poor and estimate. The highest confidence was for trees with short fire return intervals (e.g. ponderosa pine, 6 yr, good confidence), in contrast to trees with long fire return intervals (e.g., subalpine conifers, 508 yr, poor confidence). In vegetation types where woody material is not available for fire scar analysis (e.g. chaparral, grassland), fire return intervals are even more poorly known and confidence is rated as poor or estimate. Another consideration in the assignment of levels of confidence is that fire return intervals, derived mostly from work in Sequoia and Kings Canyon NP, have been extrapolated to a wider geographic area. Thus, potential regional differences in fire return interval within a vegetation class are not considered in the analysis.

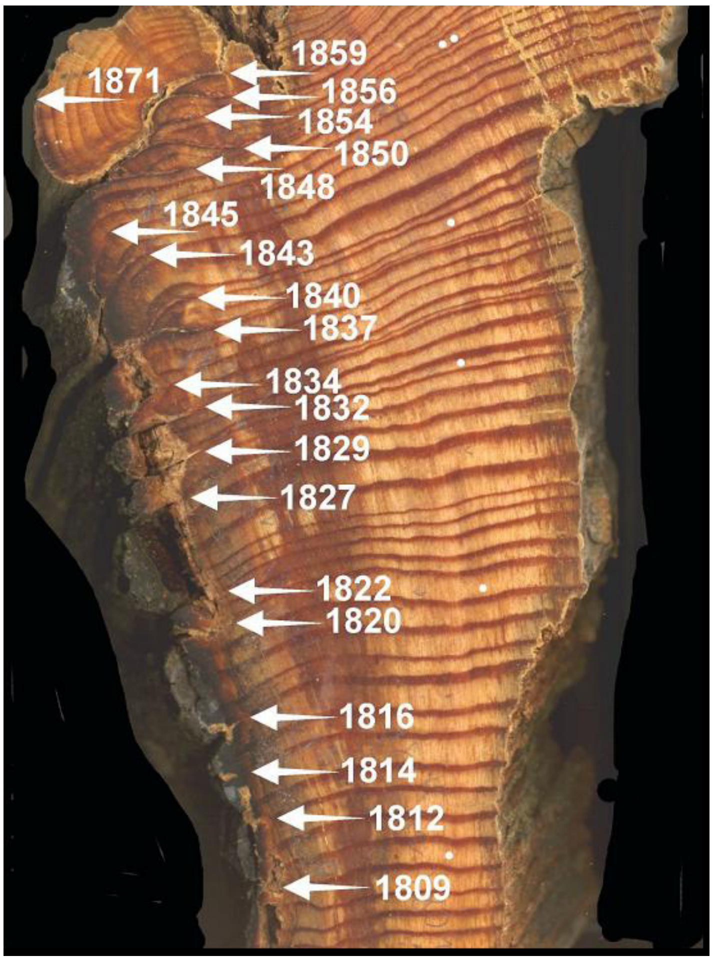

Figure 2-11 Photograph of fire scars (photo – Tony Caprio, Sequoia and Kings Canyon National Parks)

2.3.2.3 Processing

The maximum fire return interval (FRImax) layer was created using the vegetation layer and the FRImax assigned for each of the 29 vegetation classes. Fire history grids were used to create a single grid that contained the year of the most recent fire. Cells with an unknown fire history were assigned 1899 as the year of the most recent fire. The Time Since Last Fire (TSLF) grid was created from this by subtracting the year of the most recent fire from the current year.

The FRID index was then calculated as (TSLF - FRImax) / FRImax, which represents the number of fire return intervals missed since the last fire. Negative values of FRID (0 to -1) indicate little or no departure from historic fire return interval. Increasingly positive values indicate increasing departure from historic fire return interval. FRID values were classified into four categories (Low [≤0], Moderate [>0 – 1.9], High [2 – 4.9], and Extreme [5 – 16]) for display. Note that non-burnable areas (e.g., barren, cropland, water) were excluded from the analysis.

An example calculation of FRID is presented below for ponderosa pine-mixed conifer vegetation type (Table 2-6).

Table 2-6. Example calculation of FRID for ponderosa pine forest using FRImax = 6 (see Appendix E) and assuming time since last fire (TSLF) of 76 years.

Equation:

FRID = (TSLF - FRImax) / FRImax

Input values:

TSLF = 76 years

FRImax = 6 years (see Appendix E)

Calculation:

FRID = (76 - 6) / 6

FRID = 11.67 (missed almost 12 fires)

2.3.2.4 Results

A map of FRID values classed as low, moderate, high, extreme are shown in Figure 2-12. Acres within each FRID class and their distribution between Levels of Confidence are shown in Table 7. The majority of the acres in the Extreme FRID class also have the highest Level of Confidence. A map of Level of Confidence of fire return intervals constructed using the vegetation layer and the confidence level category for each vegetation class is shown in Figure 2-13.

Table 2-7 – Area and percent distribution between Levels of Confidence for each FRID class in the SSGIC analysis area.

FRID Class	**Area (acres)**	**Percent of Acres in Each FRID Confidence Level**					
		Good	Poor	Very Poor	Estimate	Not-Analyzed	*Total*
Extreme	1,612,282	28.7	0.0	60.4	10.9	0.0	100.0
High	823,726	8.4	25.3	37.4	28.9	0.0	100.0
Moderate	88,945	11.3	0.8	41.4	46.5	0.0	100.0
Low	1,745,861	5.3	14.8	17.4	62.5	0.0	100.0
Not Analyzed	508,664	0.0	0.0	0.0	0.0	100.0	100.0
Total	*4,779,478*	*13.3*	*9.8*	*33.9*	*32.4*	*10.6*	*100.0*

2.3.2.5 Recommendations

Improvements are necessary in the quality and standardization of vegetation and fire history data among agencies. An example of the lack of standardization is that fire perimeter data were collected over different years and used different minimum mapping units. Vegetation mapping among agencies also showed different mapping resolution and vegetation classifications.

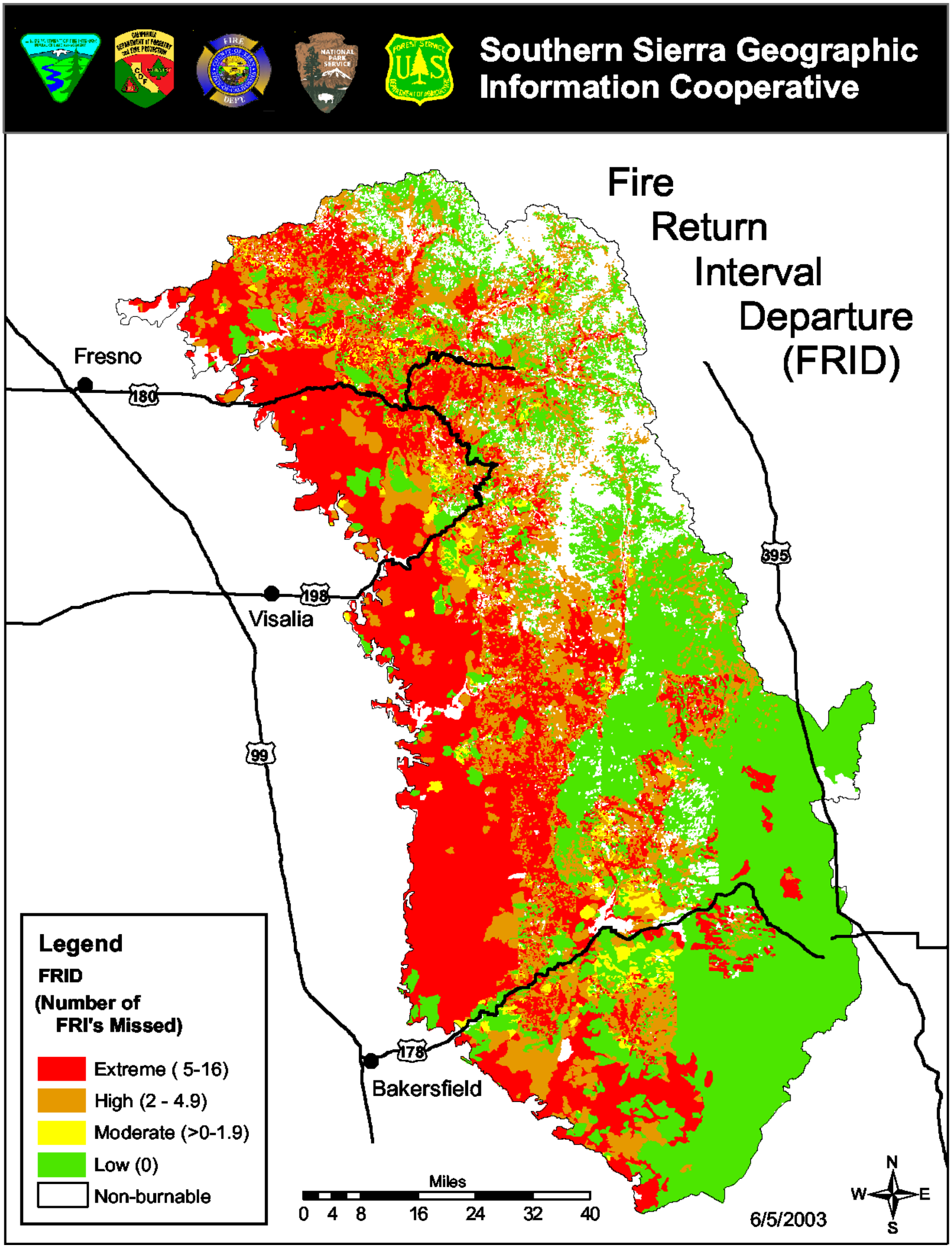

Figure 2-12 Fire Return Interval Departure (FRID) values for the SSGIC analysis area

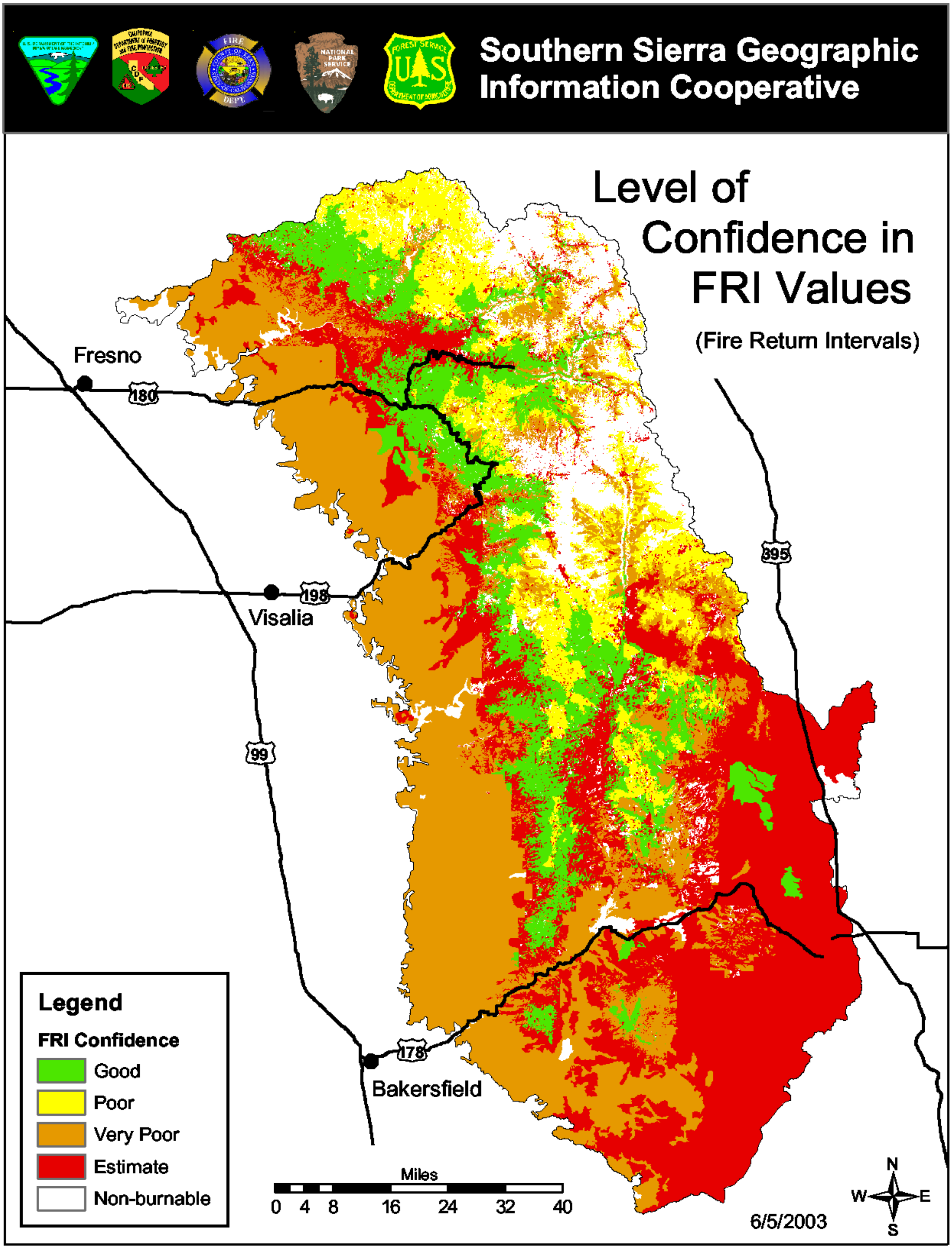

Figure 2-13 FRID Confidence levels for the SSGIC analysis area

Table 2-8 – Distribution of each WHR type among FRID classes. Rows sum to 100% for each WHR type.

WHR Type	Description	FRID Class: Extreme	High	Moderate	Low	Non-burnable	Total
		Percent of WHR Type in FRID class					
ADS	Alpine/Dwarf Shrub	0.0	0.2	0.0	98.7	1.1	100.00
AGS	Annual Grasses	73.1	13.3	1.3	12.1	0.1	100.00
ASC	Alkali Desert Scrub	0.0	0.0	0.0	100.0	0.0	100.00
BAR	Barren	0.4	1.0	0.0	1.7	96.8	100.00
BBR	Bitterbrush	0.5	0.0	0.0	99.3	0.2	100.00
BOP	Blue-Oak Foothill Pine	61.1	28.8	4.8	5.2	0.0	100.00
BOW	Blue-Oak Woodland	79.8	12.3	1.5	6.4	0.1	100.00
CRC	Chamise-Redshank Chaparral	0.9	72.4	3.7	22.9	0.1	100.00
CRP	Cropland	0.4	0.1	0.0	0.1	99.4	100.00
DRI	Desert Riparian	0.0	0.0	0.0	100.0	0.0	100.00
DSC	Desert Scrub	0.0	0.0	0.0	100.0	0.0	100.00
IRF	Irrigated Farmland	1.4	0.0	0.0	0.0	98.6	100.00
JPN	Jeffrey Pine	0.5	62.1	8.3	28.5	0.7	100.00
JST	Joshua Tree	0.0	0.0	0.0	100.0	0.0	100.00
JUN	Western Juniper	0.3	0.1	0.1	99.5	0.0	100.00
LAC	Lacustrine	1.0	0.0	0.0	0.1	98.9	100.00
LPN	Lodgepole Pine	0.2	1.2	0.0	97.2	1.4	100.00
MCH	Mixed Chaparral	1.3	45.6	17.4	35.5	0.1	100.00
MCP	Montane Chaparral	1.1	46.4	2.2	49.3	0.9	100.00
MHC	Montane Hardwood	4.2	79.1	0.9	15.3	0.6	100.00
MHW	Montane Hardwood Conifer	81.2	9.7	0.5	8.4	0.1	100.00
MRI	Montane Riparian	0.3	0.6	0.0	98.5	0.6	100.00
OVN	Orchard and Vineyard	1.3	0.1	0.1	0.2	98.3	100.00
PJN	Pinyon Juniper	0.1	0.2	0.0	99.5	0.1	100.00
PPN	Ponderosa Pine	78.4	11.7	1.8	7.8	0.2	100.00
RFR	Red Fir	0.5	81.9	0.3	16.7	0.6	100.00
SCN	Subalpine Conifer	0.0	0.5	0.0	97.5	2.0	100.00
SGB	Sagebrush	0.2	0.1	0.1	99.6	0.0	100.00
SMC	Sierra Mixed-Conifer (white fir)	69.9	11.2	1.5	17.2	0.2	100.00
URB	Urban	2.5	1.7	0.7	1.0	94.1	100.00
VIN	Vineyard	2.2	0.0	0.0	0.0	97.8	100.00
VOW	Valley Oak-Woodland	0.6	73.1	0.0	26.3	0.0	100.00
VRI	Valley Foothill Riparian	1.6	87.0	0.3	10.9	0.3	100.00
WAT	Water	0.5	0.6	0.0	1.3	97.5	100.00
WFR	White Fir	4.4	0.0	0.0	0.0	95.6	100.00
WTM	Wet Meadow	0.7	86.2	0.2	9.8	3.2	100.00
NA		36.6	4.4	0.4	21.9	36.7	100.00

Table 2-9 – Distribution of each FRID class among WHR types. Columns sum to 100%.

WHR Type	Description	FRID Class				
		Extreme	High	Moderate	Low	Non-burnable
		Percent of FRID Class in WHR Type				
ADS	Alpine/Dwarf Shrub	0.0	0.0	0.0	0.1	0.0
AGS	Annual Grasses	15.6	5.5	5.2	2.4	0.1
ASC	Alkali Desert Scrub	0.0	0.0	0.0	1.8	0.0
BAR	Barren	0.1	0.6	0.1	0.4	83.6
BBR	Bitterbrush	0.0	0.0	0.0	0.0	0.0
BOP	Blue-Oak Foothill Pine	5.2	4.8	7.4	0.4	0.0
BOW	Blue-Oak Woodland	39.4	11.9	13.6	2.9	0.1
CRC	Chamise-Redshank Chaparral	0.0	1.2	0.6	0.2	0.0
CRP	Cropland	0.0	0.0	0.0	0.0	6.0
DRI	Desert Riparian	0.0	0.0	0.0	0.0	0.0
DSC	Desert Scrub	0.0	0.0	0.0	24.6	0.0
IRF	Irrigated Farmland	0.0	0.0	0.0	0.0	0.1
JPN	Jeffrey Pine	0.0	12.3	15.1	2.7	0.2
JST	Joshua Tree	0.0	0.0	0.0	1.0	0.0
JUN	Western Juniper	0.0	0.0	0.0	0.8	0.0
LAC	Lacustrine	0.0	0.0	0.0	0.0	0.9
LPN	Lodgepole Pine	0.0	0.2	0.0	8.5	0.4
MCH	Mixed Chaparral	0.2	11.5	40.7	4.2	0.1
MCP	Montane Chaparral	0.1	7.8	3.5	3.9	0.3
MHC	Montane Hardwood	0.1	2.5	0.3	0.2	0.0
MHW	Montane Hardwood Conifer	10.7	2.5	1.3	1.0	0.0
MRI	Montane Riparian	0.0	0.0	0.0	0.2	0.0
OVN	Orchard and Vineyard	0.0	0.0	0.0	0.0	0.6
PJN	Pinyon Juniper	0.0	0.1	0.1	18.1	0.1
PPN	Ponderosa Pine	7.6	2.2	3.1	0.7	0.1
RFR	Red Fir	0.1	24.8	0.8	2.4	0.3
SCN	Subalpine Conifer	0.0	0.1	0.0	12.2	0.9
SGB	Sagebrush	0.0	0.0	0.1	6.0	0.0
SMC	Sierra Mixed-Conifer (white fir)	20.7	6.5	8.0	4.7	0.2
URB	Urban	0.0	0.0	0.0	0.0	0.1
VIN	Vineyard	0.0	0.0	0.0	0.0	0.3
VOW	Valley Oak-Woodland	0.0	1.6	0.0	0.3	0.0
VRI	Valley Foothill Riparian	0.0	0.3	0.0	0.0	0.0
WAT	Water	0.0	0.0	0.0	0.0	5.3
WFR	White Fir	0.0	0.0	0.0	0.0	0.0
WTM	Wet Meadow	0.0	3.4	0.1	0.2	0.2
NA		0.0	0.0	0.0	0.0	0.1
	Total	99.80%	99.80%	100.00%	99.90%	100.00%

There is a need to improve estimates of pre-Euro-American fire regime characteristics, such as fire return intervals, across many of the vegetation types. For some vegetation types, it is not feasible due to loss of record. As an example, in the blue oak or grassland vegetation, it will be nearly impossible to adequately date fire return intervals because little record exists. Fire return intervals could only be assigned with low confidence to many vegetation types. Existing FRI values were originally developed for the SEKI vegetation classifications and required crosswalking to WHR vegetation classifications. Additionally, there was no existing FRI information for some WHR vegetation types that occurred in the SSGIC area, but not in SEKI.

FRID estimates may be improved by incorporating variables other than vegetation class, such as aspect, into the mapping of FRI values. As an example, fire frequency in low elevation mixed conifer forests can be two to three times more frequent in south aspects than north aspects (Caprio, 1999). Also, it would be useful to predict future FRID values either to reflect existing or proposed management activities or to project which areas will move into a higher FRID class with time. Lastly, it may be worthwhile to develop a DRID (Disturbance Return Interval Departure) which includes factors besides fire that affect ground conditions such as timber harvest or agricultural grazing.

FRID is an indicator of *condition class* (as defined by Hann and Bunnell, 2001). FRID can be directly related to the national reporting standard for condition class as shown in the diagram (Figure 2-14).

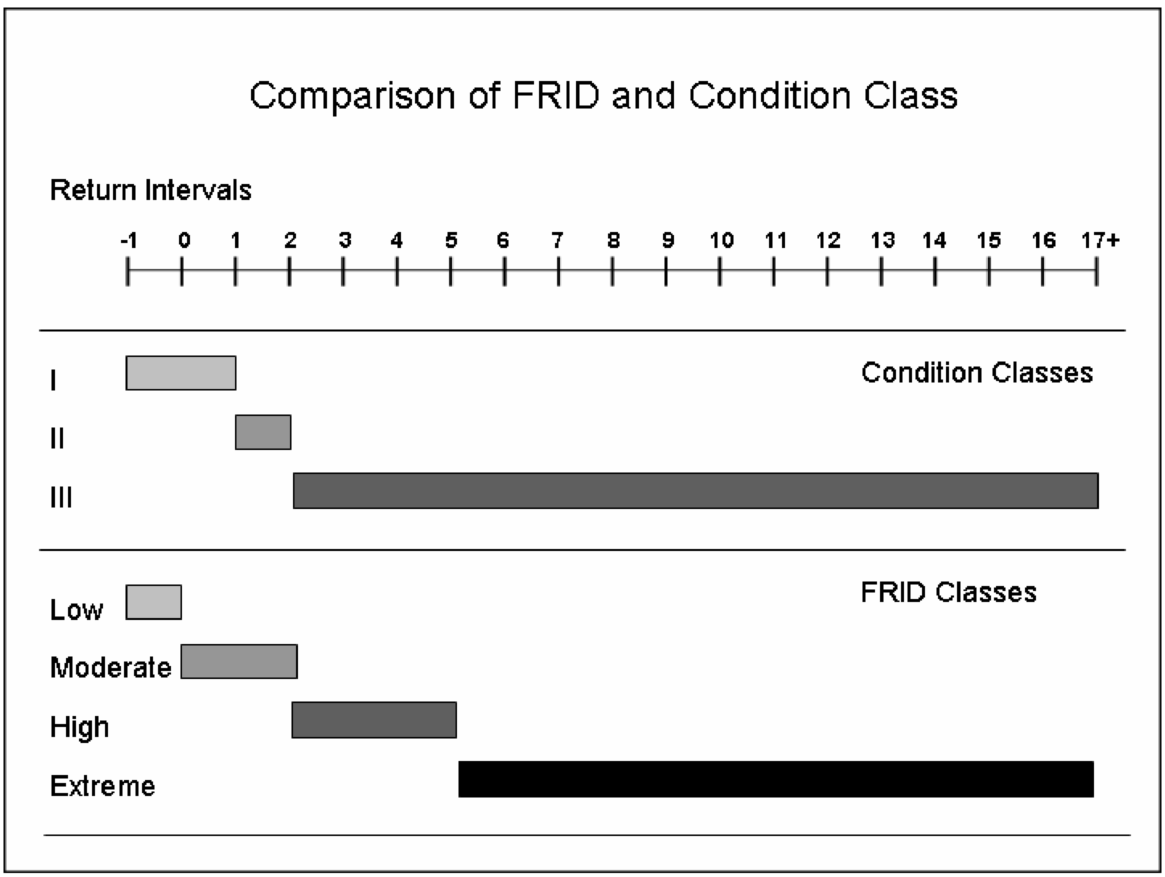

Figure 2-14 FRID and Condition Class relationship

2.3.3 VALUE: Social/Economic Values, Asset Analyzer

2.3.3.1 Overview

Social and economic values were represented by a number of different data themes. These themes described assets ranging from human-built structures to natural resource values (e.g., sequoia groves). These asset themes were likely to be valued differently by different agencies -- some given more weight in an analysis than others depending on the agency. For this reason, it became clear that a decision support tool was needed to aid in the integrated assessment of these assets. The tool needed to be able to accommodate agency-specific and project-specific alternatives. As a result, the Asset Analyzer software application was developed (see below, 2.4) based on the earlier Asset Analyzer model developed by CDF (http://www.fire.ca.gov/Fire EmergencyResponse/FirePlan/fireplan.pdf).

The original Asset Analyzer model developed by CDF uses a weighted sum to integrate multiple asset datasets into a single asset dataset. It was originally implemented at low resolution (about 450 acres), known as Quad81 (from dividing a 7½' map quadrangle into 81 cells, 9 vertical by 9 horizontal). The CDF Asset Analyzer was manually implemented, which made the evaluation of multiple weighting scenarios cumbersome.

During the SSGIC analysis process the need for a more flexible decision support tool, that could quickly create a range of alternative scenarios, was apparent. The SSGIC used the logic of the CDF Asset Analyzer and developed an ArcView 3.x Spatial Analyst extension. Also called the Asset Analyzer, it allows the user to efficiently select and weight input datasets to create an output dataset at a user specified resolution (see below, 2.4).

The Asset Analyzer also proved useful as a comparative weighting tool for weighting different alternatives and assisting in optimizing selection of fuel treatment areas (see below, 2.5).

A description of the social/economic values datasets developed by SSGIC follows.

2.3.3.2 Data Sources

Nine asset datasets were developed for these analyses. Seven of these were provided by CDF's Fire and Resource Assessment Program, and two were developed from NPS, USFS, and BLM data. The seven data sets from CDF were:

Hydroelectric Power – Identifies the 20 miles of watershed upstream of a "R" (River Run) power plant. This focuses on the potential for siltation at the power plant. Values assigned are related to the generating capacity of the power plants.

Water Supply – Identifies 20 miles of watershed that feeds water storage facilities. This focuses on the potential loss of water storage capacity due to siltation following fires.

Water Diversion – Identifies places where water is directly removed for use as a domestic water supply and the number of connections in place. This was created as a ¼ mile buffer around point diversions.

Range Value – Represents the dollar value of forage potentially destroyed by fire.

Soil Erosion Potential – This is the soil “K” factor multiplied by slope. “K” factor is a measure of soil erodibility from the US Natural Resources Conservation Service Universal Soil Loss Equation.

Structures – This is based on the “Housing Density” (HDENSITY) attribute of 2000 census block data defining the number of housing units per acre.

Threatened Wildland Urban Interface (WUI) – Uses federally-defined WUI communities with surrounding buffers assigned a threat factor by CDF.

The additional datasets developed by SSGIC were Sequoia Groves and Firefighter Risk. The Sequoia Groves dataset was merged from NPS, USFS and BLM sequoia datasets. Tule River Indian Reservation sequoia groves were excluded from the dataset because of the sensitive nature of their sequoia grove data.

The Firefighter Risk dataset was created using methods developed by Sequoia and Kings Canyon National Parks' staff and extended to include the SSGIC analysis area. Firefighter Risk is a measure of potential hazard to firefighters after an ignition has occurred and is derived from a model that uses slope, elevation, aspect, fuels, and road accessibility data.

2.3.3.3 Processing

Only the Firefighter Risk dataset required major data processing by SSGIC for application to this analysis. A description of the processing of slope, elevation, aspect, fuels, and road accessibility data follows.

Slope

The slope layer for the SSGIC project area was used. Percent slope data were categorized into high, moderate and low values as follows:

Low	0% to 10%
Moderate	>10% to 40%
High	>40%

Weighted values were assigned as follows: High = 9, Moderate = 5 and Low = 1.

Elevation

The elevation layer for the SSGIC project area was used. Thirty-meter elevation data were categorized into high, moderate and low values as follows:

Low	2,439 to 4,417 meters
Moderate	1,525 to 2,438 meters
High	1 to 1,524 meters

Weighted values were assigned as follows: High = 3, Moderate = 2 and Low = 1.

Aspect

The aspect layer for the SSGIC project area was used. Aspect data in degrees were categorized into high, moderate and low values as follows:

Low	315 to 45 degrees (NW to NE)
Moderate	45 to 135 degrees (NE to SE); 270 to 315 degrees (W to NW)
High	135 to 270 degrees (SE to W)

Weighted values were assigned as follows: High = 5, Moderate = 3 and Low = 1.

Fuels

The fuels data layer for the SSGIC project area was used. Fuel model codes were categorized into high, moderate and low values as follows:

Low	8, 15, 18
Moderate	1, 2, 3, 5, 6, 9, 14, 16, 17
High	4, 10, 11, 12, 13, 28
Unburnable	97, 98, 99

Weighted values were assigned as follows: High = 9, Moderate = 6, Low = 1 and Unburnable = 0.

Road Accessibility

The USGS Digital Line Graph (DLG) roads layer for the SSGIC project area was used as the data source. This layer, developed by USGS is attributed with a Road Type as follows:

Symbol	Road Type
2	Interstate
3	Secondary road
6	Interchanges etc.
7	State road
8	US highway
9	Trail (4-wheel)
10	Other road
14	Trail

The Road Accessibility layer is a polygon layer in which polygons were assigned to one of three accessibility categories: low, medium, or high. The SSGIC manually coded dead ends and categorized areas within ¼ mile of these as high. Other areas categorized as high were all areas more than ¼ mile (420 meters) from a road, areas closer than ¼ mile of a 4-wheel drive road, trail (symbol = 9 or 14). Areas within ¼ mile (420 meters) of a primary or secondary, maintained, or 2-lane road (symbol = 2, 3, 6, 7 or 8) were categorized as low. Areas within ¼ mile of unimproved and unpaved residential roads (symbol = 10) were categorized as moderate.

Weights were assigned as follows: High = 7, Moderate = 4 and Low = 1.

Values from each of the five source grids (slope, elevation, aspect, fuels, road accessibility) were combined into a single grid using a weighted sum. The resulting grid contained the weighted-sum of the five source grids with weights applied as follows:

Source Dataset	High	Moderate	Low
Fuels	9	6	1
Slope	9	5	1
Aspect	5	3	1
Elevation	3	2	1
Road Accessibility	7	4	1

2.3.3.4 Results

The resulting map of Firefighter Risk is shown in Figure 2-15. This map highlights areas of high-risk to those fighting fires, as well as the general public, in the southern Sierra in wildfire situations. Extensive areas of high firefighter risk are one indicator that may support the need for fuel reduction projects or other mitigation actions.

2.3.3.5 Recommendations

Asset datasets were of different value to different agencies. Datasets for some values were missing or underrepresented (e.g., natural resources). The addition of datasets from various agencies that reflect their respective values would be beneficial. The resolution of some of the data is not very useful at the watershed scale (e.g. soil erosion from STATSGO at 1:250,000). The data quality should be improved with better precision and accuracy to increase the usefulness for local area planning.

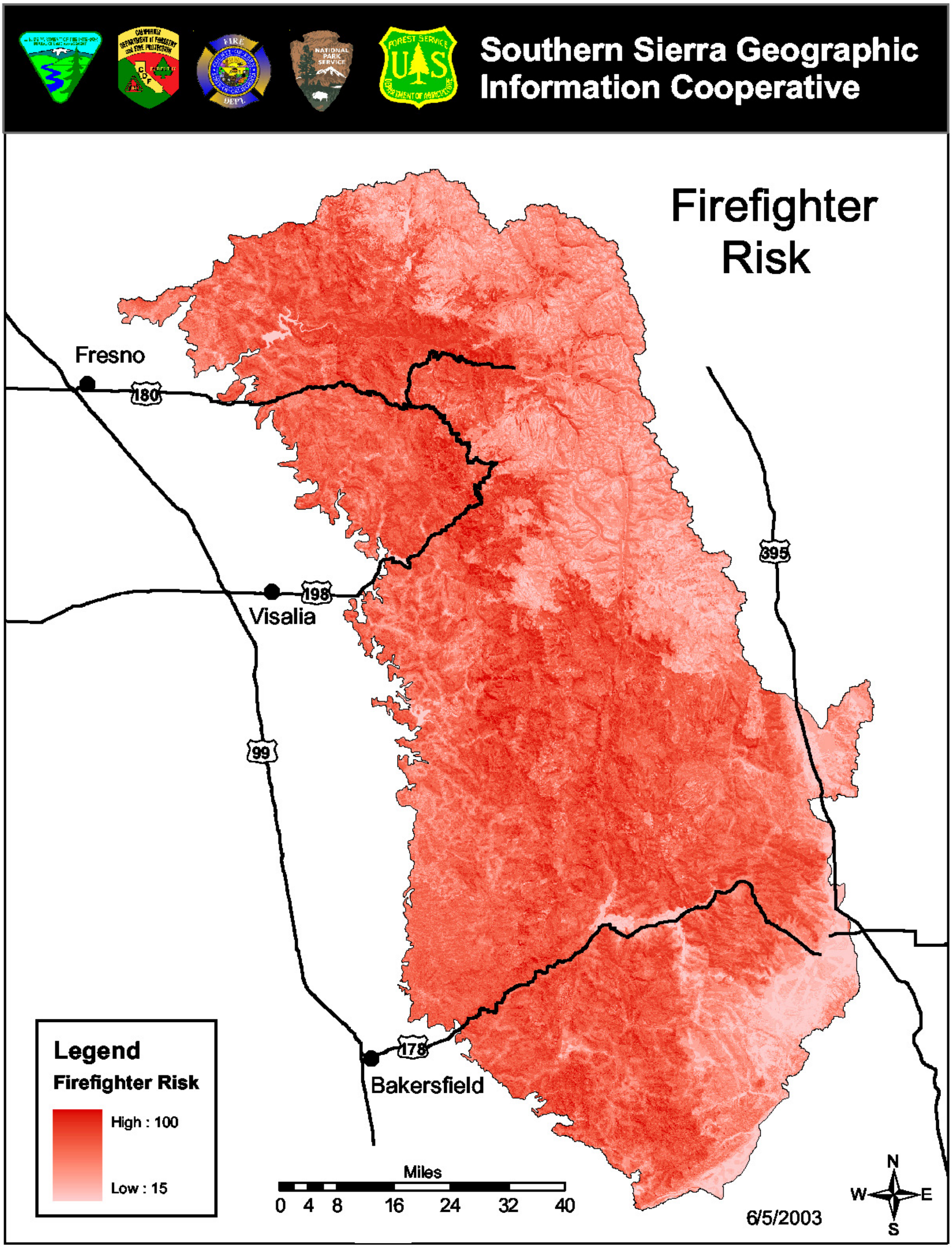

Figure 2-15 Potential Firefighter Risk for the SSGIC analysis area.

2.3.4 Risk and Hazard Integration: Wildland Fire Susceptibility Index (WFSI)

2.3.4.1 Overview

To integrate the results of risk (FOA) and hazard (FlamMap) analyses the Wildland Fire Susceptibility Index (WFSI) was implemented for the SSGIC area (Carlton, 1999). WFSI provides an ordinated index over the landscape of the probability of a cell burning. The index is calculated for each grid cell using input from FOA, FlamMap ROS, and information relating ROS to Final Fire Size (FFS), and indicates the relative probability of a cell burning. .

2.3.4.2 Data Sources

WFSI analysis uses several datasets produced for or by other analyses -- FOA ignition density (see 2.3.1), FireFamily Plus weather percentile analyses (see 2.3.1.1), and FlamMap ROS (see 2.3.1.2).

Additionally, WFSI requires the development of statistical relationships between FFS and fire ROS for local conditions. For low ROS values, data from National Fire Management Analysis System (NFMAS) Suppression Table 1 of the Interagency Initial Attack Assessment (IIAA) module (National Fire and Aviation Management Information Systems Team, 2000) for contained fires were used. For higher ROS's, the curve was fitted using fire progression maps of actual escaped fires (see below). The development of the relationship between ROS and FFS is described below.

2.3.4.3 Processing

The WFSI calculation process can be described in a step-wise manner as follows:

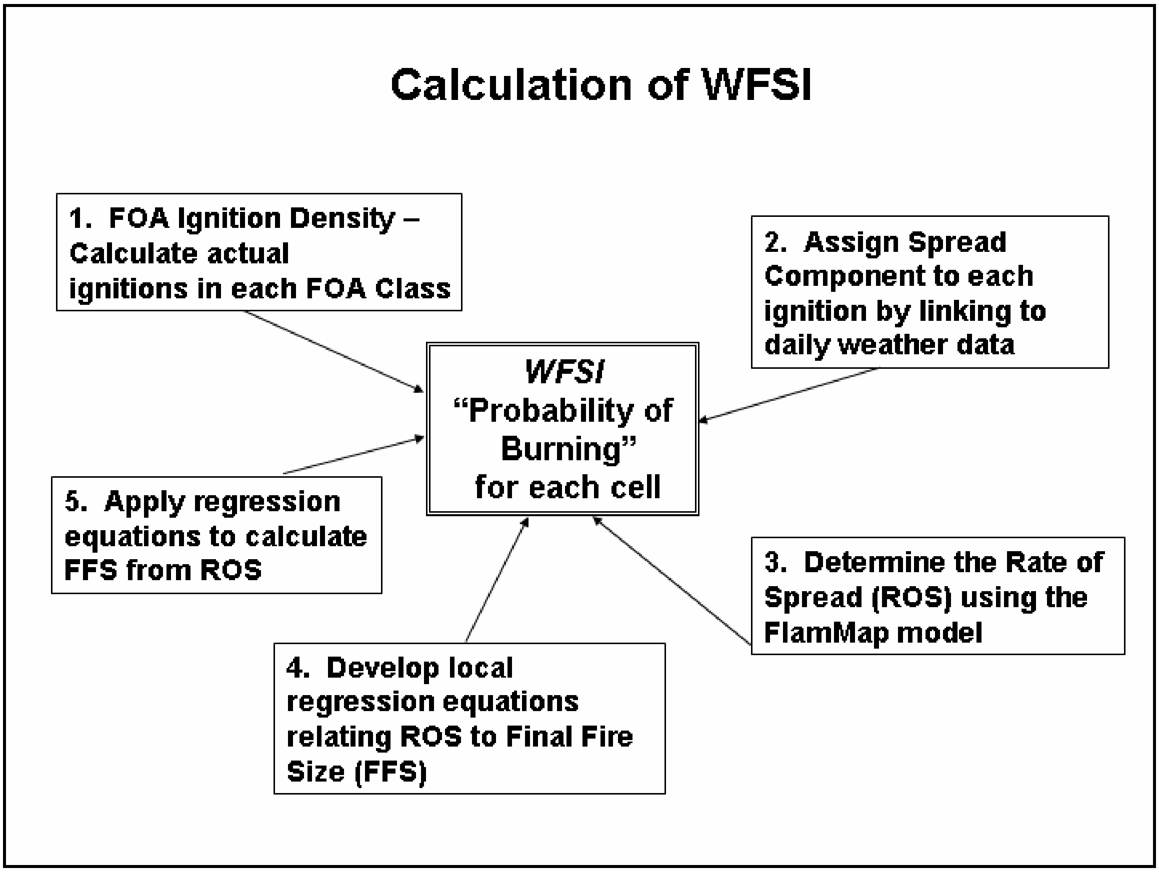

Figure 2-16 Calculation of Wildland Fire Susceptibility Index (WFSI) for the SSGIC analysis area.

Step 1 – Calculate the probability of ignition. The FOA ignition density values were used to express the probability of ignition as described previously (see 2.3.1). As a review, the limitations of the ignition dataset were:

a. Contributing agency datasets were clipped to their Direct Protection Areas.
b. Management ignited fires were excluded from the analysis.
c. Lightning and human-caused ignitions were not distinguishable.
d. Ignition dataset included the years 1981-2000.

Step 2 – Determine the spread component (SC) for each historical ignition. The date of the ignition is used with FireFamily Plus to find the spread component for that ignition on that particular date. The ignitions were then sorted by SC to determine percentile categories. The percentile categories used were Low (0-15%), Moderate (16-89%), High (90-97%), and Extreme (98-100%). Weather data from Ash Mountain were used for this purpose.

Step 3 – Determine the ROS. The output of FlamMap model was used to provide values for ROS (as described above for FlamMap).

Step 4 – Relate FFS to ROS. Regression equations relating FFS to ROS were developed for local conditions. The data supported development of curves for three strata, as listed in Table 2-10.

Table 2-10 – Vegetation strata used for development of regression equations relating final fire size to rate of fire spread.

Stratum	Fuel Models Included	Elevation
Grass/Shrub	1, 2, 3, 4, 5, 6, 15, 28	< 7500 ft
Mixed Conifer	8, 9, 10, 11, 12, 13, 14, 18	< 7500 ft
High Elevation	All	> 7500 ft

The spatial distribution of the three strata used for regression equation development is shown in Figure 2-17.

For small fires with a low ROS, data were derived from the three federal agencies' historical data for small (controlled) fires from NFMAS Suppression Table 1 of the IIAA module (National Fire and Aviation Management Information Systems Team, 2000). For larger fires with higher ROS's, data from actual escaped fires were used (Table 2-11). Fire progression maps were used to develop the relationship between ROS and FFS. Determination of which fires to use in the analysis resulted from discussion of topography, weather conditions, effective hours of burn time between recorded perimeters, fuels, resources available, operational strategies implemented, etc. No representative fire was available for the Mixed Conifer strata so the curve of ROS and FFS was determined based on expert knowledge.

Table 2-11 – Escaped fires used for relating ROS and FFS.

Fire Name	ROS (chains/hr)	FFS (acres)	Vegetation Stratum
Kaweah	33.3	4898	Grass/Shrub
Buckeye	37.7	3075	Grass/Shrub
Jack's Creek	41.8	5693	Grass/Shrub
Choke	17.4	3926	High Elevation

A maximum FFS was identified for each equation (stratum) to prevent prediction of unrealistically large final fire sizes at high rates of spread. These were 34,000 acres for Grass/Shrub, 7,500 acres for Mixed Conifer, and 3,500 acres for High Elevation.

Regression equations were developed with Prism software (http://www.graphpad.com/prism/Prism.htm) and the form judged to have the "best fit" was a double quadratic equation:

$$Y = E + AX^B + CX^D$$

where Y is FFS (acres), X is ROS (chains/hr), and A, B, C, D, and E are fitted coefficients as shown in Table 2-12. The E coefficient was set to 0.1 for Grass/Shrub and for Mixed Conifer in order to avoid FFS's of zero when ROS was positive.

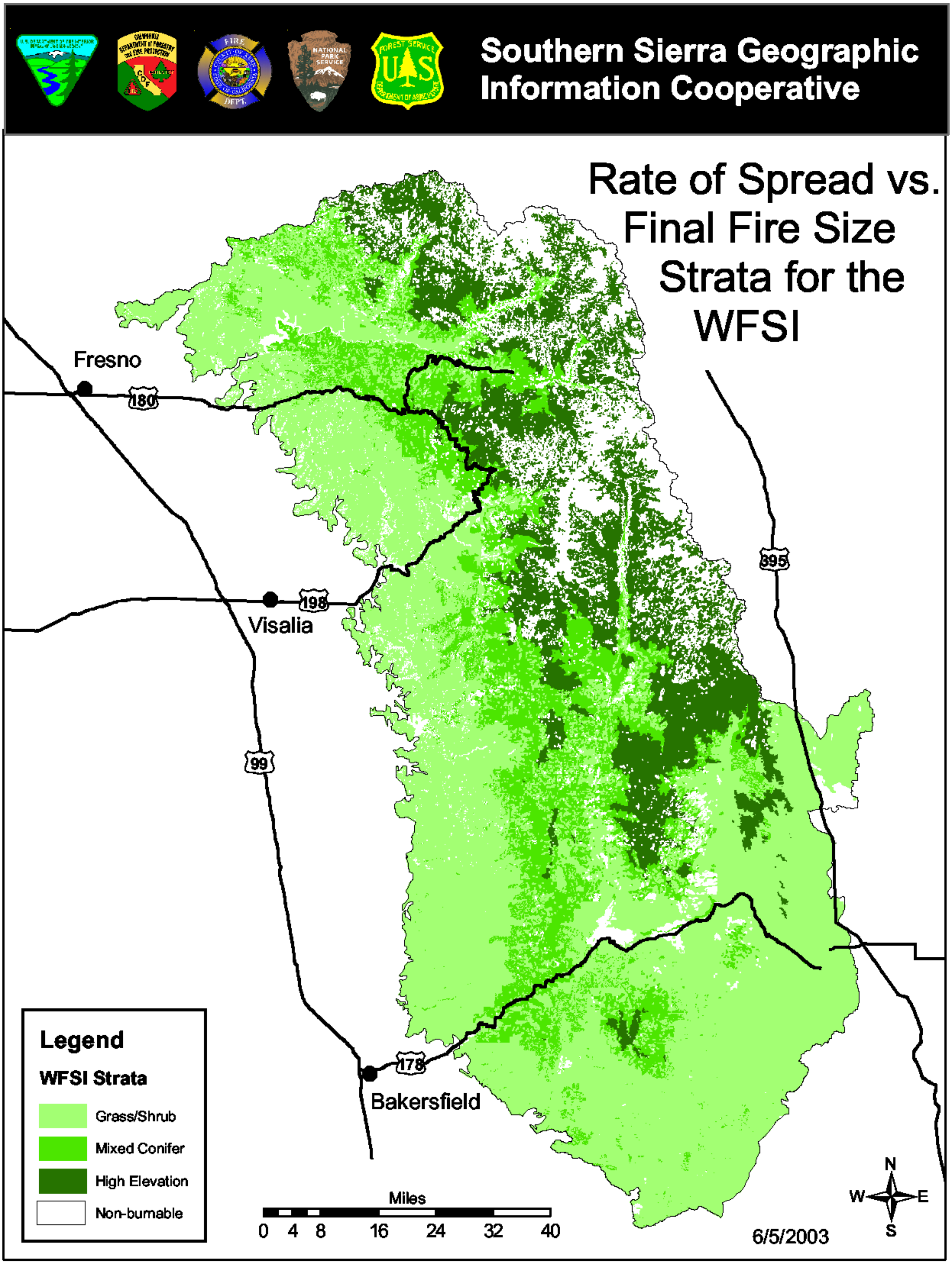

Figure 2-17 Vegetation strata used for WFSI regression equations relating rate of spread to final fire size.

Table 2-12 – Coefficients of regression equations used to predict FFS, acres from ROS (chains / hr).

Equation: $FFS = E + A(ROS)^B + C(ROS)^D$			
Coefficient	**Grass/Shrub**	**Mixed Conifer**	**High Elevation**
A	0.02339	-0.01128	0.0268
B	3.607	3.013	3.771
C	-0.02237	0.01626	0.0268
D	3.561	3.041	3.771
E	0.1	0.1	0

These relationships between ROS and FFS for each of the three strata are shown in Figure 2-18.

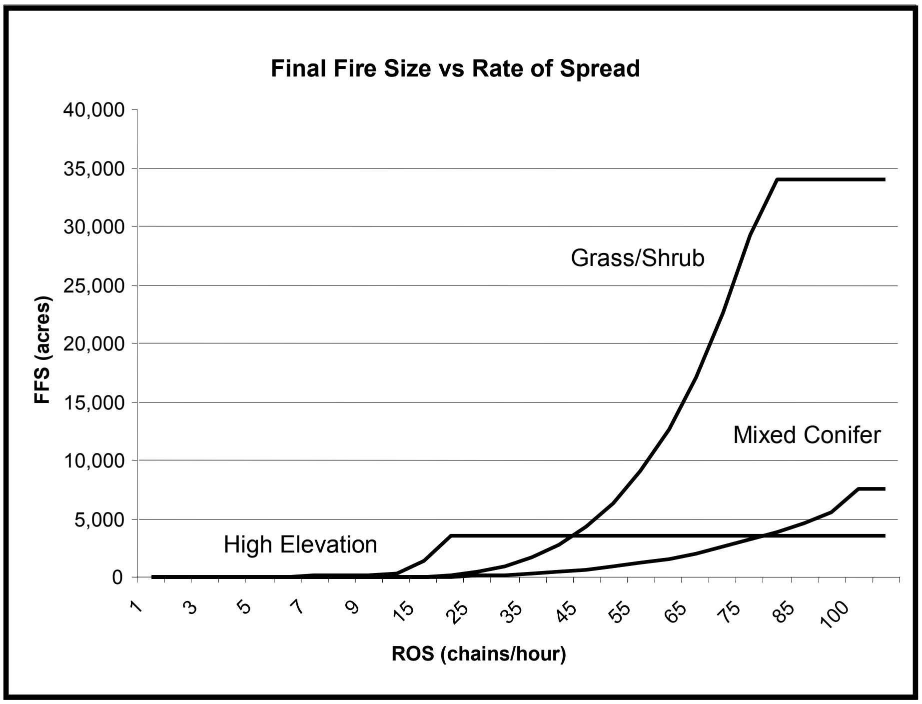

Figure 2-18 Relationships between final fire size and rate of spread used for analyses.

Step 5 – Create grid of FFS. The equations developed (above) were applied to the ROS grid created by FlamMap for each weather category to produce a FFS grid for each of the three strata. The FFS grids for the three strata were then combined to create a single FFS grid for each weather category.

Step 6 – Calculate the WFSI. The WFSI index is the sum of the probabilities over all (four) weather categories:

$$WFSI = \sum \frac{FFS * (\text{Number of Total Ignitions in FOA})}{(\text{Number of Acres within FOA})}$$

An example of the calculation of WFSI for a single cell is presented in Table 2-13.

Table 2-13 — Example calculation of WFSI for a single cell. Values are not actual data but designed for ease of calculation. This example assumes a 20,000 acre FOA class with 50 historical fires. The calculated probability of ignition for this FOA class is 2.5 ignitions/1,000 ac/yr using hypothetical values.

Example Calculation of WFSI Value for a Single Cell					
	Weather Percentile Category				Total
	Low	Moderate	High	Extreme	
Weather percentile categories (by definition)	0-15	16-89	90-97	98-100	
Percent of days in each category (by subtraction of above)	15	74	8	3	100
Range of Spread Components in each weather category as predicted by Fire Family Plus	0-9	10-19	20-39	40+	
Percent of ignitions that occurred in each weather category based on ignition date link to weather data	10	80	4	6	100
Predicted number of ignitions based on percentiles from above row	5	40	2	3	50
Average ROS from FlamMap (chains/hour)	2	5	10	20	
Final Fire Size based on ROS above and regression equations (acres)	4	25	200	400	629
Predicted annual acres burned (number of ignitions above x FFS)	20	1000	400	1200	2620
Probability of an acre burning (Predicted annual acres burned/acres in FOA class)	0.001	0.05	0.02	0.06	0.131
	WFSI for a cell is the sum of the probabilities of an acre burning across all four weather percentile categories				

2.3.4.4 Results

The resulting map of WFSI is shown in Figure 2-19. WFSI values have been grouped into 10 classes for display. WFSI is greatest in areas where both FOA and FlamMap ROS are high (e.g. lower Kern River canyon).

2.3.4.5 Recommendations

WFSI results depend strongly on FOA and are biased toward zero where FOA values are biased toward zero. Very low or zero values of WFSI occur where values of FOA are zero. Elimination of the zero FOA class would substantially increase WFSI values especially where high values of FlamMap ROS occur. WFSI could be recalculated after FOA values are reclassed to include a probability of ignition greater than zero in the lowest FOA class.

WFSI as calculated here is suppression oriented because of the data used to relate ROS to FFS. Since these data were from suppressed fires the curves derived may not be appropriate for other fires. This is especially the case for NPS lands where a full suppression policy is not implemented. As an alternative, two sets of WFSI indices could be calculated – one representing a full suppression strategy and the other representing fire use.

Additionally, more than one weather influence zone might be implemented in the WFSI analysis.

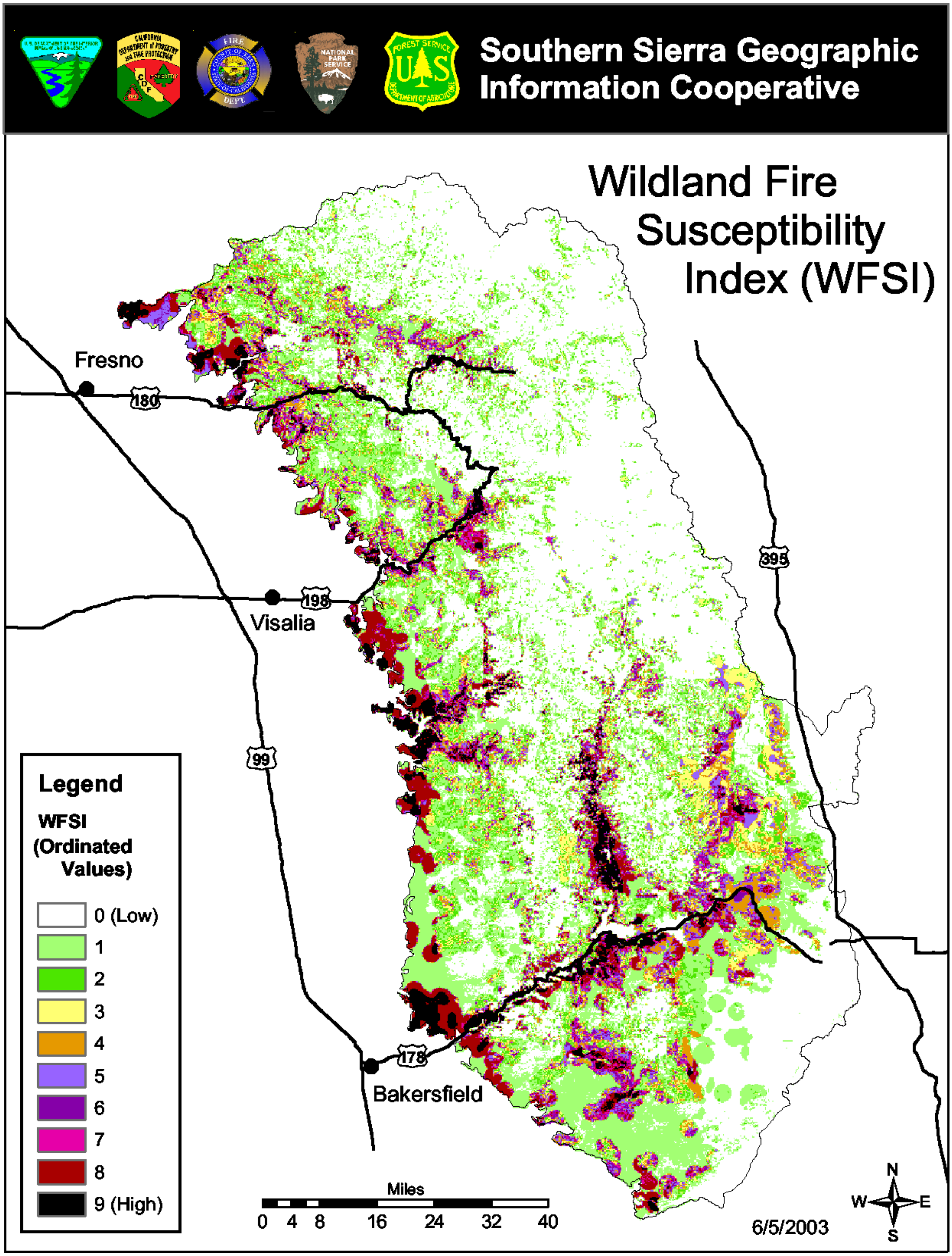

Figure 2-19 Wildland Fire Susceptibility Index (WFSI) for the SSGIC analysis area.

2.4 Asset Analyzer ArcView Application

2.4.1 Introduction

Asset Analyzer is a decision support tool that allows users to weight and compare alternative scenarios using multiple input themes. The main inputs are spatial data (as two or more raster grids) that quantitatively represent landscape variables. The output is a weighted-average grid of the input grids based on weights formulated by the user. Asset Analyzer facilitates grouping output values into a user-defined number of classes that can be readily visualized. A user can specify several different sets of input themes, weight each theme differently, and produce many different scenarios for examination. Asset Analyzer, developed through a contract with Space Imaging Inc., is implemented as an extension for ArcView 3.x that requires Spatial Analyst. The extension was designed and developed as a tool that can be used by an ArcView user with beginning technical skills and no Spatial Analyst experience. However, the user must understand the concepts of raster data and data re-scaling (or normalization). The Asset Analyzer extension is available for download on the SSGIC web server (http://ssgic.cr.usgs.gov) by following the links to Find Documents/Analysis Tools.

2.4.2 What does Asset Analyzer do?

Asset Analyzer produces a weighted-average grid. The user supplies suitable input grids (containing integers with each cell having a value between 0 and 100) and assigns a weight for each grid. Then Asset Analyzer computes a weighted-average grid for the user-supplied inputs. For an example of this calculation see Figure 2-20. This example shows the use of three input grids (sequoia grove locations, soil erosion potential, and predicted crown fire activity). Values in each grid are scaled between 0 and 100. Weights have been assigned for each grid (50% for sequoia grove locations, 25% for soil erosion potential, and 25% for predicted crown fire activity). Asset Analyzer calculates a weighted-average grid based on the values and weights assigned to the three input grids. Note that individual grid cells are not shown in this example. The polygons depicted in Figure 2-20 simply outline areas that might contain hundreds of square grid cells. In actual use, a weighted average is calculated for each cell in the grid.

After the weighted-average grid is calculated, Asset Analyzer then re-scales (or normalizes) the values to between 0 and 100 (Figure 2-21). Then, Asset Analyzer can categorize the normalized values into classes specified by the user. The boundaries of the classes (class range is 2 - 5 groups) into which Asset Analyzer will categorize the output values (see Figure 2-22) are entered into Asset Analyzer by the user. Asset Analyzer will suggest default values for the class boundaries, but also provides a histogram of the output grid values to aid in choosing class boundaries.

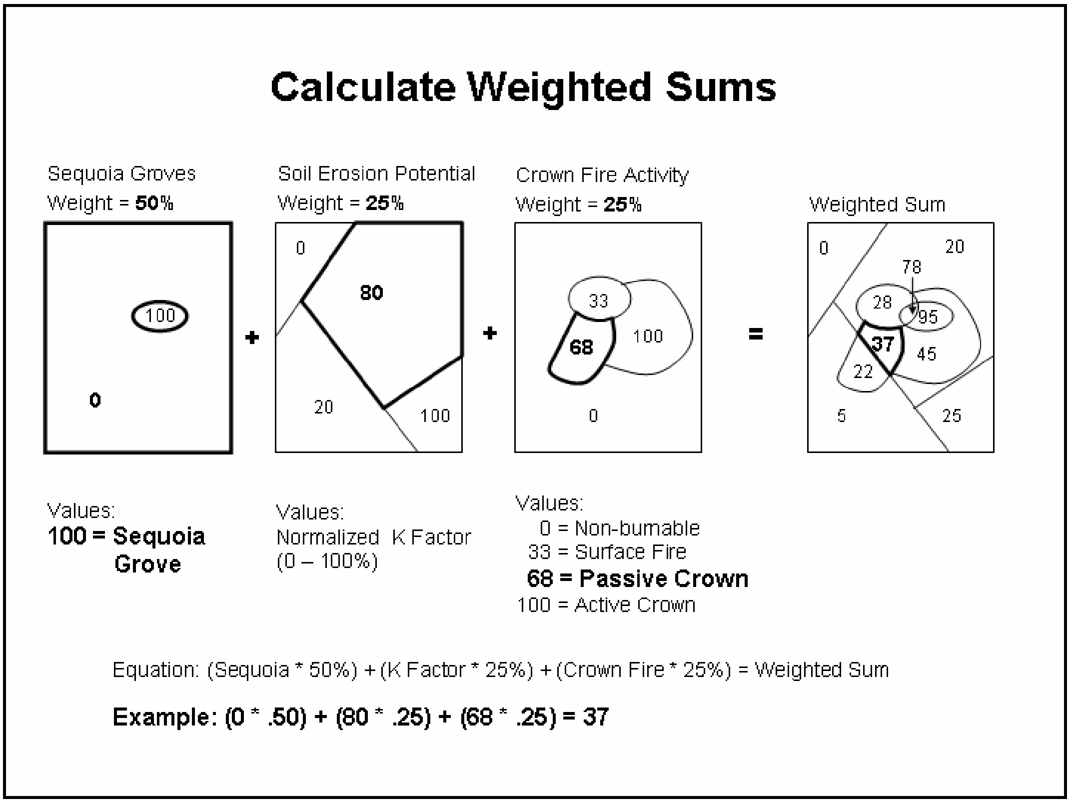

Figure 2-20 Asset Analyzer calculation of weighted average

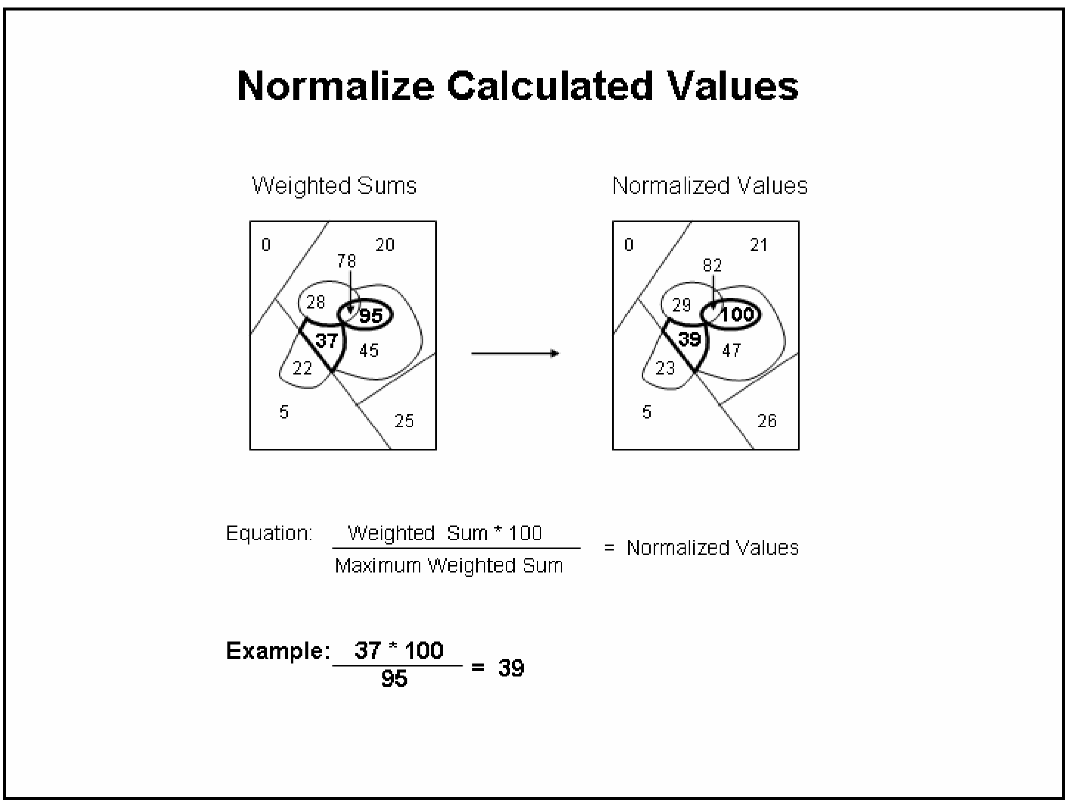

Figure 2-21 Asset Analyzer normalization of weighted average values.

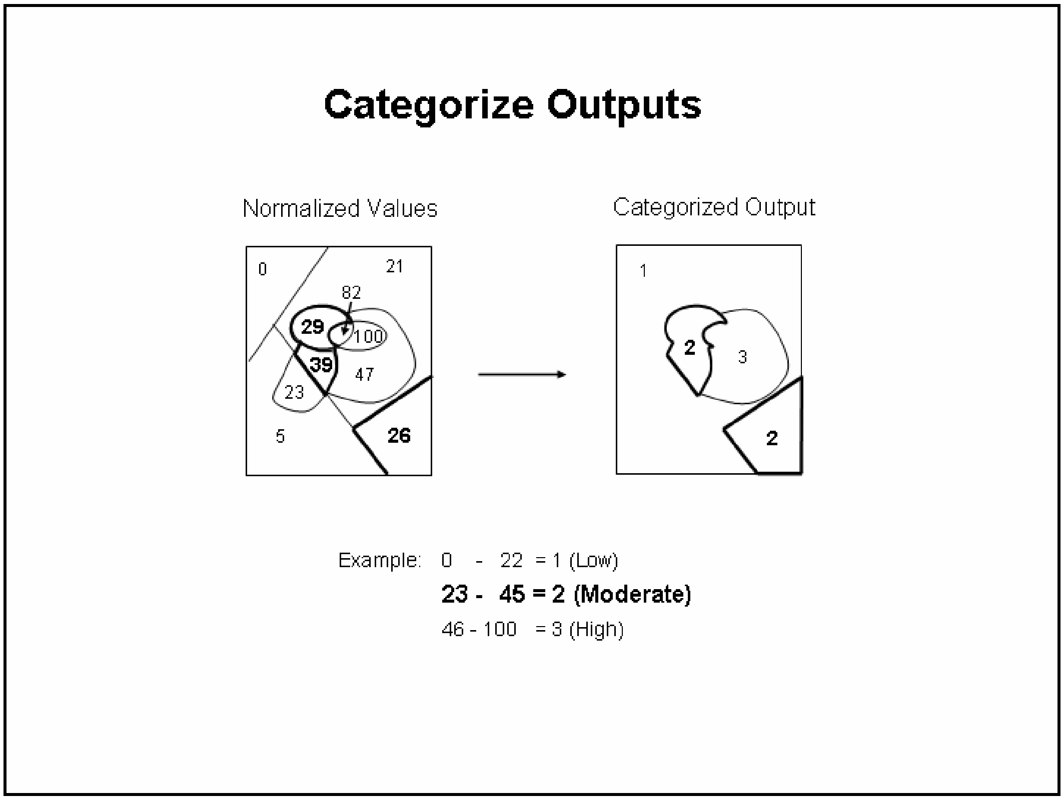

Figure 2-22 Asset Analyzer categorization of weighted average values.

For a more thorough introduction to the Asset Analyzer application, see the Asset Analyzer User Manual at http://ssgic.cr.usgs.gov.

2.5 Development of Fuel Treatment Plans

2.5.1 Integration of Risk, Hazard, and Value

The final step in the SSGIC analysis was the integration of risk, hazard, and value into a final product that could be used for project level planning and analysis. This process identified high-priority fuels treatment areas across the entire 4.8 million acre southern Sierra Nevada. The process began with selection of a subset of the datasets that fire managers felt suitably represented risk, hazard, and value. Then, Asset Analyzer was used to explore scenarios that weighted each factor differently to achieve a meaningful treatment prioritization scheme.

In the first phase, fire managers selected seven datasets to represent risk, hazard, and value for the integration analysis. These datasets were Fire Occurrence Areas, Fire Return Interval Departure, Confidence in Fire Return Interval Departure, Threatened Wildland Urban Interface, Firefighter Risk, Flame Length (FlamMap) and Crown Fire Activity (FlamMap). The selection of these datasets resulted from experience using Asset Analyzer with many datasets and observing the outputs. Experience demonstrated that including too many datasets in the analysis "watered down" the outputs and made it difficult to understand the sensitivities of the final output to the various input themes. Fire managers decided to exclude the WFSI index because it masked the individual contributions from FOA and FlamMap. Social/economic values layers were excluded because they become important only at the project-level and this initial analysis was at the landscape-level.

These seven datasets were used with Asset Analyzer in ten different weighting schemes to identify a single alternative scenario that best represented the mix of input datasets for identifying highest priority fuel treatment areas.

2.5.2 Data Processing

The seven datasets were prepared for use with the Asset Analyzer by converting to raster grids and assigning normalized values between 0 and 100. High values in the datasets corresponded to high values of risk, hazard, or value. Thus, a weighted average calculated across these datasets would represent the range from low risk, hazard, and value to high risk, hazard, and value. A description of values assigned to each dataset and the processing follows.

FOA – Eight categories based on 20 years of historical ignition data. Units of the original data are ignitions per 1000 acres per year. Category 8 (normalized to 100) represents more than 2 ignitions per 1000 acres per year.

FRID – Five categories defined by the number of Fire Return Intervals (FRI) missed follow:

Number of Fire Return Intervals Missed	Normalized Value Assigned
N/A (Non-burnable)	0
0	25
1-2	50
2-5	75
5-16	100

FRID Confidence – The level of confidence in the FRI is highly dependent on the vegetation type. For example, sufficient data has been collected in the ponderosa pine type to feel confident in the FRI values. However, very little data is available on FRI's for grasslands or desert types. Consequently, the value placed on the FRID in an analysis may be dependent on the level of confidence in the data. Categories are:

FRID Confidence	Normalized Value Assigned
Non-burnable	0
Estimate	25
Very Poor	50
Poor	75
Good	100

Threatened Wildland Urban Interface (WUI) – This dataset was provided by CDF. It contains one and one half mile buffers around federally identified WUI areas (housing densities greater than one house per 40 acres in wildland fuel types). Assigned values of 33 (low), 68 (moderate), or 100 (high) are based on a combination of hazard rank and fire probability.

Firefighter Risk – This theme was developed implementing the Sequoia and Kings Canyon National Parks model for firefighter risk. Five datasets contributed to the model and a weighted sum was calculated and values of low (33), moderate (68) or high (100) assigned.

Flame Length (Extreme Weather) – This dataset was generated by FlamMap and predicts flame length. The extreme weather category (98-100 weather percentiles) was selected to focus on the most severe behavior. The classifications were derived from the Hauling Fire Characteristics Chart (National Wildfire Coordinating Group (NWCG) Fireline Handbook) descriptions of initial attack strategies. They are:

FlamMap Flame Length (ft)	Initial Attack Strategy	Normalized Value Assigned
N/A (non-burnable)		0
0 – 4	Direct attack with hand crews	25
4 – 8	Direct attack with equipment such as engines and retardant	50
8 – 11	Indirect attack of fire required	75
> 11	Indirect attack unlikely to be successful	100

Crown Fire Activity (Extreme Weather) – This dataset was also generated by FlamMap and predicts crown fire behavior. The extreme weather category was selected to focus on the most severe behavior. A value of 33 represents predicted surface fires, a value of 68 predicts passive crown fires, and a value of 100 represents active crown fires.

Asset Analyzer was used to calculate weighted averages of these datasets using various weightings. Ten alternative scenarios, composed of different sets of weightings, were investigated (Table 2-14). Output values from Asset Analyzer were grouped into six classes ranging from low priority (0) to high priority (5) for display and analyses.

Table 2-14 –Weights applied (%) to each dataset in ten scenarios. Scenario 2 was selected for use in identifying high priority fuels treatment areas.

Dataset	Scenario Number									
	1	2	3	4	5	6	7	8	9	10
FOA	14	**17**	17	20	0	0	0	0	0	0
FRID	14	**17**	17	20	25	20	12	25	52	12
FRID Confidence	14	**13**	0	0	0	0	0	25	0	0
Threatened WUI	14	**17**	17	20	25	20	52	25	12	12
Firefighter Risk	14	**0**	17	0	0	20	12	0	12	52
Flame Length (Extreme Weather)	14	**17**	17	20	25	20	12	25	12	12
Crown Fire Activity (Extreme Weather)	15	**18**	17	20	25	20	12	0	12	12

2.5.3 Results

Each of the ten asset analyzer output alternatives or scenarios were mapped and evaluated by fire managers in the fall of 2002. Evaluation of the ten scenarios by the fire managers showed that a good range of alternatives were represented. Ultimately, fire managers selected a scenario based on their experience, local area knowledge, and represented a distribution of mapped values that optimized visual discrimination for selecting high priority target areas.

The scenario selected for use in identifying high priority fuels treatment areas was Scenario 2 (Figure 2-23). The source datasets in Scenario 2 included measures of Risk, Hazard, and Value (Ecological and Social/Economic) – the three primary elements of the SSGIC analysis process. In Scenario 2, all datasets were approximately equally weighted (~17%) except for the lower weight given to FRID Confidence (13%). This scenario included six of the seven datasets, excluding only Firefighter Risk. This layer reduced fire managers' capacity to discriminate and prioritize between different areas. Specifically, high-valued Firefighter Risk areas were so widespread and prevalent across the landscape that it didn't contribute any additional discrimination value to the analysis. Public and firefighter safety will continue to be a primary consideration in all fire planning and operational decisions.

2.5.4 Identification of Priority Fuel Treatment Areas

The results from Scenario 2 were used by fire managers to identify fire management strategy zones that should be high priority fuel treatment areas. These areas were identified as the best candidates for collaborative interagency fuel treatment areas. Five areas were identified (Figure 2-24) that comprised 1.9% of the total analysis area (Table 2-15). These target areas had a greater proportion of land in high-priority classes than the SSGIC analysis area as a whole (Table 2-15).

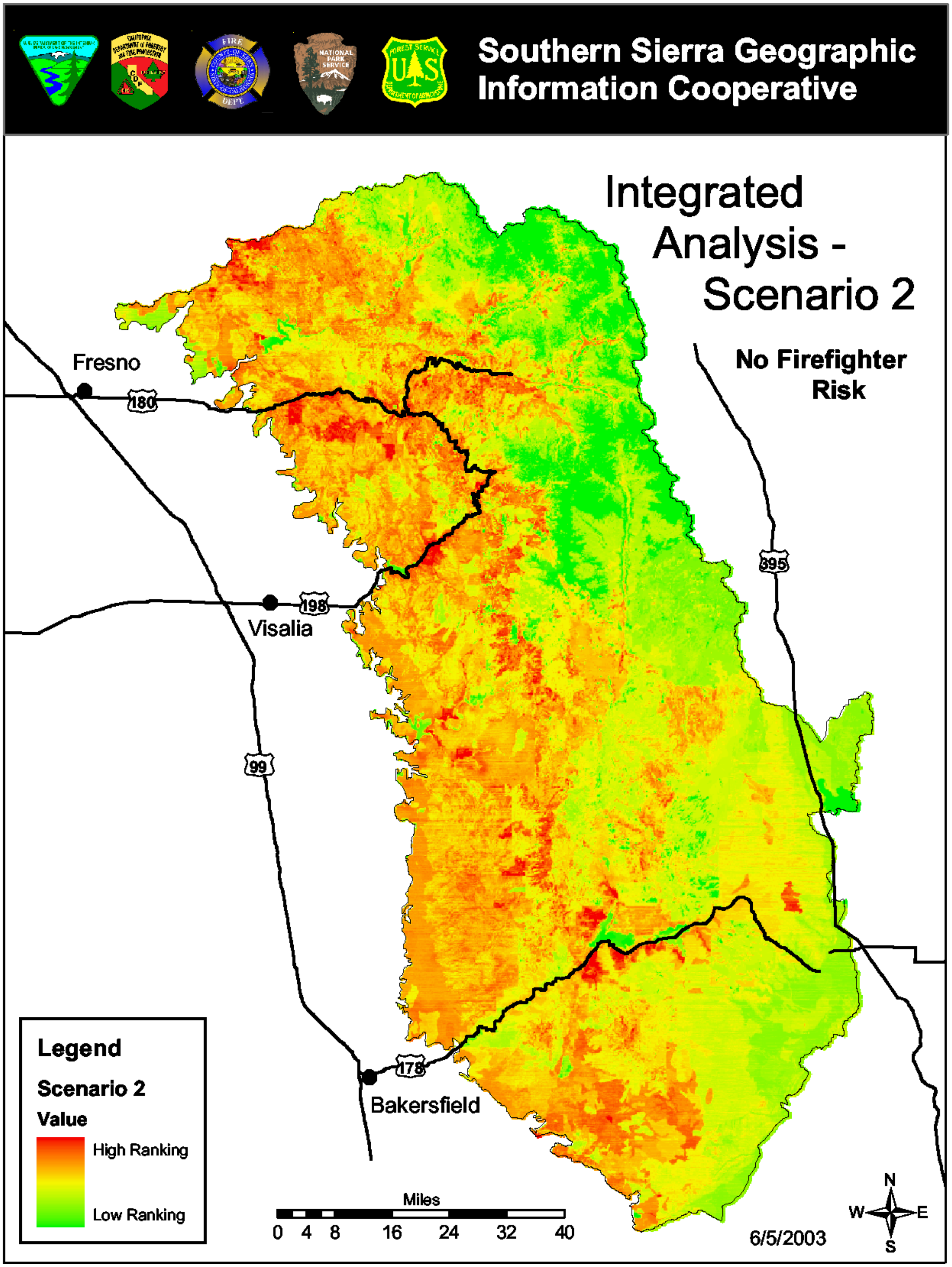

Figure 2-23 Scenario 2 of the integrated analysis. This scenario included six factors but did not include the Firefighter Risk layer.

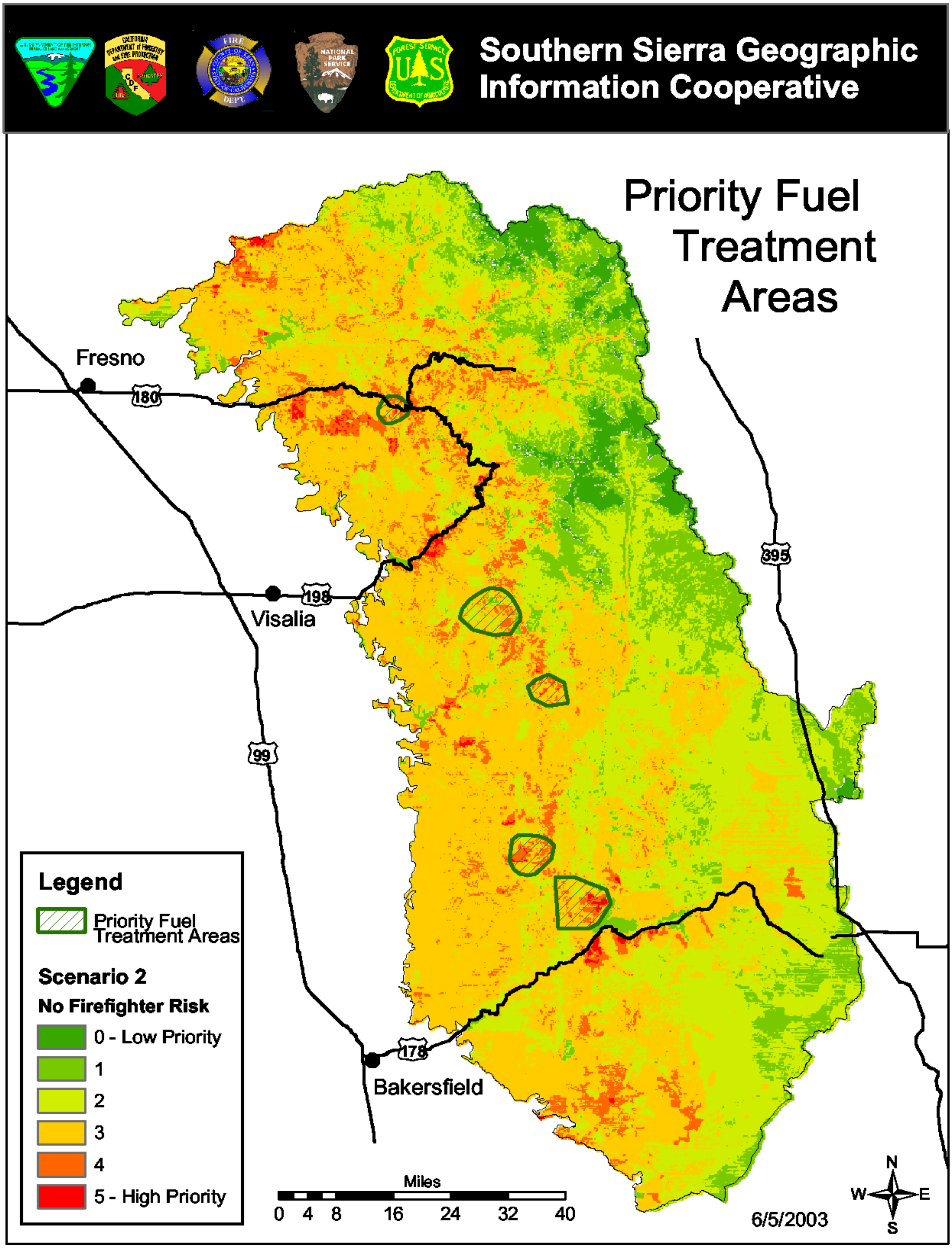

Figure 2-24 Priority Fuel Treatment Areas

Table 2-15 – Distribution by priority class of land area in target areas defined from Scenario 2 analysis compared to entire SSGIC area.

Priority Class		Entire SSGIC Area acres	percent	Target Areas acres	percent
Low	0	194,811	4.1	17	0.0
	1	608,250	12.7	3,821	4.2
	2	1,728,987	36.2	20,165	22.0
	3	1,743,528	36.5	40,992	44.6
	4	471,182	9.9	23,046	25.1
High	5	32,715	0.7	3,837	4.2
	Total	4,779,473	100.0	91,878	100.0

Finally, the five target areas were collaboratively defined by fire management staff. A set of decision rules used by managers were then captured that had been effectively employed in identifying the target areas. These decision rules could potentially be used to automate the process of identifying priority fuel treatment zones in complex multi-agency areas. Although a GIS model that includes these decision rules was not developed, it is believed to be feasible and should be considered as part of a future initiative. However, any GIS model should not replace the professional judgment of fire specialists and managers. It should only be considered a tool that can help fire managers with decision-making. These decision rules included:

- Focus on areas within one mile of agency boundaries or in a two-mile total buffer zone.
- Remove areas of fuel types not usually treated with fuels reductions (e.g., grass, blue oak woodland).
- Focus on areas where fuels reduction is an effective fire management strategy (as opposed to areas where suppression or prevention would be more effective).
- Focus on areas with a high probability for successful planning. For example, areas with a few large landowners may provide easier planning than areas with many small landowners.
- Consider cost effectiveness and feasibility of implementing the treatments, and the availability and proximity of the work force.
- Define analysis units as ecological units rather than arbitrarily drawn polygons.
- Consider the requirements for planning documents and other constraints.
- Identify questionable areas and review analytical outputs, quality of source data, and data processing in those areas.
- Recognize that professional judgment is an essential part of the analysis process that cannot be “modeled.”

2.5.5 Recommendations / Conclusions

The completion of the analysis and the establishment of a process for collaborative fuels treatment met the SSGIC goals identified in Section 1.2. The process was time-consuming and complex, but will be easier to replicate and update in the future with this newly established analysis and planning framework. Further, when fire managers and technical staffs are involved in the planning and analytic process throughout the planning cycle (start to finish), identification of optimal treatment areas will have wider interagency support and better decision-making. It is essential to use a goal-driven planning framework with interagency development and implementation of goals. Future activities, beyond the scope of the present project, would include the development of project fuel treatment plans, preparation of environmental compliance documents, and actual implementation of fuel treatments.

3 SSGIC Information Delivery via the Web

3.1 Overview of Website

The SSGIC chose to provide continuous 24/7 access to data and analyses via the internet by developing a website (http://ssgic.cr.usgs.gov/). The website allows public access to information and requires only Internet browser software (e.g. Netscape, Internet Explorer) for accessibility. Content developed by SSGIC, including many map products, is provided using existing commercial software and hardware technology. Of particular importance is the use of ArcIMS -- Internet Mapping Server software by Environmental Systems Research Institute (ESRI), Inc. – to serve dynamic interactive maps of SSGIC analyses.

The SSGIC webserver is hosted by the USGS, Rocky Mountain Mapping Center in Denver. They provide the wide range of networking, web server administration, ArcIMS support, GIS services, and Oracle/SDE administration expertise needed, as well as high-speed internet access. The Center provides physical space, firewall protection, server setup and administration, access to and administration of SDE 8.2 running on Oracle 8i for spatial data, GIS technical support, ArcIMS support and custom programming, website maintenance and development.

The website is served by an IBM Netfinity server with dual XEON 700 MHz processors and 4 GB RAM. It has 253 GB of disc storage configured as two level 5 RAID arrays. The installed software includes the Windows 2000 operating system, Apache with Tomcat Servlet web server software, ArcIMS 3.1 interactive mapping software, and custom web applications written in Cold Fusion 4.51.

3.2 Design and Use of the SSGIC website

The use of an internet website provides a common platform among SSGIC agencies for distribution of data and avoids potential agency-specific roadblocks to data distribution. Another advantage of the internet website is that it does not require any local client GIS software. The internet map serving software (ArcIMS) allows users access to map services using only their web browser. Additionally, ArcIMS managers require minimal additional software to upload data and create their own map services.

The website was designed to be scalable so that the local agencies can use it to meet other agency centric needs. In order to accommodate any agency-specific map services, each agency has been provided with their own website located at http://ssgic.cr.usgs.gov/"agency". Each agency also has its own digital storage space and access to Oracle/SDE.

The SSGIC provides website support to local agencies. To assist them, the SSGIC is preparing an ArcIMS "cookbook" with step-by-step instructions for each agency's ArcIMS manager as well as information specific to our installation of ArcIMS and website. This will allow them to perform entry level tasks quickly since they are all supporting SSGIC as collateral duties. The USGS has been a critical link in providing high level technical support beyond the expertise of most local land management units.

The website has been designed to accommodate expansion. The ability to expand to other geographic areas is readily apparent, but the expansion could also be to other agencies (such as the US Fish Wildlife Service which has jurisdiction within part of the SSGIC area). Also, expansion could occur into other resource fields, such as wildlife, exotic weeds, hydrology, etc. Other users, even if not interested in fire data and analyses, could use our seamless, best available base datasets.

3.3 Information Available on the SSGIC website

The SSGIC website provides ArcIMS map services, downloading of data, and SSGIC documentation.

ArcIMS Map Services. Interactive map services are available on the website including an overview map and all analyses completed by the SSGIC (FOA, FRID, FlamMap, WFSI, Assets, fire history, fuel treatment areas and Scenario 2). The entire SSGIC area can be viewed, or the user can select a single watershed or an individual agency to speed the process. Interactive features in common to all map services are tools to navigate the map, identify a selected map feature, query a map layer, measure distances, and print a map to a local printer. The user can control which information is displayed, and get additional help, including viewing the metadata on the currently active map. Robust help is available describing each tool (button) available in the map service and information on each map layer available.

Data Available for Download. All datasets developed by the SSGIC are available for download and include Federal Geographic Data Committee (FGDC) compliant metadata in zip files. The file format used for spatial data is the ArcInfo Interchange File (e00 extension) which can be imported by a variety of GIS programs including ArcView, ArcInfo, and ArcGIS. Data are available for the entire SSGIC analysis area as well as clipped by watershed to keep file size (and therefore download time) to a minimum if only a subset of the data is needed. Metadata can be viewed prior to download. All files can be selected via a file system interface familiar to most users as the Microsoft Windows Explorer or Netscape. Additionally, Digital Raster Graphics (DRG) quadrangles and Digital Ortho Photo (DOQ) quarter quads are available. The desired quad can readily be selected via a map interface rather than requiring the user to input the quad name.

SSGIC Documentation. Documents that describe SSGIC activities and accomplishments can be downloaded from the Document Library on the SSGIC website. Documents available include summary notes from all SSGIC meetings and workshops, SSGIC goals, agreements, posters, contact information, annual accomplishment summaries, and server file structure and file-naming convention documentation. Most documents are in PDF format. The Asset Analyzer extension is available for download by following the links to Find Documents/Analysis Tools.

3.4 Overview of Security Plan

The SSGIC contracted with The Root Group of Boulder, CO to prepare an Information Technology Security Plan for our server (The Root Group, 2003). The plan includes an evaluation of the current security status of the server and recommendations to correct discovered weaknesses. The plan addressed security controls at three levels: management, operational, and technical. Many of the security vulnerabilities identified have been corrected. The majority of the remaining issues will be resolved in the fall of 2003.

A major finding of the plan was the potential sensitivity of data and analysis outputs from a homeland security perspective, such as FlamMap outputs identifying areas with the potential for extreme fire behavior. The SSGIC proposes national identification of sensitive fire-related data and their subsequent regulation. The security plan notes the significant implications of imposing this increased level of security on the server.

Another major finding of the plan was the security limitations imposed by the ArcIMS software. Currently, there is no user-level data control within ArcIMS. This means that although access is controlled to data uploaded by individual agencies, once those data are incorporated into an ArcIMS map service they can be displayed by any agency.

Although the Information Technology Security Plan is considered sensitive information, the final report can be made available to other federal or state fire and land management agencies upon request.

4 Evaluation and Conclusions

4.1 Findings, Recommendations and Lessons Learned

During this three year project, the SSGIC fire managers and technical staffs became convinced that *collaborative* interagency planning and implementation, as well as *collaborative* fire and fuels information development and management were essential to long-term successful fuel treatments across complex landscapes in the southern Sierra Nevada. Mandates requiring collaboration exist (Interagency Federal Wildland Fire Policy Review Working Group, 2001; Western Governors Association, 2002), but managers found that collaborative planning and treatments are key for improving agencies effectiveness by identifying optimal treatment areas, treating these areas, and subsequently measuring the short and long-term effects of treatment activities.

Ongoing national efforts to bring consistency and efficiency to fire management planning and implementation should be encouraged and accelerated. Examples include the interagency Fire Program Analysis System (under development), as well as other efforts such as the Geospatial Task Group. The acquisition and use of new technologies that foster cooperation and collaboration across large landscapes and datasets should be embraced and made widely available.

As a result of three years of experience, SSGIC fire managers and technical specialists recommend that the National Fire and Aviation Executive Board (NFAEB) consider implementing and expanding this report's recommendations nationwide. Many of the recommendations dovetail with and underscore trends that are becoming evident throughout the fire community.

It is clear that many of the obstacles that hindered the SSGIC's ability to effectively collaborate were beyond the control of a single federal-state-local partnership such as ours. Without clear national strategies, policies, and support for improving interagency fuels treatment collaboration, field areas will continue to be relatively ineffective at proactively treating fuels across complex multi-agency landscapes.

Although the scope of this project focused on collaborative fuels treatments and planning, many of this report's recommendations would be fully applicable to other fire business activities such as environmental compliance, budget planning, smoke forecasting, use of wildland fire, dispatch and initial attack, suppression activities, and public education and information.

Findings, recommendations, and lessons learned from the SSGIC project are grouped into five categories: Organization and Human Resources, Data Development and Management, Analysis, Web/Technology, and Interagency Planning.

4.1.1 Organization and Human Resources

Collaborative, interagency fuels treatment planning based on the best available science is possible, but not easy. To develop the SSGIC program, concurrence and support from upper management and line officers was necessary, and was eventually obtained from all cooperating agencies. However, long-term benefits from the SSGIC can only be realized if future efforts are “institutionalized” and integrated into each of the local participating agencies workplans and organizational cultures.

The obstacles to accomplishing the interagency fire and fuels planning goals of the SSGIC were varied and included different agency planning cycles, unique agency cultures, different data management practices, different planning and reporting software, and agency-specific missions. Section 4.1.2 addresses significant issues affecting the development and use of high quality fire data for conducting reliable analysis.

Collaborative planning activities were generally considered a collateral duty for employees participating in the SSGIC effort. Consequently, these activities have not been recognized as part of most individual’s workplan or evaluations. There are no corporate reward or recognition systems for successful collaboration and thus collaboration is not included in agency goals resulting in few incentives to do so. A mandate to collaborate without any local incentives or disincentives is ineffective. As an example, a National Park Service fire management officer who helps another local, state, or federal agency in a neighboring area with complete a high-priority fuels treatment does not have any performance metric that would recognize this assistance. This may foster frustration particularly if an interagency landscape-based analysis determined that the highest-priority treatment area was outside the National Park boundary. The existing performance system is set up to foster competition between agencies instead of cooperation between them.

The solution for increasing collaboration requires more than simply providing more funding. The technical, management, and political complexities of interagency collaborative fuels planning and treatments are one of the most difficult tasks facing fire managers, yet there does not appear to be clear national level guidance or expectations on *how* agency personnel should collaborate or even how their performance should be measured.

Recommendations:

- The NFAEB, in concert with state and local wildland fire agencies, should develop clear guidance and metrics for measuring interagency fuels treatment accomplishments outside of intra-agency fuels planning and treatments. The new metrics should foster and reward cooperation between agencies over competition between them.

- NFAEB should direct the development and implementation of a comprehensive national strategy and framework for developing, managing, and delivering fire and fuels data and analyses. This framework should be developed collaboratively with state and local wildland fire agencies. An example of a potential national fire and fuels data framework strategy is presented in Section 4.1.6.

Interagency collaboration has high value, but it is also complex, time consuming, and expensive. To effectively and efficiently collaborate, local agency personnel should be educated on the mechanics of collaboration as well as how to foster a work environment and culture where collaborative fuels treatment planning and implementation becomes a standard business practice, rather than the exception.

The SSGIC experienced interagency collaborative difficulties in areas such as gaining interagency participation, competing collateral duties, and lack of institutional support. Early in the development of the SSGIC much discussion centered around who should participate. The decision was not easy or clear, but one factor agreed on was that the group should be geographically limited so that participants could complete round-trip travel to a common meeting location in one day. Another difficulty was that since participation in the SSGIC was a collateral duty for all involved, making progress in a program of this complexity was slow. To remedy this situation, in the second year a full-time program manager was hired to implement the SSGIC action plan.

Effective interagency fire and fuels planning in a complex multi-agency landscape will require full-time dedicated positions. The SSGIC found that using existing personnel and adding new collateral duties added significant new workload stresses. Existing personnel are essential to any successful interagency initiative, but the added workload requires additional fiscal and personnel resources. For the long-term support of an interagency program such as the SSGIC, new personnel strategies and creative thinking for accomplishing interagency work should be adopted and implemented.

Recommendations:

- The NFAEB should consider new personnel and organizational strategies for implementing interagency fuel treatment practices across increasingly complex landscapes. Within the SSGIC, the participating agencies identified a variety of new roles essential to successfully implementing an interagency ecosystem-based fuels treatment program that develops and uses best available data and information. The Southern Sierra 2003 cost estimate for developing and maintaining an interagency fuels treatment program that includes 24/7 access to best available data and maps is approximately $500,000 annually. This new program would be roughly based on the original Joint Fire Science Goals, but would be expanded to include: coordinated data management, compliance, and fuel treatments. Data collection would be coordinated and collected across agencies rather than They recommend creating the following positions for the 4.8 million acre ecosystem:

    - Interagency fire program coordinator (GS-13),
    - Interagency fire planner (GS-12),
    - Interagency GIS/Database specialist (GS-11), and
    - Interagency fire ecologist (GS-11)

    These could be newly created positions, or several could potentially evolve from existing positions. Existing positions could be restructured to include interagency responsibilities “hosted” by an agency. For example, SEKI has a Fire GIS specialist and Sequoia NF has a Fire Planner. These positions could remain where they currently exist administratively, but duties would be modified to include interagency responsibilities with new accountability standards. An additional $150,000 ($500,000 total annual costs) would be needed annually to fund outsourcing activities and contracting related to fire and fuels data development, management, and delivery. Funding would be used to support activities including interagency image acquisition, photo interpretation and image classifications, software acquisition and development, computer server support, site-level data collection efforts, local interagency training, and database design and consultation. These funds would be used to shift data collection, management, and delivery from an agency-centric focus to an interagency focus.

  The SSGIC interagency team believes that this additional $500,000 annual expenditure for four positions plus support would result in a very high long-term benefit/cost ratio and would lead to a long-term reduction in suppression costs within the southern Sierra Nevada. Further, we would expect to see long-term reduction in property damage and resource loss and increased ecological benefits across multi-agency landscape areas (as an example of the cost/benefit, that same $500,000 would replace 1 or 2 burned homes within the SSGIC). With increased interagency collaboration, we would expect to see better coordinated smoke management programs, less controversial and more comprehensive environmental compliance, more effective initial attack, and consistent and reliable data and information being presented to agency staffs and the public.

4.1.2 Data Development and Management

Practices for collecting, managing, and analyzing fire and fuels data were and continue to be inconsistent between agencies. Each agency has established specific business practices regarding data standards and management that present challenges to an interagency effort such as the SSGIC. This frequently results in integrated "lowest common denominator" data that will usually have reduced accuracy and precision. Ultimately, reliability and confidence in the data and any subsequent analyses will be reduced.

An additional complication is that many of these data are dynamic and change frequently. As an example, fire history records change each year as new ignitions occur on the landscape. Fuel data change annually as new disturbances, such as fires, logging, urban interface developments, impact vegetation and fuels. These kinds of data are used in a variety of models which must be run each year to incorporate the dynamic changes to be able to adequately measure the benefits of fuel modifications. Not every agency has protocols for managing these dynamic data, and where protocols do exist, they generally differ among agencies. Further, the expertise for managing dynamic data does not exist within every local agency so that support from cooperator agencies (or new interagency positions) is essential.

These issues result in frustration and an inability to effectively develop and manage multi-source data, run computer analyses using good input data, and ultimately may reduce the reliability of decisions that are made. Further, local fire management staffs may be skeptical of using the information because of its inherent faults, and continue to exclusively rely only on local expertise, institutional memory, and "seat-of-the-pants" decisions. While local "on-the-ground" knowledge should be an integral part of any important fire management decision, when used exclusively it may impede collaborative fuel treatment decision-making and makes it difficult to accurately document, monitor, and report on fuel treatment results. Even local expertise has limitations and can be lost as individuals move on to other areas or responsibilities. Without the combination of local knowledge *and* a formal systematic capture of that knowledge along with objective data, it will be difficult to efficiently allocate scarce resources and maintain focus on the most optimal fuel treatment areas.

An interagency fuels workshop conducted in April 30–May 1, 2002 in Three Rivers, California (BusinessGenetics, 2002) led to some surprising findings relating to fire and fuels related data management. This workshop included local and national experts including scientists, data specialists, fuels specialists, and managers. Although they found the basic missions and objectives of the local agencies participating in the SSGIC partnership were fundamentally different, they determined the existing fuels planning business activity models performed by each of the agencies were similar. It did not matter whether it was Kern County Fire Department or Sequoia and Kings Canyon National Parks, the high level activities performed in support of each agency's varying fire objectives were essentially the same. Even more remarkable, the participants found that the business processes and models for *developing and maintaining fuel and fire information* were either similar or ought to be similar. This is very encouraging because it means that "institutionalized" business processes and models for *developing and maintaining fuel and fire information* can be developed that will work across agencies – local, state, and federal. The potential for developing a uniform fire and fuels information framework is better because fire and fuels information business needs are inherently similar.

Recommendations:

- The NFAEB should direct the development and implementation of a comprehensive national strategy and framework for developing, managing, and delivering fire and fuels data and analyses. This framework should be developed collaboratively with state and local wildland fire agencies. An example of a potential national fire and fuels data framework strategy is presented in Section 4.1.6. Initially, a national strategy should be developed that includes the federal wildland fire agencies as well as state and local fire agencies. A major aim of this initiative would be to standardize business practices across agencies.

- The NFAEB should accelerate the development of national fire and fuels data standards including broadening and refocusing any existing initiatives. There are a few ongoing initiatives within the federal wildland fire community that are being spearheaded by the fire GIS and data community. However, there is a need for this work to include a broader spectrum of participants including representatives from state and local agencies, and the development of a *comprehensive* collaborative strategy for both identification and implementation of standards.

- The NFAEB should provide direction in establishing policies governing the identification, publication and distribution of sensitive data. Data security was identified as a concern in the SSGIC security plan (The Root Group, 2003).

  > *"Any potential arsonist with minimal skills and knowledge could adversely use SSGIC analyses as a means to create catastrophic wildfire within the Southern Sierra Nevada".*

  There is little guidance or policy at local, state, or national levels regarding the identification and management of sensitive fire-related data. Currently, all SSGIC-developed data are available for downloading by the public. However, the SSGIC concluded that some of the SSGIC data and analyses should be considered sensitive information – guidance on how to define and classify "sensitive" should be directed by the federal government in consultation with state and local wildland fire agencies.

4.1.3 Analysis

The SSGIC was successful at developing and implementing an interagency analysis framework. Analyses were completed that supported collaborative identification of high-priority fuel treatment areas. The scope of this project was focused on the identification of optimal fuel treatment areas rather than implementing actual on-the-ground treatments. However, because it took SSGIC three years to develop the datasets and perform the analyses, some of the datasets and analyses are already becoming obsolete. Maintaining the currency of dynamic datasets and changing analyses is a large task that was addressed in Section 4.1.2.

SSGIC managers and technical specialists concluded that it is possible to develop a series of standardized interagency geospatial fire planning analyses and tools with standardized data inputs and well-defined protocols. The application and use of these analyses may vary according to an agency's mission, but standardization is achievable. These geospatial analyses should focus on ordinating areas of risk, hazard, and values.

Recommendations:

- The NFAEB should consider directing the development of standardized geospatial planning analyses including technical software tools with standard data input requirements and well-defined protocols and business workflows. These analyses should focus on measuring and ordinating risk, hazard, and values across landscapes, rather than agency-centric traditional approaches. This initiative should be developed with state and local input and offer some local flexibility.

  Subsequent to this standardization of analyses, a geospatial "fire planning and analysis toolkit" should be deployed as a modular extension for the ESRI ArcGIS 9.x software application. The focus should directly benefit local level fire planning, but be scaleable to regional and national levels.

- The NFAEB should direct the development of a common set of terminology and language to define the terms "risk", "hazard", "values" and other appropriate terminology in concert with the state and local wildland fire community. Integral to development of standardized analyses will be the development and implementation of fire and fuel standards as described in Section 4.1.2.

Developing standard analyses with some flexibility built in to them would be cost effective. Currently, agencies or collaborative groups have to "invent their own wheels" when developing geospatial analyses and evaluating fuels across landscapes. It is time consuming, expensive, and results in inconsistent results that are usually only relevant to a local area. "Cookbook" geospatial analysis solutions with the tools, standards, and needed resources would provide local agencies with practical incentives and pre-defined technical (including geospatial) roadmaps for evaluating different management alternatives.

4.1.4 Web/Technology

Internet mapping technologies are an effective tool for delivering maps and data to fire staffs and the public. SSGIC website user statistics showed that map creation is a popular application that has benefits not historically available. Technology was not a limiting factor in accomplishing SSGIC goals. In fact, some available technology was recognized as valuable to the SSGIC but not used for a variety of reasons. As an example, SSGIC development of browser-based *interactive* mapping and data development (e.g., ESRI feature-based mapping) was considered but rejected primarily because of the time constraints.

A serious constraint to effectively using technology is the limited understanding of GIS, data, and web technologies by the local, state, and federal fire community. Technology transfer to the field was recognized as a big constraint even in the southern Sierra Nevada where these emerging technologies have been effectively used for several years. This is an important hurdle that still must be overcome. There is a need for increased training of the fire community to understand and use the available technology, data, and analyses.

Recommendation:

- The NFAEB should direct additional effort to increasing the wildland fire community's understanding of GIS, data, and web-based technologies. This effort should include input and assistance from state and local wildland fire community. Existing efforts appear to be somewhat inadequate.

SSGIC experienced challenges in finding a host agency or organization to administer an interagency server. The SSGIC could not locate "out-of-the-box" solutions for setting up and deploying an interagency server with web-based mapping. A workshop was held in Sacramento, California (Pacific Meridian Resources, 2000) that developed four options for deploying an ArcIMS mapping server. This was used as the foundation for deploying an SSGIC server. A separate written agreement was developed between the USGS in Denver and the National Park Service to administratively manage this server (Appendix C). These obstacles reinforce the need for an interagency fire and fuels framework that would develop a national strategy and technical solutions for developing, managing, and delivering fire and fuels data framework as described in Sections 4.1.1 and 4.1.2.

Recommendation:

- The NFAEB should direct the development and implementation of a comprehensive national strategy and framework for developing, managing, and delivering fire and fuels data and analyses. This framework should be developed collaboratively with state and local wildland fire agencies. An example of a potential national fire and fuels data framework strategy is presented in Section 4.1.6.

Server security has proven to be an ongoing obstacle to interagency access to the SSGIC web site (The Root Group, 2003). New security measures, in response to attacks from outside, have made access even more difficult. As a consequence of being an interagency program, the SSGIC has been at the forefront of attempting to re-establish the connectivity lost due to these new security measures. Newly established security policies are challenged by the need for interagency access as is the case for the SSGIC. By implementing a common framework for developing, managing, and delivering data, these kinds of challenges can be addressed at a national level, rather than through individual local interagency initiatives.

4.1.5 Interagency Planning

Part of the reason for the SSGIC's success related to the management of the initiative by a broad range of fire and technical specialists. In simpler terms, the SSGIC team had a balanced mix of both fire and technical GIS/data staff. Without this partnership it would have been difficult for an initiative of this complexity to have succeeded. There was a constant system of "checks and balances" by both disciplines that created an effective synergy.

Recommendation:

- The NFAEB should re-define the mission, authority, and responsibilities of the National Wildfire Coordinating Group's Geospatial Task Group (GTG). It is recommended that the group expand its scope to include non-spatial data coordination in addition to spatial data, and re-name the GTG to better reflect that revised mission. As an example, the group could be called "Fire Data Integration and Analysis Task Group." The SSGIC recommends that the GTG include membership that has formal representation from both fire management and the GIS/Data community. Further, this group should have membership and input that represents the local, state, and federal fire communities. The SSGIC recommends that a full-time, interagency federal wildland fire GIS Coordinator position be established to coordinate interagency geospatial fire activities.
- It is also recommended that the initial goals of the revamped GTG include developing a comprehensive geospatial/data needs assessment. The primary aim of the assessment would be a roadmap for developing an interagency fire and fuels information system that coordinates and, where appropriate, integrates local, state, and federal efforts. A conceptual example of a fire and fuels information system is described in section 4.1.6.

The SSGIC believes many activities must occur before the public and agencies will begin to see widespread landscape level fuel treatments that are routine, conducted efficiently and effectively, and include pre- and post-treatment monitoring and accurate measurement of results. Landscape-scale planning and implementation must include collaborative development and management of data standards, development of interagency client-server computer systems, consistent business processes, effective fire and fuels data standards, standard interagency software applications, integration with other existing fire applications, appropriate security policies and enforcement, and personnel who are committed to working together.

The SSGIC believes the investments made by the SSGIC can be leveraged and applied by other wildland fire agencies, including interagency efforts focused on complex landscapes with multi-agency jurisdictions.

4.1.6 Example of an Interconnected National Fire and Fuels Information Framework

One of the SSGIC recommendations is for the NFAEB to direct the development and implementation of a comprehensive national strategy and framework for developing, managing, and delivering fire and fuels data and analyses. This framework should be directed at the federal level, but developed collaboratively with state and local wildland fire agencies. In fact, it would be difficult to implement this endeavor without voluntary participation from state and local agencies. Further, one would expect many of the best solutions and ideas to come from both state and local governments. This part of the SSGIC final report broadly identifies the components necessary to deploy a coordinated and comprehensive national fire and fuels information framework. It begins to try to answer the question of *how* we interconnect fire and fuels data nationwide.

This proposed framework could be integrated as a subcomponent of *The National Map* initiative (http://nationalmap.usgs.gov/). *The National Map* is a new partnership initiative coordinated by the U.S. Geological Survey (USGS) that is being implemented as a consistent framework for geographic knowledge that provides public access to high-quality, geospatial data and information from multiple partners to help inform decision-making by resource managers and the public. This proposed fire and fuels information framework could be described as a component of *The National Map* and could be called The National Fire Map. It would leverage benefits (including business and technical processes) from this larger umbrella initiative and assure some consistency and standardization with other nationwide data initiatives. Further, it would enhance the wildland fire communities' ability to use the technical skills and expertise of the USGS and its partner organization.

A simple mission statement for this framework might be expressed as follows:

> *Develop, manage, and present the best available wildland fire and fuels data and information without regard to political, jurisdictional, or administrative boundaries.*

What would the framework accomplish?

It would provide access to fire and fuels data and other analyses about the United States and its territories that can be extended, enhanced, and referenced by both the public and government agencies.

The framework would promote cost effectiveness by minimizing the need to find, develop, integrate, and maintain non-spatial and geospatial fire and fuels data each time it is needed. It would provide *framework* data with consistent sources, standards, and documentation that could be updated regularly.

It would enhance both public and firefighter safety by providing data and analyses that enhance wildland fire managers' ability to proactively manage and treat fuels and to provide safer, more informed incident response.

The framework would improve support for emergency response and provide a clearinghouse for best available data and information to support large fire incidents.

It would enhance the ability of wildland fire agencies to measure performance and improve accountability.

Finally, it would improve management of natural and cultural resources through more informed decision-making.

There would be eight basic components to The National Fire Map.

1) Data – A comprehensive needs assessment would identify and rank non-spatial and geospatial data needed to effectively manage wildland fire and fuels programs at the local, regional, and national levels. These data would be distributed across numerous nodes that seamlessly connect all important geospatial fire and fuels data and information across the entire United States. The National Fire Map would use the best available data, but would focus on long-term development and improvement of important fire and fuels data.

2) Systems – These systems would be a collection of servers and related hardware, software, and database systems distributed and managed across multiple enterprises at different government levels (e.g., could be regional, state or federal systems). These systems would

adhere to general standards and protocols that would promote consistency and standardization among them.

3) Business Processes – These include standard operating procedures, guidelines, and established protocols. Business processes defines how data content is managed, how transactions are handled, and how decisions are made.

4) Standards – Consistent data models including attributing across agencies is essential. Agencies must agree on common data attributes that will be collected by everyone. Consistent methods for geospatially analyzing risk, hazard, and value analyses would be developed. These standard methods would not preclude or prevent local analyses, but could serve as important templates with demonstrated value and practical application. Terminology would be standardized. As an example, *risk* would be defined consistently across agencies enabling *risk* assessments to be compared across different geographic regions, but still maintain the highest resolution analyses possible.

5) Applications – This area focuses on uploading, downloading, and delivering data and information (including maps) to the public and wildland fire staffs. Further, it would support frequently automated pre-defined analyses such as risk, hazard, and values that used best available data. This would also support management of dynamic data and provide near real-time access to data and analyses. Suites of geospatial tools would be collaboratively developed in different wildland fire business areas such as incident response, fire planning, and smoke management.

6) Integration – These framework data could be integrated into other systems that have needs for non-spatial or geospatial data or both. It would include "handles" that allow other applications (e.g. Fire Program Analysis System, fuels planning, dispatch) to "plug" into the clearinghouse framework and use the data necessary to run their specific application.

7) Security – This component reflects maintaining the integrity and preservation of data and systems and manages appropriate access and user privileges by the public and agency personnel. Some fire data and analyses are sensitive in nature and must be protected by standards and protocols directed at the federal level with state and local input.

8) People and Organization – This is the most important element. This initiative should be characterized by a major "customer" focus with fiscal incentives provided to federal, state and local agencies that willingly "plug-in" and are effectively collaborating. It is expected that some existing positions, including fire planners, fire ecologists, and GIS/database specialists, would be shifted to an interagency focus with broader accountability standards. New positions should be looked at with broader stakeholder accountability and beyond traditional agency centric performance management. Outsourcing is a viable alternative to creation of new federal, state, or local government employees.

The National Fire Map as presented here would NOT do the following:

- It would NOT create a new federal wildland fire management organization.
- It would NOT create a top-down information management structure with one central data repository and a single centralized server. However, it would include a well-defined architecture that was decentralized with interconnected servers.
- It would NOT throw out existing fire and fuels data initiatives that are already working.

- It would NOT throw out field experience and wisdom that cannot be modeled or adequately represented by data.

The "organizational" structure of The National Fire Map would be integrated into the existing wildland fire organizations at the federal, state, and local levels. Responsibilities would be delegated to a variety of federal, state, and local agencies with strategic oversight by the National Interagency Fire Center. Rough estimated costs for a fully operational National Fire Map Initiative would be about $46 million annually, although some of this would include existing or planned expenditures such as the Landfire project. All the estimated benefits are difficult to measure but would result in cost savings that included: 1) long-term reduction in suppression costs, 2) improved ecosystem health with better fuel treatment decisions, 3) improved smoke management capabilities, 4) more effective and efficient environmental compliance, 5) lower cost to other new and existing applications that use non-spatial or geospatial data (e.g., Fire Program Analysis System), 6) better reporting and measurement of fuel treatments, 7) better and lower cost research due to ease of access to data, 8) improvements to firefighter and public safety, 8) near real-time access to best available data, and 9) improved accountability to the public, Congress, and state and local elected assemblies.

The National Fire Map would include the following organizational levels, basic responsibilities, and rough estimated costs (estimated $46 million annually).

1) National Interagency Fire Center

   - Provides Strategic Direction and Guidance for The National Fire Map including development and implementation of national policy.
   - Coordinates development of fire and fuel data and analysis standards.
   - Coordinates development of technical tools and applications.
   - Assures integration of other outside applications that would use framework data.
   - Coordinates and tracks performance of Clearinghouse Centers and Ecoregions.
   - Distributes, manages, and accounts for funds expended in support of The National Fire Map.
   - Estimated cost is about $1 million annually.

2) Clearinghouse Centers

   - Six to 12 Clearinghouse Centers would be established nationwide.
   - Manage and coordinate Data Centers including hardware, software, and applications development and management.
   - Implement national data and application standards.
   - Develop technical tools and applications consistent with national policy and direction.
   - Coordinate data development, management, and delivery of data and information within an area of responsibility (e.g., California Department of Forestry might become a Clearinghouse Center for local, State, and federal agencies in California).

- Administer dynamic map clearinghouse and training activities for ecoregions.
- Estimated cost is about $10 million annually.

3) Ecoregions
    - Thirty to 40 Ecoregions would be established nationwide.
    - Coordinate fire effects and fuels inventory and monitoring.
    - Implement national data and application standards.
    - Develop, implement, and manage formal interagency agreements.
    - Assure best available data are being developed and used.
    - If necessary, establish Provinces to improve local ecoregion collaboration (e.g., the Sierra Nevada Ecoregion could be divided into a northern and southern province to improve logistics and improve local-level support).
    - Local interagency staffs would implement and manage local data development activities and analyses.
    - Estimated cost is about $30 million annually.
4) Business Support Centers
    - Develop applications consistent with national strategy.
    - Provide specialized technical expertise (application development, project management, security, etc.)
    - Examples of Business Support Centers would be the USGS or a University.
    - Estimated cost is $5 million annually.

4.2 Potential and Direction to Continue SSGIC Program

The SSGIC has made a significant investment in data integration, treatment prioritization analyses, web development, and cultivating a motivated interagency team. They are continuously looking for ways to capitalize on this investment and continue to provide support to the fire management community in the southern Sierra Nevada so that this critical interagency collaborative effort can continue. Several opportunities are being investigated to continue the program. The several avenues being investigated include:

- Continued local support

  There is momentum from the local agencies to support continued collaborative fire management. The agency fire staffs are actively exploring ways to continue supporting the SSGIC utilizing existing available resources in creative ways. This includes establishing shared positions utilizing existing employees.

- Joint Fire Science Program Grant

  The relationship established between the SSGIC and the USGS Geography Discipline, Rocky Mountain Mapping Center in Denver has been mutually beneficial. Both groups see the same needs and are moving in the same direction in a number of areas and plan to submit a proposal to Joint Fire Science Program to address these needs. They include:

  - Increased capability to users to upload data and perform analyses via their web browser.
  - Web deployment of the Asset Analyzer application
  - Automate the process to update and maintain spatial data
  - Automate the process to update analyses
  - Automate the process to update metadata
  - Develop processes to demonstrate change and track accomplishments

- Fire Program Analysis (FPA) System (http://fpa.nifc.gov/)

  The FPA system is a national (five federal resource protection agencies) program to produce a common interagency process for fire management planning and budgeting. It will encompass all aspects of fire planning and budget including modules for Preparedness, Hazardous Fuel Reduction, Extended Attack, Large Fires and National Fire Resources, Wildland Fire Use, and Prevention. The SSGIC has been identified as one of four prototype areas to beta test the Fire Program Analysis system. This is a parallel effort including only the federal agencies of the SSGIC and somewhat modified analysis area to meet FPA needs.

- LANDFIRE (http://www.landfire.gov/)

  The LANDFIRE project is an interagency research and development effort to develop consistent and accurate methods for producing geospatial data of vegetation conditions, fire fuels, risks, and ecosystem status at the national, regional, and local scales for implementation of the National Fire Plan. LANDFIRE is seeking beta test sites and the SSGIC has expressed an interest in participating.

- National Map (http://nationalmap.usgs.gov/)

  The National Map is a USGS effort to provide public access to high-quality, geospatial data and information from multiple partners. The National Map is seeking pilot sites to which the National Map could be linked. The SSGIC plans to become a pilot.

- Air quality community (http://BlueSkyRAINS.org/)

  BlueSkyRAINS joins the BlueSky smoke modeling framework with the Rapid Access INformation System (RAINS) based web serving technology. BlueSkyRAINS is an effort of the USFS and EPA currently being tested in the Pacific Northwest. Air quality is a significant problem in the SSGIC analysis area, which also includes complex terrain that challenges smoke-dispersion modeling. For these reasons, the SSGIC could potentially be a good test site for the implementation of BlueSkyRAINS in a new geographic area.

4.3 Conclusions

The principal investigators believe that there is a need for increased national leadership on important issues presented in this report and the National Fire and Aviation Executive Board should consider spearheading radical change to many existing fire and fuels information business practices.

The southern Sierra Nevada continues to experience significant improvements with local interagency fuels planning and treatment activities. In 2003, there has been an increase in cooperative fire activities not seen before in the Southern Sierra. This includes cooperatively managing lightning caused fires (> 5,000 acres) being managed as fire use fires by the US Forest Service and National Park Service. Historically, these fires would have been suppressed or not allowed to cross over agency boundaries. This Joint Fire Science Funded project has served as a catalyst for this improved cooperation and strengthened personal relationships and trust that has fostered a stronger ecosystem approach to treating fuels.

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Appendices

Appendix A: Principal Investigators

Principal Investigators:

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Appendix B: SSGIC Cooperative Agreement among five stakeholder agencies

Agreement

Between

Sequoia and Kings Canyon National Parks

And Sequoia National Forest,

California Department of Forestry and Fire Protection Tulare Ranger Unit,

Bureau of Land Management, Bakersfield Field Office, and

Kern County Fire Department.

This Agreement is entered into between the Sequoia and Kings Canyon National Parks, hereinafter referred to as the "Park Service"; Sequoia National Forest, hereinafter referred to as the "Forest Service"; California Department of Forestry and Fire Protection -Tulare Ranger Unit, hereinafter referred to as "CDF"; Bureau of Land Management, Bakersfield Field Office, hereinafter referred to as the "BLM"; and Kern County Fire Department, hereinafter referred to as the "County". These agencies collectively have established the Southern Sierra Geographic Information Cooperative, hereinafter referred to as the "SSGIC".

ARTICLE I - BACKGROUND AND OBJECTIVES

The purpose of this Agreement is to design, test, and implement an interagency landscape-scale information framework for interagency fire coordination, including planning and support that effectively and efficiently manages interagency GIS and information sharing in the Southern Sierra; to provide data development and utilization that is seamless, readily accessible and available; to enhance and optimize the use of data and analysis modules; to defining, develop, and evaluate appropriate analysis modules; and to develop interagency fuels management plans. The Joint Fire Science Program has funded this initiative in the amount of $317,000. The Joint Fire Science Program is a partnership of six federal agencies established in 1998 to fill the gaps in knowledge about wildland fire and fuels.

The geographic scope of this project includes the Kings, Kaweah, Tule, Kern, Caliente, and Mojave watersheds as shown in Attachment A, "Southern Sierra Geographic Information Cooperative Area".

ARTICLE II - AUTHORITY

This Agreement is entered into under the authority of the Reciprocal Fire Protection Act, 42 USC 1856a, which authorizes agencies to enter into agreements for mutual assistance for fire protection activities.

ARTICLE III - STATEMENT OF WORK

A. The Park Service agrees to:

1. Provide overall project coordination guidance and oversight.
2. Provide GIS technical coordination between the SSGIC and the link to the various watershed councils.
3. Manage and disperse funds according to an approved project plan.
4. Reimburse all other parties contingent on prior approval as stated in Article VIII
5. Hire and manage a federal employee(s) dedicated to support the SSGIC objectives at the Park Service Ash Mountain office in Three Rivers, CA.

B. The Forest Service agrees to:

Provide GIS technical coordination between the SSGIC, Tule River Indian Reservation, and the Sierra and Inyo National Forests.

C. The CDF agrees to:

Provide GIS technical coordination between the SSGIC and the CDF Fresno-Kings Ranger Unit, Fresno and Tulare Counties.

D. The BLM agrees to:

Provide GIS technical coordination between the SSGIC and the US Fish and Wildlife Service, and the BLM California Desert District.

E. County agrees to:

Provide GIS technical coordination between the SSGIC and Kern County and the Kern
Council of Governments.

F. All agencies mutually agree to:

1. Develop and update, as needed, a project plan and participate fully in implementing the project plan.
2. Establish a steering committee with designated agency representatives.
3. Establish, manage and support contracts related to this Agreement as appropriate within agency guidelines.
4. Cooperate and contribute required services and best available data necessary to

implement the project plan and accomplishment of project objectives.

ARTICLE IV - TERM OF AGREEMENT

This Agreement shall become effective on the date of the final signature and shall remain in effect for five years.

ARTICLE V - KEY OFFICIALS

A. The personnel listed below are identified as key officials and considered essential to the project being performed under this Agreement.

1. NATIONAL PARK SERVICE
Pat Lineback
GIS Coordinator
Sequoia and Kings Canyon National Parks
Three Rivers, CA 93271
(559) 565-3275

2. FOREST SERVICE
Aaron Gelobter
Fire Management Officer
Sequoia National Forest
900 W. Grand Ave.
Porterville, CA 93257
(559) 784-1500 ext. 1121

3. CDF
Gary Marshall
Operations Chief
Tulare Ranger Unit
1968 South Lovers Lane
Visalia, CA 93277
(559) 732-5954

4. BLM
Acting Tony Sarzotti
Fire Management Officer
Bakersfield Field Officer
3801 Pegasus Drive
Bakersfield, CA 93308
(661) 391-6051

5. COUNTY
Dave Ward

Deputy Chief
Kern County Fire Department
5642 Victor Street
Bakersfield, CA 93308
(661) 391-7023

B. Any change in key officials must be agreed to by the other key officials.

ARTICLE VI - PAYMENT AND INVOICES

A. Payments will be made by the Park Service as follows, subject to prior approval by the Park Service's GIS Coordinator, as provided in Article VIII of this Agreement:
1. To the Forest Service and to BLM on a quarterly basis through OPAC. Billing invoices shall be directly submitted through the key NPS official identified in VA1.
2. To the CDF or County through Electronic Funds Transfer upon submission of an invoice to the key official designated in Article VA.

B. OPAC information:
1. Park Service: Agency Location Code (ALC): 14-10-0099, Job Code: 8550-0001-454
2. Forest Service: ALC: 12-40-1100
3. BLM: ALC: 14-11-0008

C. Nothing in this Agreement shall be construed as obligating the Park Service, Forest Service, CDF, BLM, or County to expend any funds in excess of those appropriated by law for any given fiscal year.

D. The commitment of funds in furtherance of this Agreement shall be authorized by individual written Task Agreements issued against this Agreement by a Park Service contracting officer identifying each project or group of projects, amounts of funding, account number(s), and any other special term or condition applicable to that project.

ARTICLE VII - LIABILITY

Each party agrees to waive all claims against every other party for compensation for any loss, damage, personal injury, or death occurring in consequence of the performance of this Agreement.

ARTICLE VIII - PRIOR APPROVAL

Any expenditure of funds will require prior written approval by the NPS GIS Coordinator and issuance of a task agreement signed by the NPS contracting officer. Prior to the commencement of any work arising under this Agreement, a proposal from the requesting agency describing the deliverable product, delivery schedule, and funding shall be submitted to the NPS key official.

ARTICLE IX - MODIFICATION/TERMINATION

A. This Agreement may be modified at any time upon written approval of the parties.

B. Each party may terminate its participation in this Agreement by providing 60 days written notice to the other parties.

C. This Agreement may be terminated by mutual written agreement of all parties.

ARTICLE X- ATTACHMENTS AND APPENDICES

Attachment A - Southern Sierra Geographic Information Cooperative Area map

ARTICLE XI - AUTHORIZING SIGNATURES

Agreed Upon and Approved by:

"Signed"

____________________ __________
Richard H. Martin — Date
Park Superintendent
USDI - National Park Service
Sequoia and Kings Canyon National Parks

"Signed"

____________________ __________
Arthur L. Gaffrey — Date
Forest Supervisor,
USDA - Forest Service
Sequoia National Forest

"Signed"

____________________ __________
David Hillman — Date
Chief, Tulare Ranger Unit
California Department of Forestry
and Fire Protection

"Signed"

____________________ __________
Ron Fellows — Date
Field Office Manager,
USDI ¬ Bureau of Land Management
Bakersfield Field Office

"Signed"

____________________ __________
Daniel Clark — Date
Chief, Kern County Fire Department
County of Kern

Appendix C: Memorandum of Understanding between NPS and USGS

MEMORANDUM OF UNDERSTANDING
BETWEEN SEQUOIA AND KINGS CANYON NATIONAL PARKS
AND
UNITED STATES GEOLOGICAL SURVEY

This Memorandum of Understanding, herein referred to as "Agreement" is entered into between the Sequoia and Kings Canyon National Parks, hereinafter referred to as the “Park Service”; and the United States Geological Survey, hereinafter referred to as the “USGS”.

ARTICLE I - BACKGROUND AND OBJECTIVES

A. An agreement was entered into between the Park Service, Sequoia National Forest, California Department of Forestry and Fire Protection, the Bureau of Land Management, and the Kern County Fire Department to develop a landscape-scale framework for interagency wildland fuels management planning (see Attachment A). These agencies collectively have established the Southern Sierra Geographic Information Cooperative, hereinafter referred to as the "SSGIC". The Park Service is the lead agency with oversight and fiscal responsibility for the SSGIC. The USGS has the responsibility to provide governmental entities and the general public with current accurate, geospatial data and geographic information, and remotely sensed data for the United States and its outlying areas of jurisdiction.

B. The USGS is assisting the Park Service with developing and managing an Internet Mapping Site that will be used to meet important goals of the SSGIC.

C. The purpose of this Agreement is to design, test, and implement an interagency Internet Mapping Site using appropriate hardware and software.

D. The geographic scope of this project includes the Kings, Kaweah, Tule, Kern, Caliente, and Mojave watersheds as shown in Attachment B “Southern Sierra Geographic Information Cooperative Area”.

ARTICLE II - LEGISLATIVE AUTHORITY

This Agreement is entered into under the authority of the Reciprocal Fire Protection Act, 42 USC 1856a, which authorizes agencies to enter into agreements for mutual assistance for fire protection activities.

ARTICLE III - STATEMENT OF WORK

A. The Park Service agrees to:

1. Serve as liaison between the SSGIC and the USGS.

2. Purchase all hardware and Software required to directly support the SSGIC Web Server with the exception of the Oracle and SDE licensing.

NOTE: SDE is an ESRI product that allows storage and management of spatial data in a relational database management system (RDBMS).

3. Develop, Implement, and Maintain Web Interface including data downloading, uploading, and Internet Mapping functionalities.

4. Maintain and Update geospatial data as needed.

5. Issue Interagency Acquisition Agreements in accordance with Article VI to transfer funding to USGS for activities arising pursuant to this Agreement.

6. Be responsible for maintaining and implementing the system security plan.

B. The USGS agrees to:

1. Provide overall technical consultation and guidance for establishing and maintaining an Internet Mapping Application.

2. Set up and manage an SSGIC Server located at the USGS Offices located in the Federal Center in Denver Colorado, including:
    a. Regular and jointly agreed upon backups of data.
    b. Operating System and Web Server Maintenance including upgrades.
    c. Applications Systems Maintenance including upgrades for Internet map server and web server software.
    d. Completion of any needed hardware upgrades to server including addition of either processors or additional hard-drives.

3. Support the storage and maintenance of vector data utilizing the GEOMAC fire web site as an SDE/Oracle repository and presentation mechanism for SSGIC vector data.

NOTE: GeoMAC is an application developed during the 2000 fire season by the **Geo**spatial **M**ulti-**A**gency **C**oordination Group. GeoMAC is an internet based mapping application which allows firefighting coordination centers and incident command teams to access online maps of current fire locations and perimeters using standard web browsers such as Netscape Communicator™ or Microsoft Internet Explorer™.

4. Assist the SSGIC in the development of a Federal Geographic Data Committee (FGDC) compatible data clearinghouse using the SSGIC server.

NOTE: The **F**ederal **G**eographic **D**ata **C**ommittee coordinates the development of the National Spatial Data Infrastructure (NSDI). The NSDI encompasses policies, standards, and procedures for organizations to cooperatively produce and share geographic data. The 17 federal agencies that make up the FGDC are developing the NSDI in cooperation with organizations from state, local and tribal governments, the academic community, and the private sector.

5. Assist with the development of the system security plan.

6. Provide existing USGS geospatial files as needed.

C. Both agencies agree to:

Report on results and provide recommendations to other regional collaborative groups interested in setting up Internet Mapping Sites.

ARTICLE IV - TERM OF AGREEMENT

This Agreement shall become effective on the date of the final signature and shall remain in effect for three years.

ARTICLE V - KEY OFFICIALS

The personnel listed below are identified as key officials and considered essential to the project being performed under this Agreement.

A. PARK SERVICE

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B. USGS

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FAX: 303-202-4020
Email jdguthrie@usgs.gov

ARTICLE VI - PAYMENT AND INVOICES

A. The commitment of funds in furtherance of this Agreement shall be authorized by individual written Interagency Acquisition Agreements issued against this Agreement by a Park Service contracting officer identifying each project or group of projects, amounts of funding, account number(s), and any other special term or condition applicable to that project.

B. Nothing in this Agreement shall be construed as obligating the Park Service to expend any funds in excess of those appropriated by law for any given fiscal year.

ARTICLE VII - LIABILITY

Each party agrees to waive all claims against the other party for compensation for any loss, damage, personal injury, or death occurring in consequence of the performance of this

Agreement.

ARTICLE VIII - PRIOR APPROVAL

Any expenditure of funds will require prior written approval by the NPS GIS Coordinator and issuance of an Interagency Acquisition Agreement signed by a Park Service contracting officer. Prior to the commencement of any work requiring exchange of funds, a proposal from the USGS describing the deliverable product, delivery schedule, and funding, shall be submitting to the Park Service key official.

ARTICLE IX - MODIFICATION/TERMINATION

A. This Agreement may be modified at any time upon written approval of the parties.

B. Either party may terminate this Agreement by providing the other party 60 days advance written notice.

ARTICLE X - ATTACHMENTS AND APPENDICES

A. Attachment A - Agreement Between Sequoia and Kings Canyon National Parks And Sequoia National Forest, California Department of Forestry and Fire Protection Tulare Ranger Unit, Bureau of Land Management, Bakersfield Field Office, and Kern County Fire Department.

B. Attachment B - Map of six watersheds comprising the Southern Sierra Geographic Information Cooperative Area.

ARTICLE XI - AUTHORIZING SIGNATURES

Agreed Upon and Approved by:

"Signed"

____________________ ________________

Richard Martin Date
Park Superintendent,
USDI - National Park Service
Sequoia and Kings Canyon National Parks

"Signed"

____________________ ________________

Craig D. Skalet Date
Acting Chief,
USGS-Rocky Mountain Mapping Center

Appendix D: Crosswalk of Fire Cause Codes among agencies

Agency	Source Field 1	Values	Definition	Destination Cause_Gen	Definition Cause_Gen (1202 Definitions)	Cause_Sum
BIA	General_Cause	0	Null	9	Miscellaneous	Unk
BLM	Cause	0	Unk	9	Miscellaneous	Unk
		1	Natural	1	Natural	Nat
		2	Human	0	Unknown	Man
SEKI	Cause	10	Campfire	2	Campfire	Man
		11	Smoking	3	Smoking	Man
		12	Arson	5	Incendiary	Man
		13	Debris/Pile	4	Debris Burning	Man
		14	Children	8	Children	Man
		15	Unknown	9	Miscellaneous	Unk
		20	Lightning:No Suppression	1	Natural	Nat
		21	Lightning:Suppressed	1	Natural	Nat
		22	Lightning: Suppression Zone	1	Natural	Nat
SeqNF	Stat_Cause	1	Lightning	1	Natural	Nat
		2	Equipment Use	6	Equip Use	Man
		3	Smoking	3	Smoking	Man
		4	Campfire	2	Campfire	Man
		5	Debris Burning	4	Debris Burning	Man
		6	Railroad	7	Railroad	Man
		7	Arson	5	Incendiary	Man

Agency	Source Field 1	Values	Definition	Destination Cause_Gen	Definition Cause_Gen (1202 Definitions)	Cause_Sum
		8	Children	8	Children	Man
		9	Miscellaneous			Unk
SieNF (pre 99)	Stat_Cause	1	Lightning	1	Natural	Nat
		2	Equipment Use	6	Equip Use	Man
		3	Smoking	3	Smoking	Man
		4	Campfire	2	Campfire	Man
		5	Debris Burning	4	Debris Burning	Man
		6	Railroad	7	Railroad	Man
		7	Arson	5	Incendiary	Man
		8	Children	8	Children	Man
		9	Miscellaneous	9	Miscellaneous	Unk
SieNF (99-00)	Cause	Misc		9	Miscellaneous	Unk
		Lightning		1	Natural	Nat
		Campfire		2	Campfire	Man
		Arson		5	Incendiary	Man
InyoNF	Stat_Cause	1	Lightning	1	Natural	Nat
		3	Smoking	3	Smoking	Man
		4	Campfire	2	Campfire	Man
		9	Miscellaneous	9	Miscellaneous	Unk
CDFTu	Cause	1	Undetermined	9	Miscellaneous	Unk
		2	Lightning	1	Natural	Nat
		3	Campfire	2	Campfire	Man
		4	Smoking	3	Smoking	Man

Agency	Source Field 1	Values	Definition	Destination Cause_Gen	Definition Cause_Gen (1202 Definitions)	Cause_Sum
		5	Debris Burning	4	Debris Burning	Man
		6	Arson	5	Incendiary	Man
		7	Equipment Use	6	Equip Use	Man
		8	Playing with Fire	8	Children	Man
		9	Miscellaneous	0		Man
		10	Vehicle	6	Equip Use	Man
		11	Railroad	7	Railroad	Man
		12	Powerline	6	Equip Use	Man
KrnCo	Cause_CDF	1	Undetermined	9	Miscellaneous	Unk
		2	Lightning	1	Natural	Nat
		3	Campfire	2	Campfire	Man
		4	Smoking	3	Smoking	Man
		5	Debris Burning	4	Debris Burning	Man
		6	Arson	5	Incendiary	Man
		7	Equipment Use	6	Equip Use	Man
		8	Playing with Fire	8	Children	Man
		9	Miscellaneous	0		Man
		10	Vehicle	6	Equip Use	Man
		11	Railroad	7	Railroad	Man
		12	Powerline	6	Equip Use	Man

Appendix E: Fire Return Intervals assigned to dominant southern Sierra vegetation types

Preliminary assignment of fire regime classes to the dominant southern Sierra Nevada vegetation types. Classes are used to assign color codes to attached map showing fire regime return interval estimates. Regime classes and "fire return interval departures" (FRID) are based on "maximum average" fire return intervals (FRI). Class ranges are given in the table. Confidence estimates and source on information is listed when FRI are given. References referred to in the table are list at bottom of table.

Fire Regime Class (FRI)	FRI					
Vegetation Type (***map color code***)	Mean	Max	Class	Confidence	Reference	Comments
Very High < 7 yr (*blue*)						
MHW Montane Hardwood Conifer (PIPO?)		7	1	estimate		low if conifer is not PIPO
PPN Ponderosa Pine	4	6	1	good	1,2,3,16,17	
High 7 - 16 yr *(red)*						
SMC Sierra Mixed-Conifer (white fir)	10	16	2	good	1,2	
SEGI Giant Sequoia (same as SMC)	10	16	2	good	13,14,15	
Moderate 17 - 25 yr (*beige*)						
AGS Annual Grasses	10	17	3	v. poor	5,10,11	
BOP Blue-Oak Foothill Pine	10	17	3	v. poor	5,10,11	
BOW Blue-Oak Woodland	10	17	3	v. poor	5,10,11	
MHC Montane Hardwood	7	23	3	v. poor	3,19	
Low 26 - 100 yr (*yellow*)						
VOW Valley Oak-Woodland		30	4	estimate		
MCP Montane Chaparral	30	75	4	estimate	12	
CRC Chamise-Redshank Chaparral		50	4	estimate		
JPN Jeffrey Pine	30	50	4	v. poor	5,7,8,17	

MCH Mixed Chaparral		60	4	estimate	12	
RFR Red Fir	30	50	4	poor	1,4,5	
VRI Valley Foothill Riparian		50	4	estimate		
WTM Wet Meadow	40	65	4	estimate	8	
Very Low > 100 yr (*green*)						
LPN Lodgepole Pine	102	163	5	v. poor	5,6,18	
PJN Pinyon Juniper		200	5	estimate		
SCN Subalpine Conifer	187	508	5	poor	5,9	
SGB Sagebrush		200	5	estimate		or class 4 but v. little of this type
JUN Western Juniper		500	5	estimate		
CPC Closed-Cone Pine		200	5	estimate		
None or Erratic (*grey*)						
ASC Alkali Desert Scrub		0	6	estimate		
DRI Desert Riparian		0	6	estimate		
ADS Alpine/Dwarf Shrub		0	6	estimate		
JST Joshua Tree		0	6	estimate		
DSC Desert Scrub		0	6	estimate		
MRI Montane Riparian		300	6	estimate		
Other (*black*)						
URB Urban		0	7	N/A		
CRP Cropland		0	7	N/A		
(***white***)						
BAR Barren		0	8	N/A		
WAT Water		0	8	N/A		
Other			8	N/A		
Unknown			8	N/A		

BBR Bitterbrush	500	estimate
LAC Lacustrine (***blank***)	0	N/A
IRF Irrigated Farmland	-9	N/A
OVN	-9	N/A
VIN Vineyard	-9	N/A
WFR	-9	N/A

1 Caprio and Swetnam 1993, 1994, 1995; 2 Kilgore and Taylor 1979; 3 Stephens, unpublished data in Skinner and Chang 1996; 4 Pitcher 1981, 1987; 5 Caprio unpublished data; 6 Keifer 1991; 7 Taylor, unpublished data in Skinner and Chang 1996; 8 Skinner, unpublished data in Skinner and Chang 1996; 9 Caprio, Mutch, and Stephenson unpublished data; 10 Mensing 1992; 11 McClaren and Bartolome 1989; 12 SNEP 1996; 13 Swetnam et al. 1991; 14 Swetnam et al. 1992; 15 Swetnam 1993; 16 Warner 1980; 17 McBride and Jacobs 1980; 18 Sheppard 1984; 19 Stephens 1997

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