Fire Management for California Ecosystems

California Department of Forestry and Fire Protection, August 28, 1995

Executive Summary

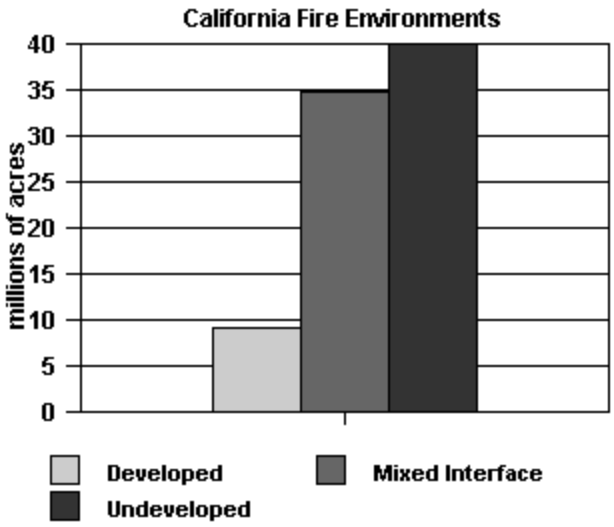
Ecosystem Management and Fire Environments

The biological, social, and institutional diversity of California challenges the ability of land management and fire protection agencies to maintain the functional integrity of ecosystems while meeting the increased levels of fire protection demanded by the public for natural resources, life, and property. This is particularly evident in the urban-wildland interface where continued population growth and changing land uses pose increasing wildfire risks to ecological and social systems.

In order to meet these demands, the state must lead the way toward a more comprehensive approach to fire management that recognizes the relationship between ecosystem health and the creation and maintenance of fire safe communities, and that enhances suppression activities with aggressive pre-fire management. An ecosystem-based framework is useful for this process because it allows the state to identify values at risk, management options, and institutional impediments in fire planning. This paper includes an examination of how population density, ownership, and vegetation interact to create different types of fire environments, each of which merits a customized strategy that includes pre-fire, suppression, and post-fire options.

Census data was used to define three types of fire environments developed, mixed interface, and undeveloped that occur across public and private lands. The selected thresholds represent strictly theoretical points at which increasing population density progressively constrains ecosystem management and fire protection options. Using these criteria, more than 9 million acres (9.1 percent) of California fall into flammable, developed fire management environments. More than 35 million acres (34.9 percent) are flammable, mixed interface; and nearly 40 million acres (40 percent) are in flammable, undeveloped environments.

Ownership data indicate that, for most fire environments, planning and implementation of viable strategies will require participation by multiple owners. Although most of the developed fire environment occurs on private land, nearly one million acres are in federal ownership. While over half of the mixed interface environment occurs on private lands, about 40 percent resides in federal ownership. Undeveloped fire management environments are dominated by federal ownership, but the private sector still owns over 8 million acres of this type. Vegetation types cross both density and ownerships categories.



Comprehensive Planning and Impediments to Interagency Coordination

The department is uniquely positioned to guide the development of customized strategies for fire management across jurisdictional boundaries. Recognizing that no single institution or entity has the authority or the means to accomplish the full range of options needed, the department should build on the success of cooperative fire suppression planning efforts such as FIRESCOPE to address pre- and post-fire planning needs. This process must include all stakeholders and must confront funding and equity issues related to fire protection for private and public values.

To achieve this, the department must address institutional impediments to interagency cooperation, including technical, operational, budgetary, statutory, and organizational barriers. The department must strive with other state and federal agencies to:

- Work with academia to coordinate research on risk and hazard assessments, wildfire effects on private and non-commodity values, the role of fire in long-term ecosystem management, and the effectiveness of pre-fire options for mitigating risk and damage.
- Develop appropriate long-term strategies for integrating pre-fire and suppression planning, and address legal and fiscal concerns such as prescribed fire liability.
- Work with university extension, the media, and educational institutions to communicate new information and research results to local government, private industry, the financial community, and citizens.
- With the State Fire Marshal as lead, increase efforts with local government and community groups to identify opportunities to implement pre-fire projects in conjunction with the private sector.
- Coordinate the use of federally funded state and private forestry programs and state cost-share programs with pre-fire management where possible.
- Develop mechanisms for timely re-investment of national forest harvest receipts in forest health and pre-fire management programs in the forests of origin according to direction established through consultation with the state and local governments, and bioregional and watershed groups.
- Evaluate the potential impacts on ecosystem protection of proposals to alter fire protection jurisdictions or to relocate suppression resources.
- Correct existing inconsistent and inequitable emergency cost recovery policies, particularly among state agencies and local agencies.
- Consider regulatory changes to facilitate tiered planning processes, and to facilitate federal agency interaction with broad-based, collaborative and public/private partnership groups.
- Consider monitoring and adaptive management needs for ensuring that pre-fire management is consistent with ecosystem management and environmental protection.
- Continue the development of a total cost plus net value change framework for CDF's Fire Plan. CDF should include federal agencies, local government, and the public in its planning and implementation processes.

Strengthening the Role of Local Government, Citizens, and the Private Sector

The efficient allocation of public and private resource to minimize the total cost of fire protection has been undercut in some areas by the lack of adequate information from fire agencies about risk and hazard; the reliance on FEMA as insurer of last resort; lack of aggressive zoning, infrastructure development and building code enforcement by some local governments; and lack of compliance with fire safe laws by citizens. The state can guide local and federal agencies to rectify policies that serve as disincentives to investment in pre-fire management, particularly those related to land use, mitigation of exposure, and disaster recovery. These discussions will require strong leadership by state and federal officials, and local government.

- The State Fire Marshal should advise local government on appropriate land use, infrastructure development, and building code enforcement authorities to mitigate wildfire risks.
- The state should provide information to the financial and development community, homeowners, and local agencies about the risks of development in different fire environments, mitigation options and costs, and mitigation maintenance programs.
- FEMA should coordinate its operations with the state's overall fire management policy, particularly with respect to the development and implementation of post-fire mitigation plans, and the requirement of mitigation implementation for recovery assistance.
- FEMA hazard mitigation grants should be made available for areas at risk, even if they have not suffered a recent disaster.
- Local government must work with the State Fire Marshal to ensure that citizens comply with fire safe laws.
- The state should sponsor discussions about regulatory relief, market mechanisms, and incentives for private sector businesses that support pre-fire management goals, such as biomass, wood products, and solid waste disposal industries.
- The state should develop ecosystem-based, pre-fire management strategies in conjunction with grassroots groups, environmental organizations, watershed groups, and others through the Fire Strategies Team and the California Biodiversity Council.
- The state should demonstrate the costs and effects of different types of development to local government to assist them in making informed, cost-effective land use planning decisions.

Summary

In order to meet the increased demand for protection of natural resources, life, and property, California must develop comprehensive fire management strategies across ownerships that emphasize pre-fire objectives in land use planning, development, and vegetation management. Additional investments in fire management should reflect assessments of all stakeholder values, both commodity and noncommodity. This process will require increased cooperation among agencies; an examination of existing policies that serve as disincentives to pre-fire management; leadership in developing alternatives to those impediments; and an increased response by citizens, local government, and the private sector.

In California, recent actions by the insurance industry provide the state an opportunity to work with citizens, local government, and the financial community to clarify fire risks of development

in fire-prone areas, and to identify and evaluate mitigation options for reducing risks and damages. CDF should also continue to refine its Fire Plan to analyze the total costs of fire protection and fire impacts to local, state and federal agencies, to evaluate the potential impacts of fire protection budget changes, and to examine equity issues. It is only through this comprehensive, participatory process that the state can meet the fire protection demands of the future.

Introduction

As the importance of fire's role in ecosystem processes becomes increasingly evident to the public, a consensus has emerged concerning the need for integration of fire ecology, fire management, and ecosystem management planning. The U.S. Forest Service defines *fire management* as "planning, implementing, and monitoring the application of fire and protection from fire to achieve healthy (1) ecosystems and fire-safe communities adjacent to wildlands, using the knowledge of fire ecology, fire physics, and socio-economic impacts. This paper provides an overview of the social, ecological, and economic realities that constrain fire management planning, and discusses the role of the state and other actors in dealing with institutional impediments and opportunities associated with a comprehensive approach to fire management for the nineties and beyond.

Healthy Ecosystems and Fire Safe Communities

Fire shapes the structure and regulates the functions of ecosystems. It has dominated California's landscape for as long as there has been vegetation to burn. Even without people, the state's volatile combination of climate, terrain, and vegetation produces one of the most combustible natural fire environments on earth. But the addition of more than 30 million people coupled with changes in land management during the twentieth century has created a dynamic fire environment that clearly challenges the ability of land management and fire protection agencies to achieve ecosystem management while providing the increased levels of fire protection demanded by the public for natural resources, life, and property.

Land and fire management have in many cases increased fire hazard. In some shrub types, fire suppression appears to have shifted the fire regime away from more, smaller fires toward fewer, larger fires under more severe weather (2). In conifer types, fire suppression appears to have led to an increase in fuels (3). Silvicultural practices have produced forest structured dominated, not by old growth, but rather by younger, denser stands of greater flammability. These changes provide both impetus and context for the demand for increased fire protection.

This increasing demand for protection requires the development of a more comprehensive, ecosystem-based approach to fire management which recognizes that people and structures are central values to California ecosystems. The proliferation of houses and their consequent exposure to loss have become defining criteria of those environments. This is not to imply that ecological integrity need necessarily be sacrificed to protect life and property, but rather to demonstrate that ecosystem health is inextricably linked to the creation and maintenance of fire safe communities. The manner in which ecological integrity and human needs are reconciled,

however, depends on a clear articulation of public and private values at risk from fire that enables us to cost-effectively achieve ecosystem and fire protection goals.

Nowhere is the relationship between ecosystem health and fire safe communities more evident than at the *urban-wildland interface*, a term used to describe fuel environments in which fire can cross readily between structural ("urban") fuels and vegetation ("wildland") fuels. In California the boundary between these fuel types, or *fire interface* (4), does not occur exclusively in a small transitional zone between wildlands and developed areas. Rather, the interface fuel environment occurs over a significant portion of the state and is intermixed with fuel environments ranging from exclusively wildland vegetation fuels on one end of the spectrum, to predominantly synthetic structural fuels on the other. At a finite scale, every building near flammable vegetation has its own fire interface. At the landscape scale, several types of interface definitions have emerged. Clusters of buildings along a fringe of developed area that are vulnerable to wildfire form what is known as a "classic interface." A more common scenario occurs where rural homes are intermixed among expanses of vegetation, forming what is known as the "mixed interface." These intermixed landscapes retain significant wildland values, supporting many native or relatively undisturbed plant communities, wildlife habitat, and productive, high quality watersheds. In fact, their "value" may effectively increase with population growth as indigenous species become rarer and legally require greater levels of protection.

With more and more of California's population moving into wildland areas, traditional vegetation fires have higher probability of becoming interface fires and inflicting great damages on both ecological and social systems. In recent years some of the most destructive conflagrations in United States history have occurred when such fires have crossed the fire interface and burned into communities, overwhelming the response capabilities of urban fire departments. Likewise, structure fires in such areas can easily spread to surrounding vegetation and quickly overwhelm wildland fire protection systems, sometimes inflicting incalculable damage to ecosystems.

The advent of "mega-catastrophes"--a term coined by the insurance industry since 1990 to describe phenomena where insured losses exceed $1 billion--reflects this trend, and is beginning to destabilize existing relationships for providing relief and recovery when disaster occurs. Since 1990, there have been six mega-catastrophes, including two California interface fires in Oakland (1991) and southern California (1993). The losses have resulted in increased insurance premiums and the withdrawal of companies from some areas. These losses suggest the need for a holistic approach to fire management that enhances fire suppression efforts with more aggressive pre-fire management during land use planning, development, and vegetation manipulation activities; and fire protection options that contribute to sustainable fire-adapted ecosystems.

Ecological and Demographic Diversity

Wildfires are contagious phenomena that frequently start in one area but move into another, traversing landscapes diverse in ecological, demographic, and institutional terms. California spans ten degrees of latitude, resulting in a climatic diversity unmatched by any other state in the United States. Precipitation ranges from less than three inches per year (including the driest spot in the nation) to more than 100 inches. The state's topography is equally diverse, with elevations ranging from the lowest (-282 feet) to among the highest (14,495 feet) in the nation, and is characterized by steep canyons and hillsides in many areas. This unique physical diversity

provides habitat for nearly 650 wildlife species and more than 5,000 species of plants--many more than in all of the central and eastern United States and adjacent Canada combined. As a result, the state contains a wide variety of vegetation types and fire regimes, ranging from moist redwood forests of northwestern California to dry Colorado Desert mesquite in the southeastern part of the state. A raging wildfire may impact one section of the state while another receives rain, snow, or coastal fog.

The diversity of population density throughout the state is as important to California's fire environment as its ecological diversity. Large portions of the state are among the most sparsely populated areas of the United States, including the heavily forested North Coast and Klamath regions, the Great Basin plateau east of the Sierra Nevada crest from the Owens Valley northward, and the Mojave and Colorado Deserts of the southeast. By contrast, the sprawling metropolitan areas of the Los Angeles Basin, San Diego, Sacramento, and the San Francisco bay area are among the most densely populated areas in the country. And of course, there is every gradation in between, from quiet valley farm communities to the booming "exurbs" of the Sierra foothills and the extended metropolis of dozens of "edge cities" and burgeoning regional centers like Redding, Santa Rosa, Fresno, Bakersfield, and Riverside. Ecological values persist in even the most densely populated landscapes. This is exemplified by the number of threatened and endangered species populations identified in southern California and the variety of conservation efforts that have been initiated to protect these values.

Institutional Diversity

The institutional complexity of fire management in California reflects its economic, social, and political diversity. Federal, state, and local agencies share responsibility for different aspects of fire management. This diversity of statutes and authorities provides both opportunities and impediments to comprehensive fire planning approaches.

In California, 45 percent of the state's land is in federal ownership, 4 percent is in state ownership, and 51 percent is privately owned (5). Federal land management agencies are authorized to protect and manage forest and rangeland natural resources on their ownerships. Land management activities are governed by laws, such as the National Environmental Protection Act (NEPA), the National Forest Management Act (NFMA), Forest Land Management and Planning Act (FLPMA), the federal Endangered Species Act (ESA), and Federal Advisory Committees Act (FACA). These laws dictate the content and process of planning activities, and impact the ability of federal agencies to interact with state and local fire agencies on vegetation management projects that include private lands. On the other hand, because federal agencies own significant amounts of land, they have considerable expertise in activities that can be used to manage the fire environment at landscape and ecosystem scales.

On California's private, city, county and state-owned wildlands (55 percent of the state), land management activities that can contribute to fire protection goals are implemented primarily by private landowners and a few government managers. These activities are governed by state laws, such as the California Environmental Quality Act (CEQA), the Forest Practices Act (FPA), the California Endangered Species Act (CESA), and others which have their own distinct set of regulatory requirements and associated costs. Preliminary estimates by the California Department of Forestry and Fire Protection (CDF) indicate that landowners invest about

$3,000,000 annually in pre-fire management activities. However, smaller landowners often lack expertise, resources, and clear incentives to invest in adequate pre-fire management, especially in interface areas where the land and vegetation are not managed for economic income. CDF can provide additional assistance through the Vegetation Management Program (VMP), a cost-share program for fuels management and prescribed burning. Other state and private forestry assistance programs can be used to support pre-fire management, but recent federal budget cuts have reduced their availability.

The diversity of the fire service (state, federal, and local agencies responsible for fire protection) with respect to fire suppression provides an additional level of complexity. Institutions have different fire protection mandates, and as a result they are not prepared to respond to fire in the same way. Federal agencies are budgeted primarily to protect natural resources under federal management and to design tactics appropriate for their land base. The U.S. Forest Service is generally well equipped to fight forest fires, and the Bureau of Land Management has more experience with rangeland fires. Federal agencies generally staff dispatch and stations during daylight hours and revert to an on-call system at other times. Staffing can be extended during periods of high fire danger. On a fire, managers have the option to pursue confine, contain or control strategies (6) on initial attack. While federal agencies are not budgeted for protecting property and structures within or adjacent to their holdings, the Federal Emergency Management Agency (FEMA) can provide reimbursement for suppression, recovery, and mitigation on private lands if fires are declared as state emergencies.

CDF is mandated to provide wildland resource fire protection on state responsibility areas (SRA) (7). Its suppression activities are guided by principles designed to maintain landowners' options for future management, and it has no authority to "manage" land through the use of wildfire. During fire season, CDF provides staff at dispatch and fire stations around the clock and employs control as its sole initial attack strategy. It is not budgeted to provide protection for structures, *per se*, unless structure fires threaten wildland values.

Local fire districts and urban fire departments, on the other hand, are primarily responsible for providing structure protection on SRA and all fire protection on local responsibility areas (LRA), but have not tradition-ally been properly equipped to suppress fires in wildland-type vegetation included within LRA. For example, in the past, urban fire departments had little need for all-terrain vehicles since they were never expected to operate far from fire hydrants or to leave pavement, just as wildland fire agencies had no use for the specialized equipment required to mount interior attacks on structure fires.

Ultimately, however, fire burns without regard for jurisdictional boundaries or policies, and the results may preempt the management perspective and capabilities of individual institutions. As the interface fire problem has proliferated in California's fire environments, tactical distinctions have blurred, and it is no longer possible for individual agencies to predict with certainty the "type" of fire they will confront. Nor is it practical for every agency to be fully equipped and prepared for every fire scenario, since no single agency is equipped to deal effectively with a fire that starts as a vegetation fire, crosses the fire interface, and threatens structures. The development of an intricate structure of mutual and automatic aid, reimbursement for services, insurance and disaster relief reflects the need for a broad spectrum of organizational strengths, firefighting tactics, and equipment to protect different types of landscapes.

Delineating Fire Management Environments

In order to achieve more comprehensive, long-term fire management planning, the citizens, business community, and agencies of California must recognize the values at risk, management options, and institutional constraints associated with different fire environments. This can be achieved, in part, by delineating fire environments within an ecosystem context that considers:

- population density--as it contributes to values at risk,
- ownership--as it defines responsible institutions and entities, and
- land cover--as it determines values at risk and management options.

The Distribution of Population

Perhaps the most realistic place to begin to define fire management environments is the distribution of human population, since the formulation of public policy--from firefighting tactics to taxation--is fundamentally related to social values. For the sake of this discussion, U.S. Census data are used to delineate three classes of population density--undeveloped, developed, and mixed interface--describing fire management environments that require fundamentally different approaches to ecosystem-based fire management. The selected density thresholds represent theoretical points at which increasing population progressively constrains ecosystem management and fire protection options. These do not reflect existing statutory definitions, nor are they intended to advocate new definitions.

Undeveloped. Includes all areas of the state with less than one house per 160 acres and located more than five kilometers from any area with a housing density greater than one house per 160 acres and arranged in a contiguous block of 50,000 acres or more. The size threshold reflects an assumption that 50,000 acres represents the minimum size needed for ecosystem management, i.e. the minimum area within which historic fire regimes may have created a shifting mosaic of forest structure, and within which the fire service has a reasonable chance of containing an escaped fire. The five km buffer assumes that fires starting on the edge of the block and growing to 20,000 acres will not enter areas of greater housing density.

Developed. Includes all areas of the state with a housing density greater than one house per five acres plus all areas within two kilometers of such developed areas. This includes all "classic interface" areas. The buffer around those areas provides defensible space in which to halt the spread of encroaching fire.

Mixed interface. Includes all areas between developed and wildland areas, including areas with housing densities less than one house per five acres but greater than one house per 160 acres. Mixed interface areas consist of those areas that are most typically characterized by areas with scattered houses interspersed with vegetation.

Table 1 portrays the extent of these three fire management environments. Of the 13.8 percent of the state that falls into the "developed" class, nearly nine million acres (9.1 percent of the state) can be considered flammable developed fire environments. The other five million are either under water or irrigated. "Mixed interface" comprises a significant portion of the state (over 46 millions acres), comparable in extent to that of undeveloped areas (Map 1). More than 35 million

acres of these (34.9 percent of the state) remain as potentially flammable mixed interface. Assuming that little undeveloped land is irrigated, the total extent of the flammable "undeveloped" fire management environment amounts to nearly 40 million acres or 40 percent of the state.

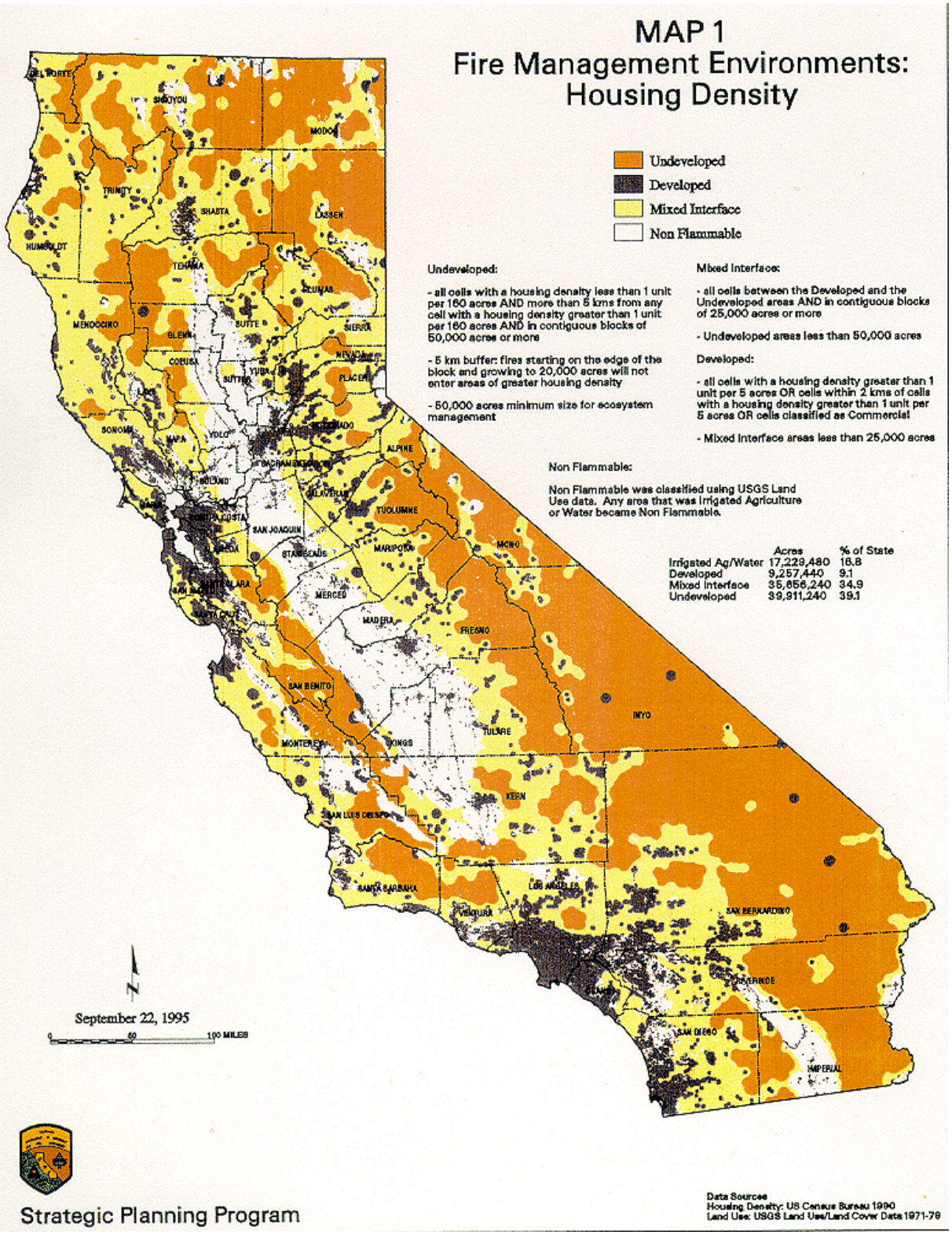


Table 1. Fire Management Environments of California, in acres and as percent of total state land area. (Analysis based on 1990 U.S. Census block data.)

	Developed Acres	% of state	Mixed interface Acres	% of state	Undeveloped Acres	% of state
Non-flammable (water/irrigated)	4,858,000	4.7	11,033,320	10.8	1,338,160	1.3
Potentially Flammable	9,257,440	9.1	35,656,240	34.9	39,911,240	39.1
Total	14,115,440	13.8	46,689,560	45.7	41,249,400	40.4

The Geography of Ownership

An examination of ownership indicates an additional level of complexity, and consequently an increasing number of fire environments, that must be considered in developing a comprehensive planning approach. Virtually all categories of land ownership in California (private sector, and state, local, and federal agencies) are responsible for some portion of each of the developed, undeveloped, and mixed interface fire environments, and therefore confront the same spectrum of fire and ecosystem management issues. Table 2 portrays the fraction of each ownership category in the three density-defined fire management environments.

Developed fire management environments challenge all three types of owners. Most of the developed fire management environment occurs on private land (7.6 million acres), constituting about 83 percent of the 9,257,440 acres of developed fire environment. Nonetheless, the BLM and the U.S. Forest Service together own nearly a million acres of developed fire management environment. While these areas constitute a small fraction of the agencies' total ownership, the proportion within individual national forests can be significant: San Bernardino National Forest has 17 percent of its land in the developed category and the Lake Tahoe Basin Management Unit has 27 percent (data not shown).

Mixed interface fire management environments also confront all landowners. Unlike the developed fire management environments, mixed interface fire environments form a large proportion of the total extent of both U.S. Forest Service and BLM lands (43 and 23 percent, respectively). Once again, within individual national forests, the proportion can be much greater. The national forests in southern California have very high levels (e.g., 91 percent in the Cleveland), but national forests in the central and northern Sierra also have high levels (e.g., 72 percent in the El Dorado, 63 percent in the Plumas).

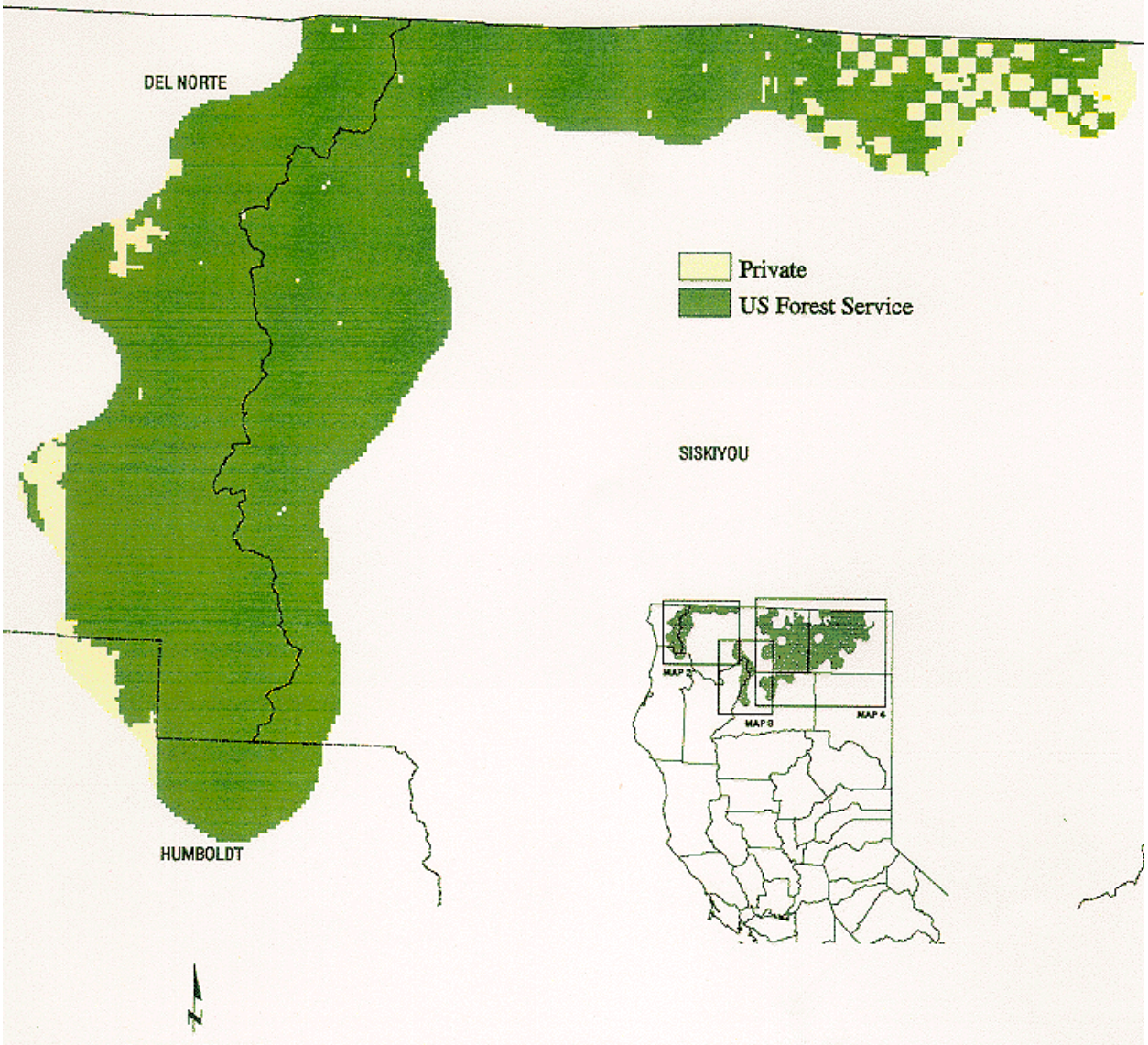
Finally, the undeveloped fire management environment is also found on all types of ownerships, and is not solely the province of the federal land management agencies. These environments constitute approximately half of the U.S. Forest Service ownership and three-fourths of BLM ownership. The private sector owns over eight million acres of undeveloped land, approaching amounts owned by either the BLM or the U.S. Forest Service.

Table 2. Fire Management Environments, in acres and as percent of ownership area, by ownership. (Data from Teale Data Center ownership layer. Percent rows may not sum to 100 because of rounding.)

Ownership	Developed		Mixed interface		Undeveloped		Non-flammable	
	acres	%	acres	%	acres	%	acres	%
Private	7,642,120	14.7	19,751,680	38.0	8,347,040	16.1	16,260,400	31.3
County/city	75,160	14.9	247,200	49.1	124,760	24.8	56,520	11.2
State	142,720	7.4	718,320	37.1	950,040	49.1	125,840	6.5
BLM	324,920	1.9	4,072,200	23.2	12,977,280	74.0	157,640	0.9
Other USDI	83,800	1.8	550,080	11.6	3,953,240	83.2	164,520	3.5
USFS	669,880	3.2	9,029,320	43.4	10,913,960	52.5	165,760	0.8
Other federal	318,720	7.0	1,285,240	28.3	2,644,920	58.3	285,400	6.3
Other	120	na	2,200	na	-	-	13,400	na
Total acres	9,257,440		35,656,240		39,911,240		17,229,480	

Within this expanded classification of fire environments, the mix and pattern of ownerships contribute to the institutional complexity of fire and fuels management. Three examples of undeveloped fire management environment regions in northern California illustrate this point. Map 2 portrays one undeveloped region in western Siskiyou County almost entirely owned by one agency, in this case the U.S. Forest Service. This configuration presents very few institutional problems. The ownership in other areas, such as an adjacent region in Trinity County (Map 3), is split evenly between the U.S. Forest Service and the private sector with some BLM land, but the ownerships are so intermingled that no owner could craft a successful strategy in isolation. In yet other situations, such as eastern Siskiyou-western Modoc (Map 4), many different owners are involved with various levels of juxtaposition and interspersion. While the U.S. Forest Service could conceivably craft a viable strategy for some of its ownership in such a region, the region as a whole requires a multi-owner strategy.

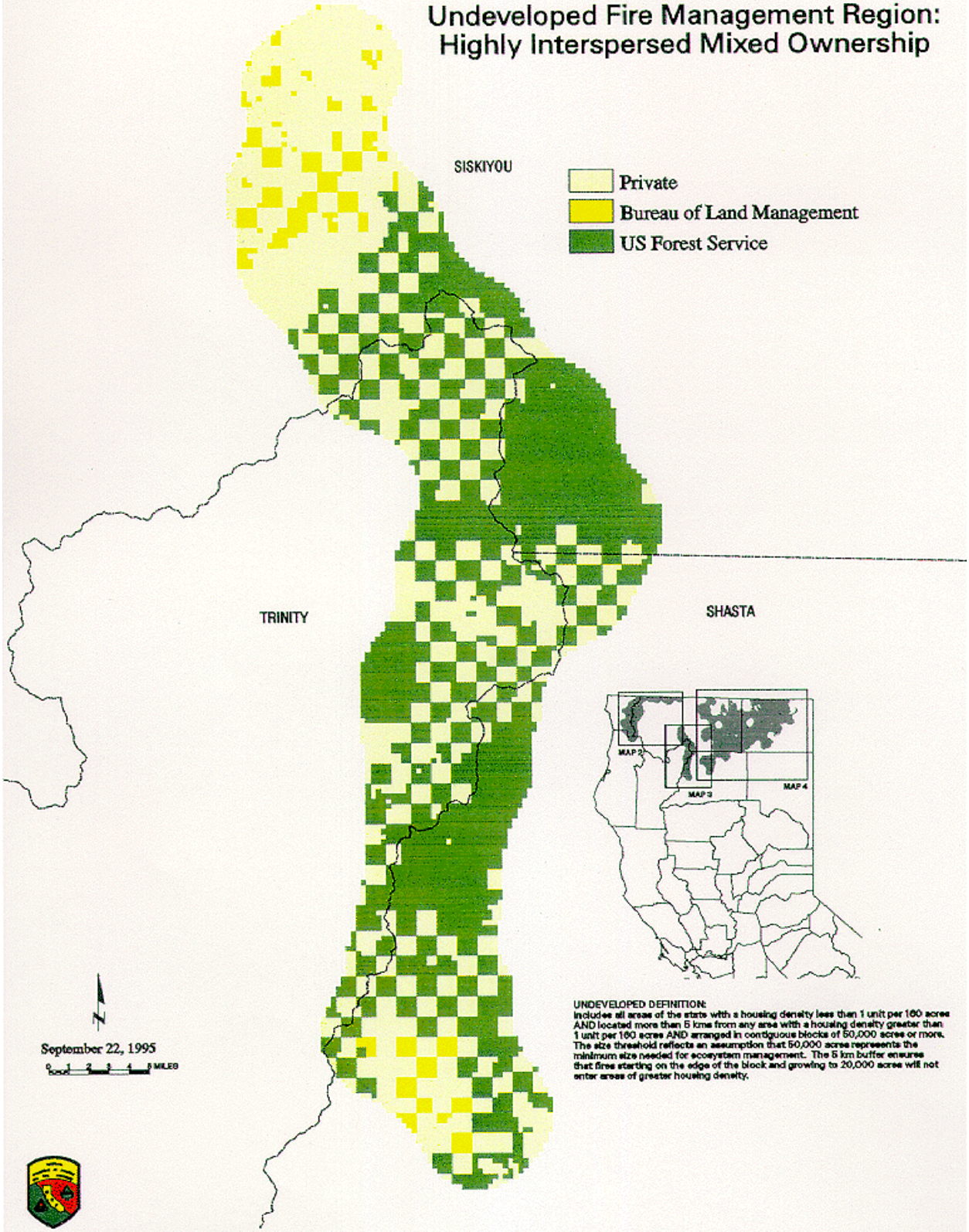
MAP 2
Undeveloped Fire Management Region: Single Agency Public Ownership



UNDEVELOPED DEFINITION:
Includes all areas of the state with a housing density less than 1 unit per 160 acres AND located more than 5 kms from any area with a housing density greater than 1 unit per 160 acres AND arranged in contiguous blocks of 50,000 acres or more. The size threshold reflects an assumption that 50,000 acres represents the minimum size needed for ecosystem management. The 5 km buffer ensures that fires starting on the edge of the block and growing to 20,000 acres will not enter areas of greater housing density.

Strategic Planning Program

MAP 3
Undeveloped Fire Management Region: Highly Interspersed Mixed Ownership



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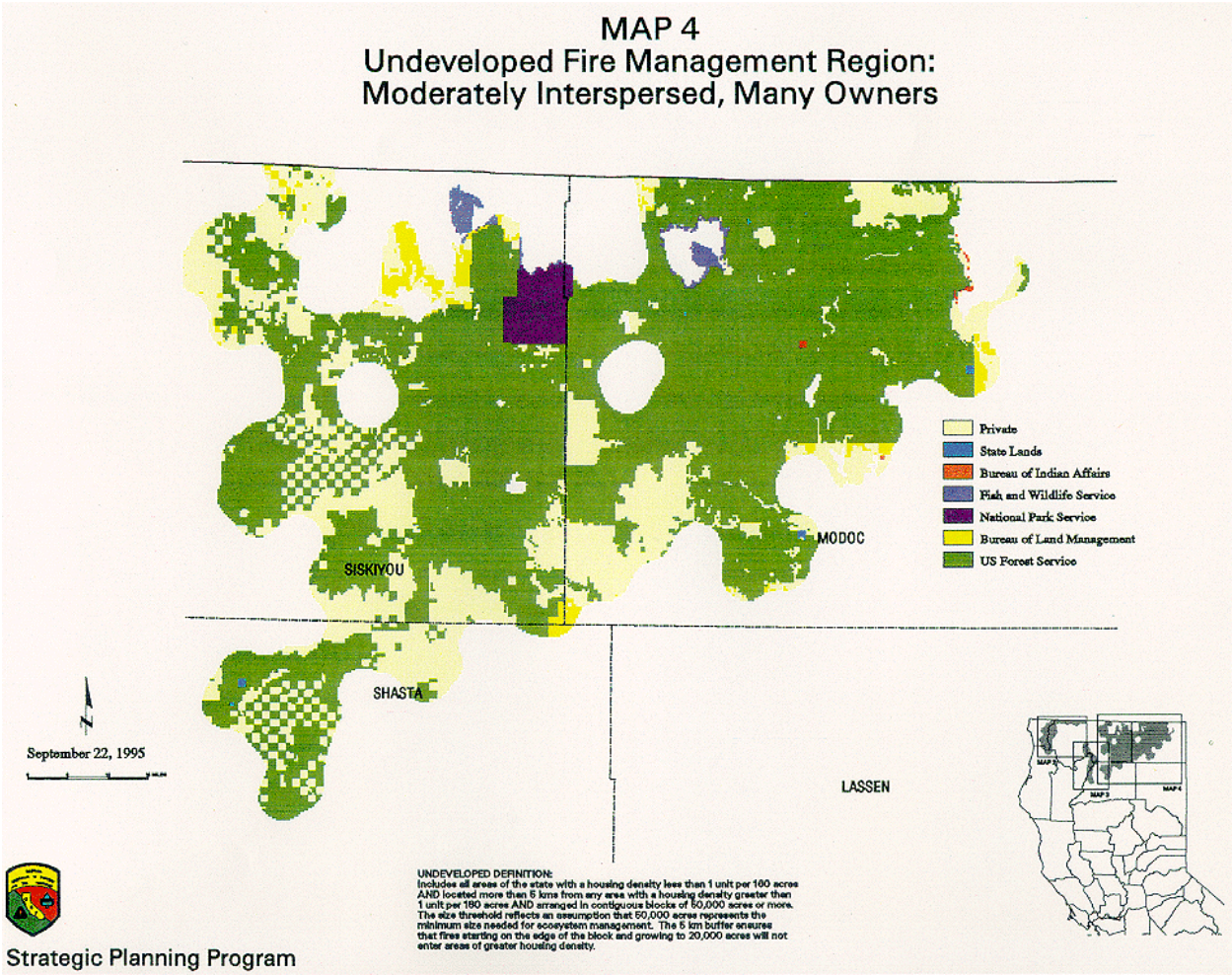
Strategic Planning Program



The Distribution of Land Cover

Vegetation (land cover) adds the final and perhaps most obvious dimension to fire environment classification. All major land cover types in California are found within each of the developed, mixed interface and undeveloped fire environments (Table 3). Desert and barren vegetation types are largely undeveloped, while woodland areas are located most often in mixed interface. The rest of the vegetation types are well distributed across the three density-defined fire management environments. The vegetation type is critical to the selection of management options because it constitutes both a value at risk and a hazard, and management decisions must reconcile these considerations.

Table 3. Major flammable land cover types, in acres and as percent of total land cover area, by fire management environment. (Data from CDF CALVEG coverage combined with Department of Conservation 1992 Farmland Mapping Coverage.)

Land cover	Developed acres	Percent of total flammable area	Mixed inter-face	Percent of total flammable area	Undeveloped	Percent of total flammable area
Conifer	1,515,480	6.4	12,069,280	50.6	10,248,080	43.0
Shrub	1,939,240	9.9	7,984,520	40.9	9,607,080	49.2
Woodland	1,312,040	11.6	6,965,520	61.5	3,048,200	26.9
Desert	831,280	4.4	4,716,440	24.8	13,489,040	70.9
Grass	600,960	10.4	3,116,880	53.9	2,061,520	35.7
Barren	43,600	2.3	452,640	23.6	1,419,680	74.1
Urban	3,014,840	88.6	350,960	10.3	37,640	1.1
Total	9,257,440	10.9	35,656,240	42.0	39,911,240	47.1

In summary, the overall interaction of population, ownership and land cover leads to a great number of distinct fire management environments within California, each of which merits its own particular fire management strategy. The definition of strategies for particular areas must of course consider additional

factors, such as fire history, other values at risk, topography, fuels management projects, and so on. Nonetheless, the three factors of population, ownership and land cover provide a starting point for a state-level discussion.

Developing Strategies for Fire Management Environments

The state's extreme diversity and complex pattern of land use and ownership mean that the effective management of fire environments requires an equally diverse and complex array, or "menu" of options from which to formulate customized solutions. Some of these options may be most appropriately provided by government, while others may be the responsibility of private citizens and businesses. Custom strategies for each of these environments can be created through combinations of pre-fire, suppression, and post-fire management options. Management options include:

Pre-fire Management

- Ignition reduction (education and arson programs, NFDRS)
- Hazard mitigation (prescribed burning or mechanical fuels treatments)

- Exposure mitigation (fire safe building standards, land use planning, insurance policy conditions)
- Fire suppression pre-planning
- Silvicultural treatments for improving forest health
- Forest management to achieve fire-resistant forest structure
- Research and technology development
- Development of reimbursement agreements and mechanisms

Fire Suppression

- Coordinated dispatch of closest, appropriate resources (local government to structures, CDF to State Responsibility Areas, federal agencies to federal lands)
- Coordinated fire management tactics (implementation of preplanned response, ICS, unified command)
- Use of air tankers, helicopters, dozers, hand crews, engines, trucks, tenders, etc.

Post-fire Actions

- Damage assessments
- Watershed rehabilitation programs consistent with values protected
- After-action analyses to devise more effective pre-fire strategies
- Disaster relief policies governing reconstruction activities

Customizing Fire Management Strategies

The appropriate strategy for each fire environment should address the full range of values at risk from wildfire, and should recognize the practical implications of implementing any strategy in the face of potential damage to life and property. The state should take the lead in refining descriptions of these environments and in establishing processes to define appropriate strategies over all ownerships in California.

In areas with few or no structures, it may be appropriate to manage the landscape for vegetation structure and patterns that simulate historic fire regimes, using traditional timber and rangeland practices that include pre-fire treatments such as prescribed fire and mechanical treatment. While this might require intensive management initially, fire suppression inputs could decline over time as management and low intensity fire work together to limit fire to appropriate levels of risk.

In undeveloped areas where landowners, private or public, wish to emphasize production of commodities such as timber, simulating the characteristic vegetation mosaic may or may not be an appropriate strategy. For example, if timber management objectives require denser stocking than would be supportable by the natural fire regime, such stands may be subject to a greater probability of loss due to higher-than-expected fire intensities. In that case, objectives might include a greater pre-fire management effort including precommercial and commercial thinnings as means for reducing ground fuels to simulate the effects of low intensity fires, fuel breaks around high-value areas, and restriction of activities during high fire danger periods. It might

also be appropriate to coordinate fire suppression policy across agencies and to provide supplemental private fire suppression to protect these resources. The impacts of these manipulations on ecosystem structure and function should be considered and mitigated where possible to maintain the health and resilience of the system.

Where homes or other improvements are present at lower densities, appropriate strategies might include enforcement of compliance with fire safe regulations and appropriate building codes to reduce the probability of fire propagating across the interface between structures and surrounding vegetation. While additional manipulation of the vegetation between structures may be desirable, it may meet with homeowner resistance because of amenity values or expense, particularly in the case of prescribed fire. The development of strategies here may require more coordinated dispatch of suppression resources from local, state and federal agencies in accordance with their different primary responsibilities (e.g., life and property, vegetation, etc.) as well as coordination of suppression policy across agencies within the area.

In more densely populated interface areas, successful protection may hinge primarily on engineering issues. Therefore, the appropriate pre-fire strategy should focus on building code compliance and improvement (e.g. non-wood roofs, water supply), fire safety regulation enforcement (e.g. road access, vegetation clearance), advanced home fire protection systems (e.g., sprinklered roofs and foam systems), and public education. Fire protection agencies are also faced with the continual need to adapt firefighting tactics and equipment to the challenges posed by the interface. For example, wildland fire engines may have all-terrain, mobile attack capabilities (but carry limited water), while local government engines, which typically are designed for structure fire protection, may not be as maneuverable off-road, but would have superior water pumping capacity. Increasingly in California, the most effective fire suppression response necessitates both types of firefighting resources working to complement each other.

None of the individual options that make up these strategies are new, and all have been tried with varying degrees of success, largely with the fire service in the lead. However, two things have not occurred. The first is a consistent, statewide commitment to comprehensive fire management by agencies, including pre-fire management, across jurisdictional boundaries. The second, and probably more important in terms of the interface challenge, is the full participation of all stakeholders and responsible parties, including citizens, local government, the business community, and agencies outside the fire service, to craft viable and equitable solutions. These changes are essential for facing the difficult choices brought on by decreasing budgets and increasing demand. Agencies and citizens must determine whether we can continue to meet desired or even existing levels of fire protection, and how we pay for them. Ultimately, the state needs to clarify the consequences of up-front investments in planning and pre-fire management versus deferred costs for suppressing disaster relief and rehabilitation. These discussions will require strong leadership roles by state and federal officials.

Comprehensive Planning and Increased Coordination

The first prerequisite for more comprehensive planning is the participation of all institutions and stakeholders in the planning and implementation of a fire management strategy for a given fire

environment. The state has the authority and perspective to convene and shepherd such participation. Participation is critical to ensuring that all values--private and public--will be provided for in the practical implementation of management options. Full participation is also needed because in most fire environments no single institution has either the authority or the means to accomplish the full range of options needed. Furthermore, in the face of declining budgets, agencies and the public must continue to aggressively confront equity issues, i.e. who benefits and who pays for fire protection investments and services.

Full participation in a comprehensive fire management planning effort requires a step up from the current forms of cooperation which focus largely on fire suppression. The fire service has already demonstrated its capacity for cooperative action in efforts to increase its effectiveness during multiple fire emergencies. After the catastrophic 1970 fire season in southern California, the U.S. Forest Service led an effort that brought together CDF, the California Office of Emergency Services (OES), and the fire departments of Los Angeles City and County, Santa Barbara County, and Ventura County to establish FIRESCOPE. This program applied integrated information technology to the fire line and brought together urban and wildland firefighting perspectives. The program's systems approach to organizational structure, terminology, and information flow greatly enhanced the ability of multiple agencies to function in emergencies. As a result of outputs like the Incident Command System (ICS) and the Multi Agency Command System (MACS), FIRESCOPE is largely seen as an unqualified success that serves as a national model of multi-agency cooperation. The state should now take the lead in establishing a larger effort that adds both pre- and post-fire management, improves our assessment and planning capabilities, articulates the costs associated with more comprehensive management, and includes all the stakeholders.

Agencies and academia should work together to evaluate the cost-effectiveness of different pre-fire options, and should develop long-term strategies for integrating pre-fire actions with suppression planning. USFS, BLM, CDF, and other agencies should coordinate research for improving our ability to identify high risk/high value sites, to predict the occurrence and effects of wildfire, to understand the role of fire in long-term ecosystem management, to assess non-commodity values at risk, and to evaluate pre-fire options for mitigating risk and potential damage. This includes increased monitoring of, for example, the effects of ignition prevention programs, brush and forest stand treatments, fire safe regulations, and uniform fire codes. The agencies should also integrate analytical efforts, including technologies, methods, and data.

As information becomes available, it should be widely and rapidly communicated by agencies, university extension, media, and other educational institutions to local government, private industry, the financial community and citizens. Recent media attention has been very encouraging, but interest may wane quickly if we are fortunate enough to avoid disaster this season, and if agencies are not adequately funded for continued education and outreach. The State Fire Marshal should take the lead with local government and community groups to identify opportunities to implement pre-fire projects in conjunction with the private sector.

Agency field managers should promote and coordinate the use of federal, state, and private forestry programs and state cost-share programs for achieving pre-fire management objectives where possible. Assessment and coordinated planning are now critical in light of recent and proposed budget reductions to the Forestry Improvement Program (FIP), Stewardship Incentive

Program (SIP), and California Forestry Improvement Program (CFIP). Finally, the agencies should continue to address any organizational or "cultural" disincentives or impediments to prevention activities, to the use of prescribed fire, and to the planning and implementation of cooperative, multi-owner and multi-agency pre-fire field projects.

Overcoming Institutional Impediments for Interagency Coordination

Several institutional impediments to coordination persist. Federal and state agencies, fueled by budget cutbacks, are considering restrictive interpretations of institutional responsibility that would undercut participatory approaches and ignore the complexity of environments. For example, federal proposals to limit suppression in interface areas and state discussions about revising jurisdictional boundaries for wildland fire protection imply that landscapes are more uniform than our analysis indicates. These approaches are inconsistent with the tenets of ecosystem management and with existing multi-agency fire protection and mutual aid systems. Any proposals arising from these discussions should be carefully assessed by responsible agencies, in collaboration if necessary, for their overall effects on ecosystem protection. On the other hand, inconsistent and inequitable emergency cost recovery policies, particularly among state agencies and local agencies, must be addressed in order to ensure continued cooperation across jurisdictions.

Other budgetary policies may impede collaborative assessment and planning analysis efforts. For instance, the U.S. Forest Service requires the use of the National Fire Management System to justify budgets. While this system takes an important step by providing a cost plus net value loss framework for analyzing fire protection program options for federal lands, it prohibits the consideration of private, state or other federal resource values, and could result in lower priority for pre-fire efforts in interface areas where cooperation is most needed. Similar constraints are likely to arise for state agencies. Fiscal concerns that are contingent on statutes or legal precedents, such as prescribed burning liabilities, must also be addressed--with legislation if necessary. For this reason, participation must also include budget and legal services units of all agencies in addition to technical staffs.

As described earlier, existing federal statutes may impede inter-agency planning and project implementation. FACA, which limits the access of non-federal persons to federal decision making processes, is considered an impediment to effective cooperation with the U.S. Forest Service by some local collaborative groups interested in ecosystem-based, pre-fire management in northwestern California and the Sierra. Planning and assessment efforts, constrained by NFMA, may focus on planning units that are inconsistent with fire environments as described in this paper. Furthermore, management constraints associated with CEQA, NEPA, NFMA and existing national forest operations may not lend themselves to opportunistic approaches to implementing cooperative pre-fire projects. In particular, the absence of a mechanism to permit the timely reinvestment of timber receipts from an individual national forest in forest health and pre-fire management on that same forest isolates state and local governments and place-based groups from most appropriate source of funding for those projects. Finally, other state and federal environmental regulations may complicate the use of vegetation management tools, such as timber harvest and salvage, mechanical brush treatments, and prescribed burning. The state should work closely with federal agencies and the public to identify appropriate channels, viable alternatives, or regulatory changes that allow for more interactive and tiered planning processes,

particularly with broad-based, collaborative groups and public/private partnership groups. "Regulatory reform" efforts may, however, require additional commitments among agencies and the private sector to monitoring and adaptive management in order to ensure environmental protection goals are not compromised.

CDF should use its Fire Plan to integrate federal agencies, local government, and the public within a comprehensive planning process. In order to move beyond organizational, statutory, and budgetary constraints, the state must examine the total costs of fire protection to its citizens, including an evaluation of private and public values at risk, cost-effectiveness of pre-fire and suppression tactics, and the costs and benefits of resource rehabilitation and disaster relief policies to the public and private sector. In California, CDF's Fire Plan incorporates a total cost plus net value change assessment into state fire management planning for state responsibility lands (SRA). This approach is needed to assess the relationships of changing budgets to levels of fire protection, and to assess the cost-effectiveness of additional pre-fire investments. The plan also provides a framework for beginning to address these issues across ownership and jurisdiction boundaries as well.

Strengthening the Roles of Local Government, Citizens, and the Private Sector

The accomplishments in coordinated fire suppression planning by the fire service can be strengthened by increasing the role of local governments, citizens, private industry, and the financial community in pre-fire planning. In theory, public and private investment in community infrastructure, private construction, land management, fire suppression, insurance, and disaster relief should interact to minimize the total cost of fire protection, protect public and safety, ensure healthy ecosystems, and prevent recurrent catastrophes. In fact, this system does not appear to be operating as efficiently as it could in the private sector. Therefore, state, local, and federal agencies must examine and rectify policies that serve as disincentives to adequate investment in pre-fire, particularly those relating to land use, mitigation of exposure to fire loss, and disaster recovery.

Local governments should exercise authority over land use and construction to mitigate wildfire risk to life, property, and wildland resources. While some have aggressively addressed fire safety in general plans and project approval processes, others continue to allow development and annexations in fire-prone areas without enforcement of building codes or zoning controls. This is often due to perceived conflicts with development goals (i.e. mitigation costs will discourage developers), and local government sensitivity to citizens' concerns about property rights and government intrusion. On the other hand, the public expects near unlimited government intervention--i.e. a massive suppression response followed by disaster relief--when wildfire strikes.

Private insurance markets should, in principle, match premiums to potential liabilities and therefore provide lower rates to homeowners who take extra steps to mitigate risks (e.g. engineering measures, fuels reduction, water development, etc.), or who purchase homes in lower risk areas. Such free market interactions between the financial community and homeowners has, however, been undercut in some areas by the lack of adequate information

from fire agencies about risk and hazard; the reliance on FEMA as insurer of last resort; lack of aggressive zoning, infrastructure development and building code enforcement by local some governments; and lack of compliance with fire safe laws by citizens.

In the past couple years, the insurance industry under-estimated its financial liabilities from wildfires, and failed to raise premiums consistent with the increased risk. The large losses they suffered in the Oakland and southern California firestorms, coupled with liabilities from earthquakes and other disasters throughout the nation, led to abrupt increases in premiums or loss of coverage for some homeowners, and the withdrawal of insurance carriers from some areas of the state. Alternatives such as California Fair Plan (an assigned risk pool) and proposed bond initiatives for fuels reduction, leave room for improvement both from the perspective of homeowners, the insurance industry, and the development community.

The state should provide leadership in clarifying the diversity of fire environments, the risks associated with development in different areas, the options and costs of mitigating those risks, and the means of enforcing mitigation maintenance through time. This should assist homeowners, developers, and insurers to predict and mitigate their own liabilities. We now have a narrow window of opportunity, while the disasters are fresh in the public's mind, for discussions with agencies, the financial community and local government about reducing wildfire risks in the future so that development can proceed.

The example of the financial community's response to urban high-rise fires illustrates how adequate up-front investment by the private sector can mitigate the hazard of costly fires. Until the advent of the major interface fire disasters of the 1990s, high-rise fires represented the most costly type of urban fire disaster, both in terms of life and property value loss. The most recent major U.S. high-rise fire was the Las Vegas MGM Grand Hotel fire in 1980 which resulted in the deaths of 85 people and massive insurance liability. In the wake of that fire, however, state-of-the-art fire protection systems installed in high-rises have exceeded government codes. No bank will provide financing for a skyscraper costing $50 or $100 million without assurance that the building will be adequately insured; and no insurance carrier will provide such assurance without the type of engineered, built-in fire protection systems that were long resisted by property developers and owners. While the private sector has thus dealt with fires that threaten structures from the inside, it has only begun to apply similar methods to fires that threaten structures from the outside.

FEMA policies should also be reevaluated in terms of their contribution to minimizing long term total cost of fire in California. Provision of assistance should be conditioned on implementation of recommended mitigation plans in areas where disasters have already occurred. These discussions will require strong leadership among federal officials, local government associations, and the state. Hazard mitigation grants should be made available for areas at risk, even if they have not suffered a recent disaster. These changes appear to be under way, but the state must participate in this process and monitor those changes to ensure that they augment, rather than hinder, the overall state strategy.

Fire planning efforts must also consider the role of the private sector in implementing pre-fire management in wildland areas. Ultimately the magnitude of fuels reduction needed to restore healthier, fire resistant landscape conditions will require private sector contributions to

vegetation management and removal, waste disposal, and wood product utilization. CDF recently demonstrated the benefits of private/public partnerships activities in the Oakhurst-Ahwahnee basin of the Sierran foothills by working with a private forester, the biomass industry, and the local community to reduce brush fuel loading on more than 6,000 acres.

Unfortunately, the profitability of the biomass industry is at risk due to energy rate deregulation. Environmental regulations for air quality, habitat protection, and solid waste disposal have also begun to affect the economic viability of a number of private industries that support pre-fire work. The state must consider appropriate market-based mechanisms to address these concerns. Candidates include tax credits to promote noncommercial wood utilization, incentives to landowners to remove fuels, pollution credits for wood processing or burning activities, or even water-user fees for funding forest health and watershed improvement activities.

Emerging Collaborative Institutions

Other emerging collaborative efforts provide opportunities that may help the fire agencies to move forward in these areas. In California, the Resources Agency has taken the lead in conjunction with the U.S. Forest Service in establishing the Fire Strategies Team. This effort brings together state, federal, and local agencies, industries, broad-based grassroots groups, and environmental groups to articulate pre-fire management strategies. This team is focused on increasing fuels reduction on federal lands, removing institutional impediments to pre-fire activities and to agency coordination, and improving fuels information across ownership.

The Agency also chairs the California Biodiversity Council (CBC) which was formed to coordinate efforts by state, federal, and local agencies to protect biological diversity while ensuring economically viable communities. Since fire is central to ecosystem management and biodiversity maintenance, this group provides opportunities to focus attention on the role of fire management in specific ecosystems and to demonstrate relevant on-the-ground projects. The CBC also works closely with place-based collaborative groups, such as bioregional councils (Shasta-Tehama Bioregional Council), watershed groups, and others like the Quincy Library Group that are developing community and landscape-level management strategies for improving fire protection.

Finally, issues that relate to the interaction of long-term development policies and effective fire protection may be addressed outside the traditional fire planning community by articulating the long-term costs and benefits of development to local government and the state. The state, in cooperation with academia, public interest groups, local government and the financial community, should assess and communicate the effects of different types of development on infrastructure, health and safety, employment, social organization, quality of life, and environmental resources to local governments to assist them in making informed land use planning decisions. This should help reduce impacts to ecosystem values and fire protection capabilities.

Summary

The ability of the state to maintain and improve fire protection services to meet public demand requires the integration of ecosystem management and fire protection into a more comprehensive approach to fire management. The interaction of population density, ownership, and vegetation creates a great number of fire management environments, each of which requires a customized fire management strategy composed of pre-fire, suppression, and post-fire management options. The successful implementation of these strategies requires enhanced participation by citizens, local government, and the private sector, and an increased emphasis on pre-fire management.

This process will require a reevaluation of existing policies that govern how agencies plan, manage, and interact with others. The state, in conjunction with other agencies and the research community, should increase efforts to assess fire hazards and risk, fire effects on commodity and non-commodity losses, and the cost effectiveness of different management options for mitigating the total costs of fire protection. Fire service agencies should use this information to improve the integration of pre-fire management, and in removing impediments to comprehensive fire management.

In light of its position, authority and resources, CDF is central to the process of defining more comprehensive approaches to fire across all ownerships in California. The Department should move forward with the development of its Fire Plan, and include federal and local agencies in the process. The total cost framework presented in this plan is critical to clarifying the choices faced by agencies and the public about levels of protection and the means for maintaining or improving them. The state must work with local government, citizens, the financial community, and other agencies to identify additional pre-fire investment needs, and to determine the most cost-effective and equitable mechanisms for implementing them. It is only through this process that we can hope to meet the fire protection demands of the future.

Footnotes

1. The term *ecosystem* refers to "a [biological] community and its environment treated together as a functional system of complementary relationships" (Whittaker, R.H. 1975. Communities and ecosystems. MacMillan Publishing Co., New York. 385 p.) *Ecosystem* as a concept focuses on the whole system, rather than any single component or function within the system. An ecosystem can be said to be *healthy* if it is "active and maintains its organization and autonomy over time and is resilient to stress" (Haskell, B.D., B.G. Norton and R. Costanza. 1992. What is ecosystem health and why should we worry about it? *in* Costanza, R., B.G. Norton and B.D. Haskell. Ecosystem Health: new goals for environmental management. Island Press, Washington, D.C. p. 3-20). The closely related concept of *ecological integrity* has a less normative flavor and focuses principally on the maintenance and resilience of ecological function rather than structure (King, A. 1993. Considerations of scale and hierarchy. *in* Woodley, S., J. Kay and G. Francis. Ecological integrity and the management of ecosystems. St. Lucie Press. P. 19-45).

2. Minnich, R.A. 1983. Fire mosaics in southern California and northern Baja California. Science, 219:1287-1294.

3. Parsons, D.J. and S.H. DeBenedetti. 1979. Impacts of fire suppression on a mixed-conifer forest. Forest ecology and management. 2:21-33.

4. The term *fire interface* was coined by Butler (Butler, C.P. 1976. The urban/wildland interface. Fire Protection Notes No. 10, Sept. 1976. California Department of Forestry and Fire Protection, Sacramento). The term was later refined to describe three distinct scenarios of structure threat in vegetation fires in an article by Davis (Davis, J.B. 1988. The wildland-urban interface: what it is, where it is and its fire management problems, *in* Fisher, W.C. and S.F. Arno. Protecting People and Homes from Wildfire in the Interior West. GTR INT-251. Intermountain Research Station, Forest Service, USDA, Ogden, Utah. p. 160-165).

5. FRRAP. 1988. California's Forests and Rangelands: Growing Conflict Over Changing Uses. Forest and Rangeland Resources Assessment Program, California Department of Forestry and Fire Protection, Sacramento. 348 p. + appendices.

6. Confine means to limit fire spread through the use of natural or preconstructed barriers. *Contain* includes confine tactics and allows the construction of a control line as needed. *Control* adds a complete control line around the fire with burning out of areas adjacent to the control line as well as direct attack.

7. State responsibility lands are defined in California Public Resource Code § 4126. They consist of private forest, range, and watershed lands.