The Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems

February 15–17, 1994 **Walnut Creek, California**

David R. Weise **Robert E. Martin** *Technical Coordinators*

Contents

Contents

Contents

Contents

In Brief…

Weise, David R.; Martin, Robert E., technical coordinators. 1995. **The Biswell symposium: fire issues and solutions in urban interface and wildland ecosystems; February 15-17, 1994; Walnut Creek, California.** Gen. Tech. Rep. PSW-GTR-158. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 199 p.

Retrieval Terms: community response, ecosystem management, fire ecology, fire management, fuel management, prescribed burning

Fire has been and continues to be both a threat and benefit to humans and ecosystems. Recent large or costly fires have occurred in both the wildland-urban interface and in the wildlands. These phenomena are not new events but merely recurrences of long-standing challenges. The values at risk include, but are not limited to, human life and property, rare or unique cultural and natural resources, and ecosystem health. Much progress has been made during the past several decades regarding fire's role in wildland systems, but many issues still remain to be resolved.

This volume presents the proceedings of the symposium, "Fire Issues and Solutions in Urban Interface and Wildland Ecosystems" held February 15-17, 1994 in Walnut Creek, California. The primary objective of the symposium was to describe fire issues and problems currently facing land managers and to present state of the art solutions that are currently being implemented by local, State, and Federal organizations concerned with fire management. The focal point of the symposium was the 1991 Oakland/Berkeley Hills "Tunnel Fire"; however, the issues and solutions described are certainly regional and national in scope.

Several key issues regarding the role of fire in wildlands and in the urban interface include social barriers, fire safety, fuel management, legal barriers, multiple jurisdictions, program cost and benefits, wildland health, conflicts between wildland resources and residential structures, air quality, and liability. Social barriers include lack of general knowledge of fire's role, as well as recognition of its hazards and benefits. Legal barriers include laws, ordinances, and regulations that either restrict fire use or do not provide incentives for fire use. Implementing fire use on an ecosystem level requires cooperation between neighbors. The safety of structures built in urban interface settings or adjacent to wildland boundaries is an issue the owner faces; the liability associated with destruction by wildland fire is an issue that land managers face.

Because of the complexity of the issues regarding fire and its use, many different solutions have been developed. Researchers have identified social barriers and concerns that hinder adoption of fire safe practices by the general public. Educational efforts to prevent the public from forgetting the losses associated with catastrophic wildfires have been developed. Legal solutions to fuel management and fire hazard reduction have been developed in California and Florida to address liability issues. Community and neighborhood-based associations have developed to promote fire-safe wildland-urban interfaces. Interagency agreements were developed to apply prescribed fire at ecosystem levels to mutual benefit. Environmentally safe fire suppression techniques have also been developed.

Many proactive approaches to solving these and other fire issues were presented at the symposium. It is our hope that the symposium attendees as well as readers of these proceedings benefit from the array of topics discussed, and that the information gained from the technical sessions and this proceedings provides a starting point to solving local fire issues. This symposium presents a snapshot of the continually evolving dialogue about fire and its role as a shaper of ecosystems.

Preface

Fire has been and continues to be both a threat and benefit to humans and ecosystems. Recent large or costly fires have occurred in both the wildland-urban interface and in the wildlands. These phenomena are not new events but merely recurrences of long-standing challenges. The values at risk include, but are not limited to, human life and property, rare or unique cultural and natural resources, and ecosystem health. Much progress has been made during the past several decades regarding the recognition of fire's role in wildland systems, but many issues still remain to be resolved.

Dr. Harold "Doc" Biswell was a pioneering advocate for the study of the ecological role of fire, for the use of prescribed fire in land management, and for fuels management. He worked to reduce fire hazard in urban-wildland interface areas and lived to see one of his most dire predictions come true in the Oakland/Berkeley Hills "Tunnel Fire" of October 1991. A conference to honor Dr. Harold H. Biswell was proposed shortly after his death in January 1992. This symposium was organized to honor Dr. Biswell by addressing wildland and urban-wildland fire issues and solutions—subjects dear to his heart. We dedicate this symposium and proceedings to the memory of Dr. Harold Biswell.

Approximately 350 managers, researchers, planners, former students of Dr. Biswell and other individuals attended the symposium in Walnut Creek, California. Because the wildland and structural fire communities were equally represented in attendance, the goal to bring both groups together in a common forum was accomplished. The symposium consisted of two and one-half days of technical presentations, a one-half day field trip touring the 1991 Oakland/Berkeley Hills "Tunnel Fire," a poster session, and an evening session dedicated to Dr. Biswell's life and legacies led by Dr. James K. Agee. The technical presentations were structured around issues/problems and solutions in both wildland and urban interface ecosystems. The major topics were developed by a Steering Committee representing Federal, State, and local agencies, and university and non-governmental organizations. Speakers were selected to address the major topics. Each technical session was chaired by a moderator and included the following topics:

- History, safety, and legal and social barriers to prescribed fire (moderator—Sue Husari, USDA Forest Service)
- Wildland topics including funding of fire programs, ecosystem management, and prescribed fire (moderator—Tom Nichols, USDI National Park Service)
- Urban-wildland interface topics including use of foams, neighborhood action groups, and fire safety (moderator—Steve Bakken, California Department of Parks and Recreation)
- Legislation and ecosystem management solutions (moderators—Bruce Kilgore, USDI National Park Service; Carol Rice, Wildland Resource Management, Inc.).

The technical sessions included expert panel discussions. In addition to the session moderators, the panel moderators included Dr. Ron Wakimoto, University of Montana; Chief Neil Honeycutt, California Office of Emergency Services; and Chief Rich Aronsen (retired), California Office of Emergency Services.

In addition to the technical sessions, the conference featured a keynote speech by Chief Lamont Ewell, Oakland Fire Department, describing the 1991 Oakland/Berkeley Hills "Tunnel Fire" and a banquet with a memorial dedication to Dr. Biswell by Dr. James Agee, University of Washington. The symposium concluded with a summary of the events and issues by Robert Mutch, USDA Forest Service (retired).

Acknowledgments

A conference and proceedings of this size require a great deal of effort from many individuals. We thank the members of the Symposium Steering Committee—Rich Aronsen, Steve Bakken, Todd Bruce, Neil Honeycutt, Sue Husari, Ken Nehoda, Tom Nichols, Carol Rice, Joe Rubini—for putting together a dynamic and interesting symposium agenda. The Steering Committee was organized using the Incident Command System as the basic organizational framework. Robert Martin initiated the idea for the conference, organized the Steering Committee and served as Incident Commander (Symposium Chair); Carol Rice (Operations) was assisted by Ken Nehoda; Joe Rubini (Logistics) was assisted by Neil Honeycutt and Todd Bruce; Sue Husari (Finance) was assisted by Tom Nichols and Steve Bakken; and David Weise (Planning) was assisted by Rich Aronsen. The efforts of Sandy Cooper and Bruce Winner, University Extension - University of California, Davis, were key to providing the logistical support of program materials, registration, hotel negotiations, bus negotiations, and other activities too numerous to mention. Joe Rubini and Neil Honeycutt with the assistance of University of California, Berkeley graduate students David Sapsis, Scott Stephens, Robert Schroeder, and Maria Gutierrez developed an informative tour of the 1991 "Tunnel Fire" and fuel management activities in the Oakland/Berkeley Hills.

We further acknowledge the efforts of Eugene Hanson and Bonnie Corcoran, Prescribed Fire Research Unit located at the Forest Fire Laboratory in Riverside, California in assembling the proceedings, and the editorial and graphics assistance of Sandy Young, Laurie Dunn, Kathy Stewart, and Robert Robinson of the Station's Research Information Services. Thanks to all the authors during the long process of manuscript preparation, editing, and production. Lastly, we acknowledge the support provided by the following sponsors: University of California at Berkeley; Bay Area Wildfire Forum; City of Oakland; East Bay Regional Parks; California Departments of Forestry and Fire Protection, Parks and Recreation, Emergency Services, and the Fire Marshall's Office; USDI National Park Service; USDA Forest Service, Region 5; USDA Forest Service, Pacific Southwest Research Station; and the Society of American Foresters.

United States
Department of
Agriculture

Forest Service

Pacific Southwest
Research Station

General Technical
Report PSW-GTR-158

The Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems

Federal Recycling Program
Printed on Recycled Paper

United States
Department of
Agriculture

Forest Service

**Pacific Southwest
Research Station**
http://www.psw.fs.fed.us
General Technical
Report PSW-GTR-158

The Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems

February 15-17, 1994 **Walnut Creek, California**

Weise, David R.; Martin, Robert E., technical coordinators. 1995. **The Biswell symposium: fire issues and solutions in urban interface and wildland ecosystems; February 15-17, 1994; Walnut Creek, California.** Gen. Tech. Rep. PSW-GTR-158. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 199 p.

These proceedings summarize the results of a symposium designed to address current issues about wildfire and prescribed fire in both the wildland-urban interface and in wildlands. Thirty-eight invited oral papers and 23 poster papers describing the issues and state-of-the-art solutions to technical, biological, and social challenges currently facing land and fire managers were presented at The Biswell Symposium held February 15-17, 1994, in Walnut Creek, California.

Retrieval Terms: community response, ecosystem management, fire ecology, fire management, fuel management, prescribed burning

Technical Coordinators:

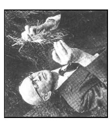
David R. Weise is Project Leader—Prescribed Fire Research at the Station's Forest Fire Laboratory, 4955 Canyon Crest Drive, Riverside, CA 92507. **Robert E. Martin** is Professor Emeritus, Department of Environmental Science, Policy, and Management, University of California, 145 Mulford Hall, Berkeley, CA 94720.

Publisher:

Pacific Southwest Research Station
Albany, California

(Mailing address: P.O. Box 245, Berkeley, CA 94701-0245
Telephone: 510-559-6300
http://www.pswfs.gov/

August 1995



The Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems

PSW-GTR-158

Memorial Dedication to Dr. Harold H. Biswell[1]

James K. Agee[2]

This conference has been named the Biswell Symposium in honor of Professor Harold H. Biswell, pioneer fire ecologist. To represent all that Harold stood for to all those who were touched by this great man is a humbling experience. The profession of fire management underwent a paradigm shift in the 1960's, and the man who, more than any other, actually shifted the focus of the fire culture was Harold Biswell. I first met Professor Biswell in the early 1960's as an undergraduate forestry student at the University of California, Berkeley. The idea of underburning forests to prevent more destructive wildfires was a revolutionary idea in California at the time, although fire was routinely used in some shrublands. Despite Dr. Biswell's contributions to our profession, he was widely criticized for the same ideas, presented in the same way, for which he received so much favorable response later in his career. Because some of his monikers, like "Harry the Torch" or "Dr. Burnwell," were acquired during the early days of controversy, I never felt comfortable with them, although "Doc" seemed acceptable to him.

Early Controversies

Two particular examples of the controversies of the early days come to mind. The first was associated with a public hearing and post-fire analysis after a human-caused wildfire near Hoberg's Resort in the early 1960's. This was the area where Doc had done some of his early prescribed burning, with Mr. Hoberg's blessings. The wildfire came up to the edge of the resort as a crowning fire, and dropped to the ground at the edge of Doc's burn unit, where it was controlled. I found the transcripts of the hearing while browsing through the unindexed stacks in the Forestry Library, University of California, Berkeley. At the hearing, Professor Biswell noted that in his opinion the fire had stopped because the fuels had been reduced in the prescribed burn area over several short-interval burns. Yet personnel from the fire suppression agency involved testified that the wind stopped exactly at the edge of the prescribed burn unit, so that a change in weather was responsible for the change in fire behavior. They were probably right that the wind slowed, but it slowed because the prescribed burned area had a dampening effect on the wildfire behavior. I was able to visit the site years later and found all the trees dead in the wildfire area and a healthy forest in the prescribed fire area. An objective analysis was sorely lacking, continuing a pattern that had persisted since the 1920's in a religious zeal to combat all fires.

At roughly the same time, the University of California issued a press release concerning Harold's research, in which he was quoted as saying the kinds of things he was to repeat for the next three decades. The press release was a narrative with quotes from Doc sprinkled throughout the text, portions of which are presented here: "The pine forests in the Sierra Nevada were open and parklike, and the most important agent in maintaining these conditions was frequent light fires. This forest was truly a product of nature—natural man and natural environment. Since the white man has suppressed fires, Biswell pointed out, the forest vegetation and landscape have undergone profound changes. To reverse these trends, Biswell recommends adopting a trick from nature and returning to controlled fire as a tool in forest management." All those who knew Doc have heard one or more of his variations on this theme, but in those days it elicited responses such as this one from a statewide fire prevention organization: "We reproduce it here verbatim (the press release) to show what is being said by opponents of fire prevention. This is the type of opinionated misinformation being spread by some people with quotable positions." Those who knew Harold also knew he was very much an advocate of fire prevention, but that he felt that a balance between fire suppression, prevention, and use was critical. Smokey Bear just could not say it all in one sentence anymore.

A continual barrage of attacks and accusations followed Harold Biswell around the State during this period of the late 1950's and early 1960's. His colleague Harold Weaver, who worked for the USDI Bureau of Indian Affairs and had been spreading a similar message since the mid-1940's, published articles that were footnoted with a disclaimer from the agency. One had to be very courageous in those days, and it is easy for us to forget those early days. A lesser man might have retreated, but Harold strode on, focusing on spreading the message that has been repeated many times, and taking the high road in terms of his professional demeanor. The logic of that message attracted many of us, including me, to become interested in fire science as a career.

The Teacher and His Research

Harold Biswell was a great teacher. I mentioned the Biswell Symposium to a professional forest consultant, now working in southern Oregon, who was once a student at the University of California at Davis, and one evening attended

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Professor of Forest Resources, University of Washington, Seattle, WA 98195.

a talk by Dr. Biswell on fire and forest management. He told me it was the best lecture he had ever heard in 4 years of college, and it profoundly altered his career path. And he is not alone. Doc was a great wildlife ecologist, a range ecologist, and a forest ecologist—just a wonderful teacher. He would interpret the landscape during driving trips throughout California, with a fantastic ability to recall when a field had been fertilized, or a forest underburned—and an uncanny ability to identify plants at a distance that I could not even see, much less identify. At Altamont Pass, southeast of Walnut Creek, California, a common practice of farmers was to fertilize fields using a template of letters, and the resulting letters, paid for by advertisers, would show up in visible "words" of different species composition and productivity of grasses and forbs. He would predict the species composition from a quarter mile away, and when we walked over from the highway, he was always right. His ability to integrate management into multiple facets of forest, shrubland, and grassland ecosystems gave all of his students a well-rounded education.

Harold was a true renaissance man. His first emphasis was in range management, and his work from the 1930's in root dynamics of grasses from Nebraska is still widely cited. Although the picture of Harold on the symposium packet shows him holding a clump of giant sequoia needles, I thought at first he was holding a perennial grass and inspecting its roots, because he was never far from his range "roots." By the time he came to California, he had been introduced to fire in the southeast United States, and began to look at fire in the ecotones between forest and grassland. Fire was commonly used in the early 1950's in the foothills to expand grazing capacity, and Harold investigated shrub and grass response. He also worked in wildlife management, on several deer range problems, particularly in the Tehama and Lake County regions. This experience enabled him to shift emphasis to the forest zone, and in particular Hoberg's Resort in Lake County, California, where he successfully reduced shrub invasion and fuel buildups in the pine forests of the resort. This was one of the first successful wildland-urban interface fire projects, and was evidence of both his innovative outlook and practical approach. Later, as he focused on mixed-conifer forests, he and his colleagues and students investigated soils, hydrology, fuels, and air quality effects of fire. Harold was always reminding us of the interactions between all these components of the ecosystem. When new issues arose, he was always learning more, teaching those around him, and always with an enthusiasm and energy that amazed us students.

In 1967, I was one of his research assistants working with him at Whitaker's Forest. What energy! He could outwalk most of us, and at times outrun us. I will never forget that during one of our "little burns," as he would call them, which we conducted with the help of inmate crews, we burned across a yellowjacket nest. Harold, an inmate, and I were kneeling around the vicinity of the nest at the time. Harold yelled and took off sprinting like Carl Lewis, leaving the inmate and I to greet the bees! I still remember the inmate and I looking at each other, astounded, as Doc safely bounded away as if shot from a cannon. The two of us laggards, of course, provided great sport for the yellowjackets. In addition, many of the short courses and tours he led in the 1970's and 1980's left the attendees gasping for breath as Doc finished talking at one site, and then would proceed at an incredible pace to the next stop.

One of the strengths of Harold's approach was a secular, rather than a revivalist, approach to prescribed fire. During the 1950's and 1960's, the only place where fire was commonly used in forests was in the South. At the Tall Timbers Research Center in Tallahassee, Florida, a series of conferences were held, beginning in 1962, and the "word" about fire was disseminated to a wider audience. Harold had several articles in the early issues of the conference proceedings, which have become classics since they were initially published 15 years ago. In 1967, he helped organize the first western Tall Timbers conference, held appropriately at Hoberg's Resort, the site of some of Harold's early prescribed burning experiments. Many of the Tall Timbers staff attended, and the concluding discussions were much like a fundamentalist revival meeting, with audience members rising and "testifying" to the benefits of fire in the forest. I was shocked—I wanted to go into fire ecology, not theology! I later realized this represented part of the ongoing institutional change in the South, and was to some extent a reaction to the earlier fire prevention "Dixie Crusaders." Harold's more secular western approach, focusing on the practicality of fire integration into forest management, was better received in California (and relieved me greatly!).

Turning Point

His innovative ideas remained controversial during the late 1960's, but his tireless extension efforts attracted a growing crowd of converts, including the National Parks Advisory Board, which met at Whitaker's Forest soon thereafter. He began to hold occasional extension tours, which soon grew in frequency and attendance. This period was a turning point in the profession's views on fire, but turning that corner was not easy. Few of us will ever experience the professional hurdles faced by Harold and his contemporaries.

I also used to think of him as the Arthur Murray of fire—he taught many agency people to dance, as they would visibly fidget while Doc provided his frank analyses of site conditions and fire hazards, and asked probing questions, usually in front of a class or tour group. Those of us accompanying Doc were able to watch these dance lessons with amusement and often learned a few dance steps ourselves—an essential part of our education. To be put on the spot helped us think on our feet.

Publication was an important part of Harold's contributions to our profession. He understood the need for publication in basic science outlets like *Ecology, Forest Ecology and Management,* or other scientific journals, and in more extension-oriented publications, too—those that would reach the public. His book, *Prescribed Burning in California Wildland Vegetation Management,* published in 1989, was a classic integration of science and interpretation. Harold took a complex problem and presented a complex answer, but in a way that most people could understand. His emphasis on publication has carried over to many of his students and colleagues.

By examining the profession's current status, and the success of Professor Biswell's students—all of those he touched—we can conclude that Harold Biswell has left a great legacy. Dr. Harold Biswell will always be remembered as a naturalist, ecologist, scientist, artist, author, innovator, friend, and teacher. The investment he made in his students will be repaid for the remainder of our lives. The discipline of wildland fire will never be the same. Thank you, Professor Harold Biswell!

Plenary Session—Issues

The Oakland-Berkeley Hills Fire of 1991[1]

P. Lamont Ewell[2]

Sunday, October 20, 1991, will be remembered as the date of America's most costly urban-wildland fire (FEMA 1992) and one of the worst fires involving loss of life and property since the Great San Francisco Earthquake and Fire of 1906 (OFD 1992).

The magnitude and range of what is simply referred to as the "Tunnel Fire" is far beyond the experience of any living American firefighter. Only those who fought the Chicago Fire last century and those who battled the Great Fire in San Francisco would be able to identify with this conflagration and firestorm.

A firestorm is defined as a fire which creates its own weather. This was certainly the case in Oakland, California—the fire itself contributed to its own spread by supplying wind to an already very windy day. A conflagration has been described as a fire which exceeds the boundaries of the city block of origin. The Tunnel Fire did much more than this by burning neighborhood after neighborhood. Both firestorm and conflagration are accurate terms when applied to the Tunnel Fire; neither, however, comes close to adequately describing what actually transpired.

The origin of the fire was on a steep hillside in what some refer to as a box canyon, above California State Highway 24, near the entrance to the Caldecott Tunnel. This is a wooded area with heavy underbrush, narrow streets, and steep terrain, densely populated with expensive houses. The unusual weather conditions of that day resulted in:

> a foehn wind that, at speeds in excess of 65 miles per hour, raced down from the crest of the Oakland-Berkeley Hills. Coupled with record high temperatures well into the nineties, the hot dry winds gusted and swirled through five years of drought-dry brush and groves of freeze-damaged Monterey Pines and Eucalyptus groves. All the conditions for a major fire disaster were present that morning of October 20, 1991. (FEMA 1992)

Firefighters were on the scene overhauling hot spots from a fire the previous day. It is important to note that Saturday's fire had been completely doused, hose lines had been left in place surrounding the burn area, and the fire area had been checked by an Oakland Fire company during the night. Fire crews had returned that morning to check for any hot spots and to pick up equipment, and were on the scene for 2 hours before the fire suddenly escaped the area of origin because of high winds.

Eyewitness accounts testify that a sole ember blew into a tree just outside the burn area, and the tree exploded into flames. The resulting fire was quickly out of control—raging around and over firefighters who were suddenly fighting for their lives. Over the course of the next several days, the fire would leave 25 dead, 150 injured, and a total of 3,810 dwelling units destroyed. The fire, which burned over 1,500 acres within an area of 5.25 square miles, would result in over $1 billion in damages (OFD 1992, FEMA 1992).

Rescue and evacuation efforts were made as firefighters were forced to fall back to defensible space.

Immediately, calls were placed to request additional fire units and air drops. Soon, streets were clogged with residents trying to get out and sightseers and emergency personnel trying to get in.

The fire quickly established four fronts: west downhill toward California Highway 24 and the Rockridge district, north toward the Claremont Hotel, south toward Broadway Terrace, and east toward Contra Costa County.

The Oakland Fire Department

The Oakland Fire Department is composed of three geographic districts, known as battalions, that are commanded by district chiefs 24 hours a day. As the fire progressed, the on-duty chiefs assumed new roles. Assistant Chief Donald Matthews was the Incident Commander, Battalion Chief James Riley was assigned as Division "A" Commander, and Battalion Chief Ronald Campos responded to Oakland Fire Dispatch Center to coordinate logistics, recall, and dispatch functions.

Later, Assistant Chief John K. Baker responded from home and was assigned the role of Incident Commander when Assistant Chief Matthews became Operations Chief. At approximately 11:45 a.m. Fire Chief P. Lamont Ewell arrived on the scene at the Command Post and officially assumed command.

The Oakland Fire Department uses the Incident Command System (ICS) to manage all emergency incidents, as was the case with the Tunnel Fire. The system consists of an Incident Commander who directly supervises four functional groups: operations, planning, logistics, and finance.

The operations and planning functions were conducted at the scene from the Department's Mobile Command Post, while logistics and finance functions were conducted from the Dispatch Center.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Fire Chief, Oakland Fire Department, 1605 Martin Luther King Jr. Way, Oakland, CA 94612.

The Dispatch Center was the basic structure of initial management of the Tunnel Fire. This structure remained intact until late in the evening on October 20 when the California Department of Forestry and Fire Prevention (CDF) provided an overhead management team to assist with the enormous task of managing such a large fire.

At this point a Joint Command was established that consisted of Oakland, Berkeley, and Piedmont Fire Departments and the CDF. Oakland firefighters were assisting with evacuation efforts as they were forced to retreat from the advancing inferno. Division "A" Battalion Chief James Riley and Oakland Police Officer John Grubensky were killed while trying to help citizens escape the fire. Both Battalion Chief Riley and Officer Grubensky were found with the remains of those people they were trying to help. These courageous men were very aware of their risky positions and had ample opportunities to save themselves, but refused to leave before the evacuation of residents was complete.

The rapid spread of the fire in four different directions presented both line firefighters and chief officers with numerous strategic challenges.

Evacuation

Even though evacuation of residents is a responsibility assigned to the Oakland Police Department, fire units were heavily involved with this effort while trying to stop the advancing flames. It has been estimated that more than 10,000 people were evacuated from the burn area, some by way of very narrow streets, through blinding smoke and blowing debris.

The Wind

The wind played a most crucial part in the scenario which manifested once the fire was established. The wind blew into the Oakland Hills from the east and over and down ridge tops. It forced flames to swirl in many different directions causing the fire to burn downhill as quickly as, and in some cases more quickly than, uphill.

The strength and speed of the wind prevented firefighters on the scene from falling back to defensible space because there was no place to hide. Fire crews were trapped and forced to protect themselves under umbrellas of water as the flames roared over and around them. One veteran firefighter observed the fire progress 100 yards in 15 seconds.

This Santa Ana-type wind pushed the fire along wide fronts, bypassed firefighters who were making a stand, and then left them in isolated pockets of unburned areas. The wind whipped the fire into the Hiller Highlands Development and consumed all combustibles (homes, vegetation, and vehicles) in 16 minutes. The wind caused the fire to pre-heat everything in its path which resulted in structures and contents exploding into flame almost instantly (OFD 1992).

Pilots flying California Department of Forestry helicopters complained that their bucket drops were not effective because the water vaporized as the strong winds dispersed it over the intensely hot fire.

Communications

The Oakland Fire Department used two operational radio frequencies to communicate between the Dispatch Center and the 30 fire companies in the City. Communication with other jurisdictions is usually accomplished on the state-wide mutual aid frequency which is referred to as the "White Fire" channel.

The effectiveness of these frequencies was soon reduced because of the overwhelming load placed upon them by fire units requesting assistance, commanders trying to place resources, and the Dispatch Center's attempts to send fire companies into the burn area.

These problems were compounded by additional fire units from surrounding cities as they began to arrive to assist with the fire. The steep hilly terrain in the Oakland Hills also interfered with radio signals, in some cases creating "dead spots" which drastically reduced radio effectiveness.

Mutual Aid

Requests for mutual aid in the form of air support and fire suppression units were made during the initial stages of the fire, and additional requests continued throughout the day.

Mutual aid requests are processed through the California Office of Emergency Services (OES). Requests were channeled through Alameda County OES which is divided into north and south zones, and then from the county level to the state.

By late afternoon, 370 fire engines from as far away as the Oregon-California state line in the north, from Bakersfield in the south, and from Nevada to the east, were in, or on their way to, Oakland.

Aircraft in the form of helicopters and large air tankers from hundreds of miles away made hundreds of water drops on the fire.

This was the largest mutual aid effort ever undertaken, at that time, in the State of California (OFD 1992).

Water Supply

Fire units lost water at the height of the fire, forcing them to retreat because the supply tanks and reservoirs which provide water to the hill area were emptied. Reasons for the loss of water were :

- Extraordinary fire suppression efforts used a tremendous amount of water (an estimated 20 million gallons).
- Residents were hosing down their roofs and vegetation, and many sprinklers were left running after evacuation.
- As homes were consumed by the fire, the water service supplying those homes began to flow freely.

Hiller Highlands alone accounted for over 400 water services.

- Water supplying the tanks and reservoirs is pumped from lower parts of Oakland to the higher elevations. The electrically powered supply pumps could not replenish depleted tanks once the fire destroyed power lines to the pumps.
- Some areas, such as the Rockridge district (which was developed in the 1920's), were supplied by 4-inch mains that are considered to be insufficient by today's standards. They could not supply enough water to fight a fire of this magnitude.

Many mutual aid fire engine companies could not hook up to Oakland fire hydrants because their 2.5-inch hose couplings were not compatible with Oakland's 3-inch couplings.

Aftermath

The Tunnel Fire will long be remembered for the magnitude of its destruction. The fire was viewed on prime time television around the world; it has been documented by professionals and laymen alike. The origin of the fire has been and continues to be the focus of investigation.

The Fire Investigation Unit of the Oakland Fire Department Fire Prevention Bureau has ultimate responsibility for finding the cause of the fire. Inspectors from the Fire Investigation Unit have worked with the Governor's Task Force which is represented by the California State Fire Marshal's Office and the Alameda County Fire Investigation Team. The Alameda County Fire Investigation Team is composed of representatives from the District Attorney's Office and the Bureau of Alcohol, Tobacco, and Fire Arms, along with investigators from the surrounding fire districts.

Fifteen hundred man-hours were spent in the first week following the fire, most of that time conducting interviews with survivors and performing overhaul operations by sifting through debris, searching for evidence.

The origin of the Tunnel Fire is located next to 7151 Buckingham Road. The cause of the fire, however, is still under investigation.

The Oakland Fire Department, as well as every other fire department in the state, has learned much about wildland/ urban intermix fires. Much has been accomplished in the past 3 years since the fire. The Oakland Fire Department is committed to doing everything possible to prevent a repeat of the 1991 Firestorm. The following is a partial account of actions taken by the Oakland Fire Department since the conflagration.

Firefighting Training and Tactics

OFD personnel have received intensive wildland training from the California Department of Forestry and Fire Prevention as well as other agencies with wildland expertise. New tactics include cold trailing (scraping the perimeter of the burn area to reveal unburned soil), utilizing new technology, such as Forward Looking Infrared Radar to find subterranean hot spots, and testing new products such as Class "A" foam.

Weather Monitoring

Two "Remote Automated Weather Stations" (RAWS) have been installed in strategic locations in the Oakland Hills. These weather stations continuously provide the Fire Department with updates in weather conditions. The Fire Department increases its level of response accordingly, as the wind speed and the temperature rise and the humidity drops.

Initial response to the report of fire varies with the severity of weather conditions. For example, low hazard dispatch requires three fire engines and two patrols. Response on high hazard days requires six fire engines, four patrols, and a helicopter, as well as the predeployment of engine companies to locations in and around high fire hazard areas.

Communications Improvements

The Oakland Fire Department has recently converted to an 800 megahertz radio system which provides a virtually unlimited number of radio talk groups. It is expected that this will mitigate much of the overload of tactical channels that was experienced during the initial stages of the fire.

In addition, proposals have been made to fire departments surrounding the City of Oakland to permit those jurisdictions to participate in the 800 megahertz radio system.

Water Supply

Adapters have been purchased and installed on all fire hydrants within the City of Oakland. These adapters will change the coupling size on the hydrants to 2.5 inches. This will standardize Oakland's hydrants, thus allowing mutual aid fire departments to hook up to Oakland's water supply.

Vegetation Management

Approximately 16,000 Oakland Hills area parcels have been inspected by Oakland Fire Department units. Fire inspectors are requiring brush to be cleared 30 to 100 feet away from structures, and at least 10 feet away from property lines and the street. All chimneys are required to have an approved spark arrestor with no trees or bushes within 10 feet. Compliance has been for the most part good, and violators have been cited and forced to abate their hazardous conditions.

Mutual Aid

Oakland has negotiated agreements with the cities of Berkeley, San Leandro, Alameda, Piedmont, and with the East Bay Regional Parks District to establish Mutual Response Area (MRA) Agreements. These agreements provide for an automatic response when a fire is reported within the MRA.

Borderline residents who report a fire will have a response from both sides of the City limits, and in many cases they will receive a faster response.

The Oakland Fire Department is committed to providing the highest quality of fire protection to the residents of Oakland.

Codes and Ordinances

The City has adopted an ordinance which requires Class "A" roofs on new structures and replacement roofs within the high fire hazard area. Further, all siding on new structures will have a one-hour rating. Additionally, the citizens of Oakland have passed a $51 million bond to prepare the City or future disasters.

References

Federal Emergency Management Agency (FEMA) 1992. Hazard mitigation report for the East Bay Fire in the Oakland-Berkeley Hills in response to the October 22, 1991 Federal disaster declaration covering Alameda County, California. FEMA-919-DR-CA.

Oakland Fire Department. 1992. The Oakland Tunnel Fire, October 20, 1991. A comprehensive report. Available from the Oakland Fire Department, 1605 Martin Luther King Jr. Way, Oakland, CA 94612.

Dr. Biswell's Influence on the Development of Prescribed Burning in California[1]

Jan W. van Wagtendonk[2]

Abstract: Prescribed burning in California has evolved from the original practices of the Native Americans, through years of experimentation and controversy, to finally become an accepted ecosystem management activity. When Dr. Harold Biswell arrived in California, he began research on improving game range by using prescribed fires and on understory burning in ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) stands. Through a series of field days that included demonstration burns, Dr. Biswell was able to educate and inform both the public and professional foresters about the benefits of prescribed fires. These field days became the basis for several university extension courses and were influential in changing the prescribed fire policies of numerous agencies. As the problem of urban encroachment into wildlands continues, the need for safe and effective prescribed burns will increase. Dr. Biswell's sound research, presentation of the facts, and patience with people and fire should guide us in the application of fire in wildland ecosystems.

Although many people have contributed to the development of prescribed burning in California, Dr. Harold H. Biswell was a major influence on the acceptance and application of fire in wildland ecosystems. Acceptance did not come easily. A history of abuse of fire and the perception that California's climate and topography precluded the use of fire galvanized objections to prescribed burning. By using his thorough research, enthusiastic teaching, and field demonstrations, Dr. Biswell was able to gain the respect of public and professional audiences alike. As a result of his untiring efforts, agencies began to change their policies to include the use of fires. His ideas became even more relevant as urban development thrust its way into wildland ecosystems.

History of Prescribed Burning in California

Native Americans were the first practitioners of prescribed burning for managing vegetation. When European Americans settled the coastal and foothill areas of California, indiscriminate burning occurred. In response to the destruction perceived to be a result of burning, some attempted to exclude all fires from the landscape. A few land owners began to use light burning to counter the effects of fire suppression on fuel accumulations. A program to improve forage for livestock by burning ranch lands was active in the 1940's and 1950's, but gradually declined as concern about the liability for escapes increased. Understory burning, particularly in ponderosa pine, did not become common until the late 1950's and continues today.

Burning by Native Americans

Native Americans have resided in the Sierra Nevada for at least 3,000 years (Reily 1987). Evidence of their use of fire has been found in some of the oldest deposits of cultural material. Fire was used to clear undergrowth, ease food gathering and hunting, and favor vegetation used for specific purposes (Reynolds 1959, Wickstrom 1987). Ethnographic studies have shown that the primary use of fire by Native Americans in the Sierra Nevada was to manage plants for basketry materials (Anderson 1993). In addition to fires set by humans, lightning ignitions ensured that fire was pervasive on the landscape when European Americans arrived in California.

Light Burning

European settlers used fire indiscriminately to clear areas for farming, ranching, and mining. The impacts of such burning was not a concern because vegetation was thought of as a nuisance rather than a resource. By the beginning of the century, timber became more important and attempts were made to suppress fires (Clar 1959). Some landowners felt that excluding all fires from the land was not beneficial in the long run and that light burning could be used to reduce fuel hazards (Hoxie 1910). Forestry professionals claimed that any fire in the forest was bad and that public and private lands should be managed under a policy of systematic fire protection (DuBois 1914). White (1920) countered with a critique of the fire protectionist policy. The controversy did not subside until USDA Forest Service researchers concluded that light burning was ineffective, impractical, and economically indefensible (Show and Kotok 1924). Fire protection became institutionalized in California in 1924 when the State Board of Forestry adopted the policy of fire exclusion (Pyne 1982).

Ranch and Game Range Burning

In the early 1940's, ranchers and hunters became concerned that rangelands used by livestock and wildlife had declined in value because of increasing brush density (Biswell

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Research Scientist, Yosemite Field Station, National Biological Service, U.S. Department of the Interior, P.O. Box 700, El Portal, CA 95318.

1989). In addition to reduced grazing capacities, the accumulation of brush posed a hazard, especially for arson fires. The California Division of Forestry (which later became the Department of Forestry and Fire Protection) recognized these problems and in 1945 began to issue burning permits to landowners. For the first time in two decades, the use of fire was officially sanctioned by a government agency.

When Dr. Biswell arrived in California in 1947, he began working with ranchers on their burning operations, and he conducted research on improving game range by using prescribed fires in chaparral. His first efforts were at Teaford Forest in the Sierra Nevada foothills in Madera County. There he worked with ranchers and farm advisors to develop techniques for using fire to kill some of the woody vegetation and then replace it with grasses to increase the grazing capacity for livestock (Biswell 1963, 1967). Range improvement burning reached its peak in 1955 when over 200,000 acres were burned (Biswell 1989). As more homes were built on adjacent wildlands, range improvement burning declined primarily because landowners were held liable for any damage from escaped fires.

Ranchers and public agencies tried to improve wildlife habitat using type conversion burns. Extensive areas on the Mendocino National Forest and on lands administered by the Bureau of Land Management were burned (Burma 1967, Doman 1967). Dr. Biswell's research was conducted in chamise (*Adenostoma fasciculatum* H.& A.) chaparral in Lake County in conjunction with the California Department of Fish and Game (Biswell 1954, 1961). Prescribed burns were used to create openings in the brush for deer, to encourage sprouting, and to favor herbaceous species. This resulted in a three- to four-fold increase in deer populations in the burned areas. Like range improvement, burning for wildlife habitat declined because of the economic costs and the liability for escapes.

Understory Burning in Ponderosa Pine

Although light burning in the forest had been practiced for many years before 1924, State and Federal policies required strict suppression and precluded using fire for forest management purposes. Prescribed fires were acceptable for grass and brush lands but not in the pine forests (Biswell 1989). Based on his experience in the southeast, Dr. Biswell felt that prescribed burns could reduce fuel hazards in pine stands so that wildfires would be less destructive and easier to control.

In 1951, Dr. Biswell started research on understory burning in ponderosa pine stands at Teaford Forest and at Hoberg's Resort in Lake County. The purpose of this burning was to improve timber production by controlling brush in the understory, reducing fire hazards, and thinning. Burn plots at Hoberg's showed that the number of manzanita (*Arctostaphylos viscida* Parry) seedlings in second–growth ponderosa pine stands can be substantially reduced and that pine seedlings may appear in abundance (Biswell and Schultz 1958). Additional studies showed that prescribed fire could be used to reduce fuel hazards (Biswell 1959, 1960; Biswell and Schultz 1956; Sweeney and Biswell 1961).

One of the most dramatic results of Dr. Biswell's research at Hoberg's occurred when a wildfire burned into an area previously prescribe burned and was easily controlled (Biswell 1963). In the treated area scarcely any needles on the trees were scorched, while outside of it a majority of the trees were killed. Thinning stands of ponderosa pine diminished debris accumulation for at least 20 years, and when accompanied with fertilization, increased growth by 134 percent (Agee and Biswell 1970a, b).

Burning in Giant Sequoia and Mixed Conifer Forests

In 1965, Dr. Biswell started his research on fuel reduction and stand modification in giant sequoia (*Sequoiadendron giganteum* [Lindl.] Buchholz) and mixed conifer stands at Whitaker's Forest near Sequoia and Kings Canyon National Parks. There, he and his students started a series of studies that would contribute greatly to the refinement of the science of prescribed burning. Litter production studies set the stage for recognizing that different species had varying fuel characteristics that would affect fire behavior (Agee and others 1978, Biswell and others 1966). Costs for cutting, piling, and broadcast burning giant sequoia stands to reduce fire hazards ranged from $115 to $146 per acre (Biswell and others 1968). Giant sequoia seedling survival was studied on burned and unburned areas that had been manipulated by Agee and Biswell (1969). They found 100 percent mortality of giant sequoia seedlings on the unburned plot, while 96 out of 1,253 survived on the burned plot.

Adjacent to Whitaker's Forest, in the Redwood Mountain Grove of Kings Canyon National Park, Hartesvelt and Harvey (1967) started another study on giant sequoia regeneration after fire. Harvey and others (1980) synthesized what was known about giant sequoia ecology in a single volume.

Graduate students took the opportunity to learn from Dr. Biswell's experience and wisdom. Bruce Kilgore (1968), a student of Dr. Starker Leopold, studied the breeding bird populations in managed and unmanaged stands of giant sequoia at Whitaker's Forest. Jim Agee (1968, 1973) did his masters degree work on fuel conditions at Whitaker's and his doctorate on the effects of prescribed fires on forest floor properties. My work (van Wagtendonk 1972, 1974) on fire and fuel relationships was conducted in Yosemite National Park because of insufficient ponderosa pine stands at Whitaker's and because the Forest Service was not amenable to burning on its land.

Field Days and Extension Courses

Beginning with the work at Hoberg's, Dr. Biswell conducted field days to discuss prescribed burning and to demonstrate its use with a small fire. These early demonstrations were controversial because many people were still uncomfortable with the idea of burning (Biswell 1989). The field days were very educational, however, and numerous resource professionals and members of the public were enlightened about the use of fire.

My first exposure to prescribed fire was at a field day sponsored by Dr. Biswell at Whitaker's Forest. In attendance were Dr. Leopold, other prominent scientists, several representatives from the USDI National Park Service and the USDA Forest Service, and other interested people. Lively discussions occurred that planted the seed for policy changes that were yet to come. On the last field day at Whitaker's Forest in 1973, 175 people attended. If the field days had continued, Dr. Biswell felt that the attendance might have soared to over 250 people (Biswell 1989).

After Dr. Biswell retired in 1973, he taught a class on fire ecology at the University of California at Davis for 2 years. For the next 8 years he taught four university extension classes. Fire ecology of forests was the subject at Yosemite National Park, while the course at Mt. Diablo State Park covered chaparral fire ecology. Classes were held on giant sequoia fire ecology at Calaveras State Park and fire ecology basics in San Diego County. These courses attracted many students, agency workers, and the general public. The mix of participants ensured that there was a good exchange of information and a healthy reexamination of attitudes about fire. Although retired, Dr. Biswell was requested by students to be on their dissertation committees as an emeritus professor. Under his guidance, Ron Wakimoto (1978) completed his doctorate on the effects of fires in chaparral in San Diego County.

Prescribed Burning Policies

Dr. Biswell's influence on agency policies and attitudes about prescribed fire have been both subtle and profound. The National Park Service and the California Department of Parks and Recreation have sought his advice and counsel and have altered their policies as a result. Less direct, but just as important, has been his influence on the Forest Service and the California Department of Forestry and Fire Protection.

National Park Service

Although experimental burning had started in Everglades National Park in 1951 (Robinson 1962), National Park Service policy did not include the use of fire at that time. Impetus for a change came from university researchers in California. In 1962, the Secretary of the Interior asked Dr. Leopold to head a committee to examine wildlife management concerns in the National Parks. The committee did not confine its report to wildlife, but rather recommended that parks be managed as complete ecosystems that include fire (Leopold and others 1963). The close association with Dr. Biswell and attendance at his field days undoubtedly influenced Dr. Leopold. The report was incorporated into National Park Service policy in 1968.

Sequoia and Kings Canyon National Parks started a fire management program in 1968 that included environmental restoration burns, prescribed natural fires, and research (Kilgore 1971, Kilgore and Briggs 1972, Parsons 1976). Yosemite's prescribed burning program followed in 1970 and its prescribed natural fire program in 1972 (van Wagtendonk 1978). Dr. Biswell and his former students played pivotal roles in these programs in both parks.

Similar to the conditions at Hoberg's Resort, wildfires have burned into park areas that have been previously burned by prescribed fires. When the Pierce fire crowned uphill into the Redwood Mountain Grove in Kings Canyon, it dropped to the ground in an area that had been burned five years before (Stephenson and others 1991). The eventual control of the A-Rock fire in Yosemite in 1990 was attributed, in part, to the prescribed burns in the area that had greatly reduced fuels in the understory (Clark 1990).

California Department of Parks and Recreation

Many California State Park rangers and managers have attended Dr. Biswell's classes and field days. Their experience formed the basis for programs to restore fire to the State Parks. In 1975, fire was carefully applied in Calaveras Big Trees State Park to allow the ecosystems to operate as naturally as possible (Biswell 1989). By 1982, prescribed burning programs were started in several other parks including Mt. Diablo, Cuyamaca Rancho, Big Basin Redwoods, and Montana de Oro.

Rangers are required to take intensive courses in fire ecology and have supervised field experience before they are certified to burn. Dr. Biswell and some of his former students have taught in these classes.

California Department of Forestry and Fire Protection (CDF)

The CDF was involved in the range burning program in the 1950's, but soon emphasized the protection function of fire management. Over the intervening years, many personnel from the agency have attended field days and special "show me" trips conducted by Dr. Biswell. At one of these field days, he recalled a CDF ranger stating, "In the fifties we were all making fun of Harold and fighting him. Now, 30 years later, we are all working for him" (Biswell 1989).

The single biggest impediment to burning on private lands was removed when Senate Bill 1704 was enacted in 1981. This bill authorized a vegetation management program for brush-covered lands and the CDF to contract with private landowners to burn on their properties. The liability issue was dealt with by requiring insurance and escrow accounts as well as state assumption of responsibility for the operation.

Forest Service

From its inception in 1905, the Forest Service had a strict policy of fire exclusion. In 1943, an exception to the policy was allowed on National Forest lands in the longleaf pine (*Pinus palustris Mill.*) and slash pine (*Pinus elliottii* Engelm) types, where private owners had burned for decades and Forest Service research had shown beneficial effects (Schiff 1962). Dr. Biswell conducted some of the early research while employed by the Forest Service at the Southeastern Forest Experiment Station. In 1941, he started his work on the integration of prescribed burning, timber production, and livestock grazing (Biswell 1958).

The Forest Service began to examine its fire exclusion policy in the early 1970's. A retreat for regional fire control officers in 1974 brought together experts from outside the Service to share their expertise. Interestingly, Dr. Biswell was not invited to attend, but several of his former students gave presentations. It was not until 1978 that the national policy changed to encompass total fire management including prevention, suppression, and use. Some of the people who were instrumental in these changes had first been exposed to the idea of prescribed burning through Dr. Biswell's writings or by attendance at one of his field days.

The Future

In the years to come, Dr. Biswell's influence will continue to be felt throughout the fire community. In particular, as the problem of urban encroachment into wildlands continues, the need for safe and effective prescribed burns will increase. His intuitive knowledge of wildland fuels led him to recognize the real threat of the recent fires in Oakland and Berkeley. Research into the weather conditions leading up to the conflagration that destroyed 625 homes in Berkeley in 1923 convinced him that, if fuels were not treated, such an event could recur (Biswell 1989). And in 1970 it did, when 37 homes were destroyed in the Berkeley and Oakland hills. Research on fuel hazards guided by him showed that the potential for even more destructive fires was present (Agee and others 1973). The 1991 Tunnel fire in Oakland and Berkeley underscored his alarm.

When Dr. Biswell first started his research on fire in California, Dean Walter Mulford of the University of California at Berkeley's School of Forestry advised him to "develop sound research, let the chips fall where they may, and not argue with people but rather listen to them and present the facts" (Biswell 1989). We would do well to follow that same advice. His research and, in particular, his patience with people and fire should guide us in the future application of fire in wildland ecosystems.

References

Agee, J. K. 1968. **Fuel conditions in a giant sequoia grove and surrounding plant communities**. Berkeley: University of California; 55 p. M.S. thesis.

Agee, J. K. 1973. **Prescribed fire effects on physical and hydrologic properties of mixed conifer forest floor and soil**. Berkeley: University of California; 57 p. Ph.D. dissertation.

Agee, J. K.; Biswell, H. H. 1969. **Seedling survival in a giant sequoia forest**. California Agriculture 23(4): 18-19.

Agee, J. K.; Biswell, H. H. 1970a. **Debris accumulation in a ponderosa pine forest**. California Agriculture 24(6): 6-7.

Agee, J. K.; Biswell, H. H. 1970b. **Some effects of thinning and fertilization on ponderosa pine understory vegetation**. Journal of Forestry 68(11): 709-711.

Agee, J. K.; Wakimoto, R. H.; Darley, E. F.; Biswell, H. H. 1973. **Eucalyptus fuel dynamics and fire hazard in the Oakland hills**. California Agriculture 24(9): 13-15.

Agee, J. K.; Wakimoto, R. H.; Biswell H. H. 1978. **Fire and fuel dynamics of Sierra Nevada conifers**. Forest Ecology and Management 1: 255-265.

Anderson, M. K. 1993. **Indian fire-based management in the sequoia-mixed conifer forests of the central and southern Sierra Nevada**. Berkeley, CA: University of California; 441 p. Ph.D. dissertation.

Biswell, H. H. 1954. **The brush control problem in California**. Journal of Range Management 7(2): 57-62.

Biswell, H. H. 1958. **Prescribed burning in Georgia and California compared**. Journal of Range Management 11(6): 293-298.

Biswell, H. H. 1959. **Reduction of wildfire hazard**. California Agriculture 13(6): 5.

Biswell, H. H. 1960. **Danger of wildfires reduced in ponderosa pine**. California Agriculture 4(10): 5-6.

Biswell, H. H. 1961. **Manipulation of chamise brush for deer range improvement**. California Fish and Game 47(2): 125-144.

Biswell, H. H. 1963. **Research in wildland fire ecology in California**. In: Proceedings 1st Tall Timbers fire ecology conference; 1962 March 1-2; Tallahassee, FL. Tallahassee: Tall Timbers Research Station; 63-97.

Biswell, H. H. 1967. **Forest fire in perspective**. In: Proceedings 7th Tall Timbers fire ecology conference; 1967 November 9-10; Hoberg, CA. Tallahassee, FL: Tall Timbers Research Station; 43-63.

Biswell, H. H. 1989. **Prescribed burning in California wildlands vegetation management**. Berkeley, CA: University of California Press; 255 p.

Biswell, H. H.; Gibbens, R. P.; Buchanan, H. 1966. **Litter production by bigtrees and associated species**. California Agriculture 20(9): 5-7.

Biswell, H. H.; Gibbens, R. P.; Buchanan, H. 1968. **Fuel conditions and fire hazard reduction costs in a giant sequoia forest**. National Parks Magazine 42(262): 16-19.

Biswell, H. H.; Schultz, A. M. 1956. **Reduction of wildfire hazard**. California Agriculture 10(11): 4-5.

Biswell, H. H.; Schultz, A. M. 1958. **Manzanita control in ponderosa**. California Agriculture 12(2): 12.

Burma, G. D. 1967. **Controlled burning on the public domain in California**. In: Proceedings 7th Tall Timbers fire ecology conference; 1967 November 9-10; Hoberg, CA. Tallahassee, FL: Tall Timbers Research Station; 235-243.

Clar, C. R. 1959. **California government and forestry**. Sacramento, CA: California Division of Forestry; 623 p.

Clark, W. 1990. **Report on the fire behavior of the A-Rock fire**; Unpublished report on file in the Fire Management Office, Yosemite National Park, CA. 4 p.

Doman, E. R. 1967. **Prescribed burning and brush type conversion in California national forests**. In: Proceedings 7th Tall Timbers fire ecology conference; 1967 November 9-10; Hoberg, CA. Tallahassee, FL: Tall Timbers Research Station; 225-233.

DuBois, C. 1914. **Systematic fire protection in the California forests**. Washington, DC: U.S. Department of Agriculture, Forest Service; 35 p.

Hartesvelt, R. J.; Harvey, H. T. 1967. **The fire ecology of sequoia regeneration**. In: Proceedings 7th Tall Timbers fire ecology conference; 1967 November 9-10; Hoberg, CA. Tallahassee, FL: Tall Timbers Research Station; 65-77.

Harvey, H. T.; Shellhammer, H. S.; Stecker, R. E. 1980. **Giant sequoia ecology**. Scientific Monograph 12. Washington, DC: U.S. Department of the Interior; National Park Service; 182 p.

Hoxie, G. L. 1910. **How fire helps forestry**. Sunset 25(7): 145-151.

Kilgore, B. M. 1968. **Breeding bird populations in managed and unmanaged stands of *Sequoia gigantea***. Berkeley: University of California; 196 p. Ph.D. dissertation.

Kilgore, B. M. 1971. **The role of fire in managing red fir forests**. In: Transactions 36th North American wildlife and natural resources conference; 1971 May 7-10; Washington, DC. Washington, DC: Wildlife Management Institute; 405-416.

Kilgore, B. M.; Briggs, G. S. 1972. **Restoring fire to high elevation forests in California**. Journal of Forestry 70(5): 266-271.

Leopold, A. S.; Cain, S. A.; Cottam, C. M.; Gabrielson, I. N.; Kimball, T. L. 1963. **Wildlife management in the national parks**. In: Transactions 28th North American wildlife and natural resources conference; 1963 [date unknown]; Washington, DC. Washington, DC: Wildlife Management Institute; 1-18.

Parsons, D. J. 1976. **The role of fire in natural communities: an example from the southern Sierra Nevada, California**. Environmental Conservation 3(2): 91-99.

Pyne, S. J. 1982. **Fire in America: a cultural history of wildland and rural fire**. Princeton, NJ: Princeton University Press; 654 p.

Reily, L. M. 1987. **Archeological investigations in the Merced River canyon: report of the 1983 El Portal Archeological Project**. Publications in Anthropology 3. El Portal, CA: U.S.Department of the Interior, National Park Service, Yosemite National Park; 287 p.

Reynolds, R. D. 1959. **Effects upon the forest of natural fires and aboriginal burning in the Sierra Nevada**. Berkeley, CA: University of California; 262 p. M. S. thesis.

Robinson, W. B. 1962. **Fire and vegetation in the Everglades**. In: Proceedings 1st Tall Timbers fire ecology conference; 1962 March 1-2; Tallahassee, FL. Tallahassee, FL: Tall Timbers Research Station; 67-80.

Schiff, A. L. 1962. **Fire and water: scientific heresy in the Forest Service**. Cambridge, MA: Harvard University Press; 225 p.

Show, S. B.; Kotok, E. I. 1924. **The role of fire in the California pine forests**. Agriculture Bulletin 1294. Washington, DC: U.S. Department of Agriculture; 80 p.

Stephenson, N. L.; Parsons, D. J.; Swetnam, T. W. 1991. **Restoring natural fire to the sequoia-mixed conifer forest: should intense fire play a role?** In: Proceedings 17th Tall Timbers fire ecology conference; 1989 May 18-21; Tallahassee, FL. Tallahassee, FL: Tall Timbers Research Station; 321-337.

Sweeney, J. R.; Biswell, H. H. 1961. **Quantitative studies on the removal of litter and duff by fire under controlled conditions**. Ecology 42(3): 572-575.

van Wagtendonk, J. W. 1972. **Fire and fuel relationships in Yosemite National Park**. Berkeley, CA: University of California; 163 p. Ph.D. dissertation.

van Wagtendonk, J. W. 1974. **Refined burning prescriptions for Yosemite National Park**. Occasional Paper 2. Washington, DC: U.S. Department of the Interior, National Park Service; 21 p.

van Wagtendonk, J. W. 1978. **Wilderness fire management in Yosemite National Park**. In: Schofield, E. A., ed. EARTHCARE: Global protection of natural areas: Proceedings of the 14th biennial wilderness conference; 1975 June 5-8; New York. Boulder, CO: Westview Press; 324-335.

Wakimoto, R. H. 1978. **Responses of southern California brushland vegetation to fuel modification**. Berkeley, CA: University of California; 278 p. Ph.D. dissertation.

White, S. E. 1920. **Woodsmen, spare those trees**. Sunset 44(3): 115.

Wickstrom, C. K. R. 1987. **Issues concerning Native American use of fire: a literature review**. Publications in Anthropology 6. El Portal, CA: U.S. Department of the Interior, National Park Service, Yosemite National Park; 68 p.

"What Do We Do Now, Ollie?"[1]

Robert L. Irwin[2]

Abstract: A personal overview of why California is suffering billion-dollar-per-year costs and losses from wildland fire is presented. Two primary and ten supplemental factors contribute to the huge losses. The primary factors are lack of planning effectiveness and lack of adequate fuels management on a sustained basis. Supplemental factors target organizational and political weaknesses that contribute to the destructive consequences of the primary factors. Correction or elimination of the dozen factors can significantly reduce costs and losses in the future. Actions to make the needed corrections are suggested.

"What do we do now, Ollie?" is an expression that means "something has gone wrong"—i.e., plans have gone awry, a procedure has failed, expected outcomes are not happening. A classic example is about two piano movers who are trying to get a heavy piano up to a second–story apartment on a flight of exterior stairs. They push, pull, strain, sweat, and get the piano to the top with great difficulty. As they rest and congratulate each other on a job well done, the piano begins to slip away. It bumps down the stairs and rolls into the street where it is struck by a passing truck and totally destroyed. That is when one mover says to the other, "What do we do now, Ollie?"

California fire agencies, planners, and others need to ask that question of themselves in relation to the State's wildland-structural fire problems.

Hard Work

California fire agencies have struggled for more than 40 years to develop the best wildland fire suppression capabilities in the world. When needed, they can activate more aircraft than many nations have in their military arsenals. The combined agencies can mobilize 20,000 firefighters with equipment and support in 72 hours or less. The agencies have a superior organizational structure in the Incident Command System, sophisticated communications, and effective multiagency coordination. And, they have consistently used these capabilities to achieve a 97 percent success ratio: only about 3 percent of all fires do excessive damage.

California land-use planning law and planning procedures have also matured over time. Slowly, but surely, the State's planning process has gotten more thorough and sophisticated. In 1971, the State upgraded standards for local governments' General Plans to improve future growth and development decisions. Also in the early 1970's, passage of the Subdivision Map Act and the California Environmental Quality Act (CEQA) offered increased opportunities for local control over project design. In 1980, General Plan Safety Elements were required to include wildland fire concerns. Since about 1987, a number of counties and some cities have refined their wildland fire safety requirements to some degree.

Hard Questions

Why then has the State continued to suffer billion dollar costs and losses annually from wildfire since 1985? Why, before the Northridge earthquake event of January 17, 1994, had the total costs and losses from wildland fire exceeded those of all the earthquakes in the State since 1934? Why has the problem gotten worse instead of better since 1950? Why has each fire season since 1987 been declared "the worst" in California's history?

Most people's answers to these questions would focus on factors such as "weather," "population growth," "development," or "politics"—which are all valid reasons, but they are also the easy answers. They only summarize categories of real causes, they do not define them.

Hard Answers

The hard answers involve fundamental cause-and-effect relationships and can be divided into two major categories: (1) lack of effective wildland land-use planning, and (2) lack of adequate fuels management on a sustained basis. Land and fire managers, planning experts, and others may argue that they deserve credit rather than criticism in these endeavors, especially because of all their positive efforts. The magnitude and pervasive nature of wildland fire losses, however, clearly indicate that efforts to date have been inadequate. The land and the people still suffer beyond acceptable limits. Why?

Lack of Effective Planning

California planning law has not been thoroughly understood and has never been assertively pursued by fire agencies. No wonder they are frequently frustrated by local government approvals of unsafe developments. Local planners have not assimilated nor institutionalized the fundamentals of fire behavior and suppression requirements. No wonder

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Retired Fire Management Specialist and former Planning Commissioner, 13771 Mark Trail, Sonora, CA 95370.

they have supported project after project in high-risk areas without adequate mitigation. Although the fire and planning cultures have increased their interactions over the past decade, they still have not communicated with each other about the fundamental requirements of their professions. There has not been much trading of skills and knowledge in the areas that could significantly improve fire safety.

Fire Weaknesses

In the past, fire agencies consistently set forth their requirements for mitigating fires at the end of the planning process, rather than at the beginning. The power of the General Plan and its requirements has remained relatively unknown and drastically underutilized by the fire community. Thus, instead of promulgating one set of comprehensive standards in the General Plan that would henceforth be applied to all projects, the agencies have placed themselves in the position of trying to achieve mitigation on one project after another—much work for low rewards.

Perhaps the most damaging omission, and the largest contributor to ineffective planning on the part of fire agencies, has been the failure to plan on a strategic basis. Every entry-level firefighter knows that fire does not distinguish between project or jurisdictional boundaries, yet that is where protection planning has stopped. *Detailed* protection planning has not been done on a total fire environment basis covering an entire watershed or jurisdiction. Thus, even relatively well-mitigated developments in high-risk areas have remained vulnerable. On major fires in the wildland-structural fire environment, Incident Commanders are constrained by the past planning failures and omissions of others. Suppression forces have little, if any, strategic initiatives in developed areas. The vegetated areas between developments are "second priority" for force assignments, and the fire moves on, only to threaten another development. Firefighting is characterized by one tactical move after another, some of which work, and some of which do not.

The wildland-structural fire situation that California has experienced during the past decades will continue to worsen unless fire agencies regain suppression initiative through implementation of strategic fire planning.

Planning Weaknesses

Local and State land-use planning in the United States has always been powerfully influenced by our political system. Elected officials, not planners, make final decisions about development. If professional planners had been "masters of their fate" during the past 40 years, things might be better today in the wildland-structural fire situation. But planners only recommend, they only propose, and every action is subject to approval of at least one elected body. Given that caveat, the professional planning culture has still shown weaknesses in wildland fire safety.

Because comprehensive, area-wide, strategic fire input that addresses overall fire potential has not been developed, planning has always been done on a case-by-case basis. A project is approved here, another there. Fire concerns and mitigation requirements have been limited to the project areas. External factors (e.g., fuels, slope, aspect, fire behavior) have not been considered. Because of 50 years of such practice, California's wildlands have become a mix of flammable vegetation and structures. This case-by-case process has often been called "ad hoc planning," meaning that no coherent overall plan exists, resulting in the failure to consider a project's relationship to its whole environment.

Wildland planning has also been negatively influenced by the urban bias that is ingrained in planners and the planning process. Although the wildland-structural fire problem began to surface more than 40 years ago, only recently has professional curriculum included the wildland issues that concern California. As late as 1990, no college or university in the nation offered a degree in wildland planning. Thus, the planning process has been overseen for decades by people whose basic training and process orientation was urban-oriented. Compounding this situation is the fact that legislators who pass laws, judges who interpret those laws, and elected officials who administer them have also traditionally been influenced by urban rather than wildland concerns.

The urban bias has resulted in thousands of subdivisions and major developments with roads on the inside and structures on the outside of the project (if planning had been more cognizant of wildland fire, roads would have been placed around developments to serve as fuel-breaks). The bias has brought perhaps 50,000 cul-de-sacs in wildland subdivisions, with only a handful suitable for helicopter operations. Power and telephone lines have been routinely planned over or alongside cul-de-sacs, preventing their possible use as emergency landing sites. Water supply facilities have not been included in their construction. One half-million miles of roads may not be capable of carrying emergency response and evacuation traffic at the same time. And, to add to that problem, fire hydrants (where feasible) have been placed at curbside just as they have been since Boston and New York began installing them in the 1830's. This requires engines and water tenders to block the very roads suppression forces and evacuees need to keep clear.

Retrofitting all of these consequences of urban bias may not be possible. However, California will continue to experience significant growth in the wildlands, and it is imperative that future wildland fire safety needs are emphasized so that they outrank urban traditions in planning.

Lack of Effective Fuels Management

The current wildland-structural fire situation has been negatively influenced by the lack of effective fuels management activities. The most destructive fires in California history are those characterized by the presence of structures intermixed with high volumes of vegetative fuels. From a simplistic view, it can be argued that "if the fuels were not there, the fire would not be there." From a more realistic view, vegetation exacerbates the problem even in cases where structures serve as their own fuel supply. With fire jumping from roof to roof and from house to house, vegetative combustion creates smoke, radiated heat, firebrands, and safety hazards that hamper suppression. Why are the fuels there?

Project Funding

The management of vegetative fuels to achieve fire protection, wildlife habitat, water production, and esthetic values has been a "step-child" in Federal, State, and local agencies for decades.

At all government levels budget allowances for fuels programs tend to be allocated after supression needs are satisfied. Sources of funding are fragmented. Some dollars come from one pocket, some from another. At the local level, bond issues, ordinances, or other special efforts may be required to authorize and fund fuel reduction programs. Many times only the initial projects are funded. Maintenance financing frequently diminishes over time, and once-effective fuels modification areas return to high hazard status.

Both the USDA Forest Service and the California Department of Forestry and Fire Protection (CDF) have missed opportunities to improve this situation. Since the mid-1970's, it has been possible to utilize General Plan requirements, the Subdivision Map Act, and CEQA to require developers to fund fuel treatments. These legal tools could have, and should have, been used to zone hazardous parts of private lands for permanent fuel breaks, greenbelts, fuel reduction, and other mitigation requirements. Some critical National Forest lands could have been included.

Landowners and developers could have been funding construction and maintenance of these improvements for the past 20 years. But that did not happen. Failure to use these opportunities may have been caused by lack of knowledge, lack of organizational purpose, or other factors. Whatever the causes, California now has thousands of developments that are more vulnerable than they need be. Natural resources on thousands of acres of National Forest land adjacent to developed areas are at high risk because the Forest Service missed opportunities to have fuels reduced by private enterprise.These conditions can be reversed to a significant degree if the wildland fire agencies begin to assertively pursue all the legal options available for fuels management.

Contributing Influences

Low levels of fuels management funding and missed opportunities are not the only reasons that California is vulnerable. A more intensive review of fuels management history shows that other forces were also at work.

Diffusion of Responsibility

Who is responsible for fuel reduction for fire protection? The answer varies around the State. CDF is primarily responsible for about 33 million acres of privately owned land in 56 of the State's 58 counties. These are classified as "State Responsibility Area" lands (SRA). SRA lands are dotted with more than a thousand rural fire districts, incorporated areas, and other land classifications described as "Local Responsibility Area" (LRA). CDF contracts with a few counties to protect SRA lands within their jurisdictions. They also contract to manage various levels of dispatch and supervision of local fire districts in other counties. The USDA Forest Service contracts with CDF to protect private lands within National Forests, in return for CDF protection of more than a million acres of National Forest land in other areas. (The term "protect" in this context means suppression, not management.) Most counties assume that their compliance with Public Resources Code 4290 (the "Defensible Space" law) fulfills their responsibility for fuel modification. Too many local fire districts feel that their fire protection responsibilities are limited to the structural component of wildland fire, the "protection of life and property," and that the vegetative component is CDF's problem. CDF acceptance for the responsibility varies, depending largely upon the orientation of the ranger in charge of the area involved. At best, the state-wide diffusion of responsibility for fuel modification has led to confusion in budgets, program actions, and serious gaps in performance. At worst, it escalates damages from the conflagrations that are becoming commonplace.

Liability

Liability has hampered attempts at fuel modification for fire protection. In the 1950's and 1960's, CDF had active prescribed burning programs for range improvement and brushland conversion. Landowners were an important part of the programs, providing equipment and work that materially reduced CDF costs. In the 1970's several of the burns escaped and caused minor to moderate damage on adjacent lands. Lawyers and insurance companies found new career opportunities. Insurance for the burns became prohibitive for landowners, and lawsuits became serious burdens to both CDF and their private cooperators. To a lesser but still significant level, USDA Forest Service activities were hampered by the same forces.

Environmental Requirements

The implementation of the California Environmental Quality Act (CEQA) brought new analytic and administrative workloads to fuel managers at the State and local levels. In its first decade of application (1971-81) there were few CEQA guidelines for fuel modification projects. Preparation of environmental documents went forward on a trial-and- error basis. The error rate was high. Lawyers found more career opportunities, and environmental groups found new crusades. Fuel managers found no increase in budgets, but much higher administrative costs and time requirements. In some cases it cost more in time and money to justify a project than it would to implement it. Frustrations mounted, motivation dropped, and production declined. Implementation of air quality controls acted to further reduce production and raise costs.

Easy Money

While it became more difficult to efficiently conduct fuel treatments, the availability of "emergency funds" did not diminish. The USDA Forest Service, the CDF, and some local fire departments had almost unlimited suppression funds. "You light them, we will fight them" became a popular firefighter slogan in the 1970's. Occasionally the United States Congress or the State legislature would complain about excessive suppression funds and require the agencies to repay part of the costs from other programs. But this did not happen often, it did not hurt very much, and it did not last very long. Following years usually saw even more emergency expenditures. Intelligent fire managers began to contrast the grief of modifying fuels with the glories and recognition of valiant suppression efforts. Fuels management lost.

Other Dynamics

The State's wildland-structural fire problem is analogous to rivers that gather volume and force from tributaries as they flow: over time, more contributory events added strength and destructive power to wildland fire. Some of the most important dynamics that supplemented the increases in destruction can be identified.

Hands-Off Local Decisions

For at least 40 years, the CDF and Forest Service made conscious (albeit unwritten) organizational efforts to avoid influence on local matters. However well intended these policies were, the result has been the profusion of less-than-safe developments in wildlands. Since about 1980 the agency comment process has improved, and a level of review on development proposals is now more routine. This improvement, however, has more to do with CEQA compliance than with agency commitment to assure fire safety. Federal and State fire inputs to local governments are still weak. With the possible exception of Public Resources Code 4290, inputs have been of a "comment" or "advisory" nature.

Failure to Pursue Legal Avenues for Better Protection

No local decision to allow less-than-safe development has been legally protested, appealed, or contested in court by fire agencies. Other Federal and State agencies have used the courts and the legislature to achieve specific safety standards at the local government level. The State Seismic Safety Commission had precise earthquake safety standards enacted into law. The State Water Resources Board and the Federal Emergency Management Agency did the same for flood plain planning and zoning. The State Department of Fish and Game has taken local governments to court to force compliance with wildlife habitat needs. Beyond the recent effort to pass the "defensible space" law, neither CDF nor the USDA Forest Service has used these avenues to improve fire protection.

Modified Mandates

The original organizational purpose for the wildland fire agencies was the protection of watershed lands and natural resources. Pressures from development, population, politics, and the honorable humanitarian desires to save lives and property have forced departures from the original purpose. The predominately tactical response (priority on structure protection) that is now commonplace in firefighting is inefficient. It may actually be contributing to higher losses in the long run.

Consider Nevada County's "49'er" fire of 1988. Total acres burned were 35,300. More than 500 structures were destroyed. CDF estimates indicate that the fire could have been controlled at about 7,000 acres (20 percent of the final total) if structures had not taken suppression priority. Many of the lost structures would have been saved if historical wildland suppression strategies had been used. Study of the "Stanislaus Complex" fires (Tuolumne County, 1987) and the "Fountain" fire (Shasta County, 1992) support this conclusion. In those cases, more than 100 million dollars in natural resources and long-term public revenues were lost because suppression resources were assigned to protect less than 1,000 structures.

Real Costs Not Documented

When elected officials approve developments their primary focus is on economic growth, tax revenues, and maximizing profit in the development and construction industries.

When fire agencies add up costs and losses they tend to amount to "negative growth."

A significant differential exists between hoped-for revenues, calculated costs, and real costs. Calculated costs show up in official records and media reports. Citizens and officials tend to accept that information. The real costs are not shown, and that leads to invalid assumptions on the part of all concerned.

A multitude of real costs has been ignored for decades. Whole towns have been shut down for days, and job holders have been delayed or prevented from getting to work. Vacationers have been diverted from their destinations. Motels, restaurants, and gas stations have lost income. Schools have been unable to conduct classes. State and local governments have spent months or years simply trying to return operations to the point they were at before conflagration struck. They have lost efficiency and public service opportunities during recovery. The "Cleveland" fire (El Dorado County, 1992) shut down the interstate highway from central California to Reno, Nevada. After several days of highway closure the Governor of Nevada complained to California's Governor that Nevada gambling enterprises were losing 8 million dollars per day because of travel restrictions. Commercial timber losses are calculated on stumpage value, not actual net return possible to local government, primary, and secondary industry. Soil and erosion costs are estimated, not validated after the fact; fire's costs for flood prevention, control, and recovery are rarely, if ever, fully documented.

These real costs (and others) were not significant 40 years ago. They are today. Full documentation of total losses could change public and governmental perspectives about fire safety. It would certainly improve cost-benefit ratios for fuel modification projects. Local officials would find it harder to justify reduced mitigation requirements on new development in the name of "growth."

The Next Questions

The next questions should be: What is the worth of the best suppression organization in the world if costs and losses continue to increase? What is the worth of planning if it does not reduce billion-dollar-per-year losses? Must California continue to suffer such unnecessary costs?

We thus return to our original question: "What do we do now, Ollie?"

Recommendations

- The Governor's Office of Planning and Research should arrange a series of "Summit Meetings" between top-level fire, fuel management, and planning professionals. Primary goals should be to increase effective communication between the disciplines, design safer planning and fire mitigation procedures, and achieve higher standards of development in vegetated areas.
- The University of California and State universities should cooperate to increase the wildland fire education requirements in all land-use planning degree programs. Every extension and continuing education course for planners should include a wildland fire safety and fuel management component.
- The University of California should cooperate with Federal, State, and local fire agencies to define and publicize the real costs of fire. The effort should also refine cost-benefit ratios for fuel management programs.
- The Governor's Office of Emergency Services should analyze the relative costs and losses of tactical versus strategic suppression efforts after all major fires. Objectives would be to define social and economic outcomes of current structure protection practices compared to fuel modification and strategic alternatives. Results should be included in all State Hazard Mitigation Reports.
- Finally, the USDA Forest Service, California Department of Forestry, State Office of Emergency Services, and the State Fire Marshall should sponsor a cooperative initiative for a Statewide "Strategic Fuel Modification Program" with the primary objective to reduce hazardous fuel volumes and future fire intensities on critical lands, regardless of ownership or jurisdictional boundaries. The secondary objective should be to provide opportunities for productive work for currently nonproductive human resources, such as inmates from overcrowded prisons, homeless, welfare recipients, and "displaced" timber industry workers.

New Thinking for a New Century

This paper has shown many of the ways in which old habits and old thinking have led the State into its present situation. Policies and practices that continue old thinking will result only in more of the same. That does not have to be the case. California does not have to continue suffering exorbitant costs and losses from wildland fire.

As the year 2000 approaches, fire agencies, planners, educators and decision-makers at all government levels must dedicate themselves to making positive change in the wildland-structural fire situation. Some of that change can happen by taking corrective action on the weaknesses addressed in this analysis. Recommendations made here can be implemented before the turn of the century.

Fire History of the Local Wildland-Urban Interface[1]

Neil R. Honeycutt[2]

Fire activity in Alameda and Contra Costa Counties has been recorded in historical documents. In pre-European times the Native Americans in the hills above the eastern shore of San Francisco Bay used fire to remove unwanted underbrush to improve the wildlife habitat. This type of "prescribed" burning may have been the earliest fire management in this region—the characteristic low levels of lightning activity in northern California resulted in few naturally occurring fires. In the 20th century, patterns of fire in this wildland and urban interface have caused much destruction. The history of fire in the area provides clues to these patterns.

---

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Chief, Fire and Rescue Branch, State of California Office of Emergency Services, 2800 Meadowview Road, Sacramento, CA 95832

PANEL DISCUSSION: Prescribed Fire: Why Aren't We Doing More? Local, State, and National Perspectives

Prescribed fire has been recognized as a potential tool for land managers for many years. The gradual recognition of the important role of fire in wildlands has been documented many times. In the United States, this recognition probably first occurred in the longleaf pine region of the southern United States. Various agencies that once focussed on fire exclusion gradually adopted the use of prescribed fire as a land management tool. By the late 1970's, many Federal, State, and local wildland agencies were actively implementing prescribed burning programs for purposes such as fuel hazard reduction and wildlife habitat management.

Even though the use of prescribed burning has increased during the past 60 years, present use of this tool falls far short of its potential use given the millions of acres of land in fire-adapted or fire-dependent ecosystems in the United States. This observation begs the question "Why aren't we doing more prescribed burning?" In order to provide several different perspectives on this question, a panel of experts was convened to discuss the issue from the perspectives of local, State, and Federal wildland agencies. Battalion Chief Donald Pierpont of the Los Angeles County Fire Department, Mr. Ken Nehoda of the California Department of Forestry and Fire Protection, and Mr. Jerry Williams of the USDA Forest Service each provided their views on the topic. Many common factors affect the prescribed burning programs of each of these agencies. The following three papers present a summary of this panel discussion.

Prescribed Fire: "Why Aren't We Doing More?" A Local Perspective[1]

Donald A. Pierpont[2]

Abstract: The ability of local agencies to mitigate wildfire hazards through prescribed burning is limited by many internal and external factors. Environmental regulations, public support, and internal departmental problems continue to limit the effectiveness of prescribed burn programs. These elements are discussed to provide a better understanding of why we are not doing more at the local level.

The factors that limit prescribed fire programs on the national and State level naturally affect local agencies as well. Federal and State environmental, air quality, and management decisions are implemented at the local level. The public's perception of these decisions affects our ability to produce modified acreage and mitigate the wildfire problem.

The cooperation of all agencies impacted by prescribed fires is essential to maximizing acreage production. Over the years we have developed excellent relationships with most of the agencies involved, and conflicts are rare. When conflicts do occur, they are usually because of a lack of understanding of the mutual benefits of prescribed fire.

The objective of prescribed fire managers is to improve wildland fire protection; environmental issues are addressed, as necessary, to achieve this objective. When prescribed fires conflict with environmental laws, we rely on enforcing agencies to assist us by identifying ways to mitigate the impact. This assistance is not always available, and developing mitigation methods is very time consuming and certainly affects prescribed fire.

The implementation of the prescribed burn program has required continual public education regarding the benefits and limitations of the program. With 12 years of experience and public education behind us, we have developed a high level of public support. The public's concern about the potential impact of our projects has not diminished, but outright opposition is extremely rare.

While developing a project in Los Angeles County, we identified one property owner who did not want to cooperate. I met with the property owner in an effort to educate him and gain his cooperation. He stated that he was planning to sell his home and did not want to spoil the view. We subsequently attempted to continue with the project and work around his property.

The property owner then took his opposition to every public forum he could think of. He contacted County Supervisors, the City Council, the Town Council, Resource Conservation District, and the media. The public, the politicians, and the media supported the project at each of these meetings. Our long-term efforts in public education had proven successful.

His final effort was litigation. He filed suit, questioning our environmental documentation. Our response required the filing of a negative declaration addressing the environmental issues. The process of public meetings and litigation proved to be very time consuming.

Contracts with cooperating property owners, for prescribed burning, are valid for only 3 years. In this case it took more than 2 years to exhaust this property owner's avenues of opposition, and there was not sufficient time left to complete the project before the 3 year time limit expired. This time limit has impacted other projects as well.

The climate of Los Angeles County is diverse, ranging from the desert to coastal plains. Wildfire season starts as the vegetation dries in the inland valleys, long before the coastal areas are dry enough to burn. The need for resources to combat these inland fires limits our ability to conduct burns along the coast.

The advent of the Paramedic program in 1970, followed by Emergency Medical Technician, Hazardous Materials, and Urban Search and Rescue programs, has dramatically changed fire departments nationwide. Today, only 7 percent of our responses are fire related and less than 1 percent are brush or grass fires. Training is naturally directed toward the areas of greatest demand, and the number of wildland fire experts has declined proportionately. Chief officers are drawn from this diverse background and, of course, reflect their experiences. These changes are also reflected in management and its response to the prescribed burn program.

Today fire chiefs support prescribed burn programs but are extremely conservative in their approach. Prescribed fire managers reflect this conservatism in their selection of projects, the size of burn units, and the conditions under which they are burned.

Every time prescribed fire managers light a match, we are placing our careers on the line.

Conclusion

The public's understanding and demand for prescribed fire continue to grow. The ongoing education of the public, other agencies, and chief officers—combined with the continued success of prescribed burning—will allow prescribed fire programs to be more productive.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Battalion Chief, Los Angeles Fire Department, 1320 N. Eastern Ave., Los Angeles, CA 90063.

Prescribed Fire: Why Aren't We Doing More? A State Perspective[1]

Ken Nehoda[2]

Before I try to answer the question "Why aren't we doing more?" I will provide some basic information on the Vegetation Management Program (VMP) of the California Department of Forestry and Fire Protection and what we have done with it.

Although the title might indicate a broader based function, the majority of the program's efforts have been and are currently focused on the prescribed burning of brush-covered lands classified as State Responsibility Area. *The Handbook and Field Guide to the Vegetation Management Program* says, "The goal of the Vegetation Management Program is to reduce the chance of large, damaging wildfires by reducing fire hazards on wildlands in California. Realizing the best mix of natural resource benefits from these lands, consistent with environmental protection and landowner/steward objectives, is the Department's intent."

VMP has been functional since 1981. Here are some statewide statistics:

- The highest amount of acreage burned in a year is about 68,000 acres.
- The lowest amount of acreage burned in a year is about 17,000 acres.
- Average annual acreage burned is about 42,000 acres.
- This year, about 14,000 acres have been burned in 27 projects.
- There are about 100 approved projects waiting to be burned, with a total project area of approximately 106,000 acres.

Over the years, most of the projects burned under this program have been located in fairly rural areas. Prescribed burns have been aimed primarily at fire hazard reduction, wildlife habitat improvement, and range improvement. As a result of this general configuration, many of the burns have been of significant size. More recently, there is a shift away from this type of project toward the urban interface. With this shift to more congested, built-up, populated areas, new issues are showing up. Among these issues are:

- Increased sensitivity toward smoke incidents.
- Significantly higher values at risk in the event of an escape.
- Smaller urban setting projects require as much, if not more planning, resources, and operational effort to conduct.
- Increasing public concern about the risk and potential adverse impacts of prescribed fire.

However, this type of project has the potential to make a difference in saving or losing structures in built-up areas. That, by itself, is enough to merit facing the associated challenges. Fuels management, as a significant component of a professional fire protection program in the wildlands and at the urban interface, is at least a part of the solution to these major fires with significant structure losses.

The Process

The process is normally initiated by one of the following actions. Either the California Department of Forestry (CDF), or its representative, such as a Contract County, contacts a landowner or group of landowners in an area where they would like to develop a project, or a landowner contacts us. Regardless of how it begins, the process must meet all of the administrative requirements. The completed package will include the following information:

1. Prescribed Burning Project Standard Agreement—This is the agreement between CDF and the landowner. If one of the participants in the project is an agency of the United States Government, a "Federal Land Management Agency Prescribed Burning Project Standard Agreement" must be included.
2. The Burn Plan—This is the primary planning document for the project and includes:
   a. General project information, i.e.: landowners' names, parcel numbers, etc.
   b. Burn area description, legal and narrative description of property, zoning, land use, estimate of area to be burned, etc.
3. Environmental Setting and Impacts—This includes general information about the following:
   a. Description of project objectives and methods.
   b. Project area topography, elevation range, slope steepness and aspect.
   c. Soils description and sensitivity to project activities.
   d. Vegetation community and dominant species.
   e. Wildlife/fisheries habitat and sensitivity to project activities.
   f. Cultural resources and sensitivity to project activities.
   g. Smoke and potential impacts to communities.
   h. Project maps.

[1] An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Program Manager, Vegetation Management Program, California Department of Forestry and Fire Protection, 1416 9th Street, Sacramento, CA 95814.

i. Copies of all letters to other agencies asking for information or concerns they might have with the project and any responses.

4. Burn Prescription—This is the synthesis of all the information gathered about dead and live fuels, anticipated weather, desired effects of the project, and smoke management into a few model inputs so that you may specify conditions which will achieve project objectives.
5. Project Cost Summary—Vegetation Management Program projects are partially funded by participating landowners. This cost sharing formula is defined in Section 1564, Title 14, California Code of Regulations. In summary, it says, "The State's share of such costs shall bear the same ratio to the total costs of the operation as the public benefits bear to all public and private benefits from the operation as estimated by the Director." Subsequent legislation was passed that allows the Department to pay all of the project costs if there are no private benefits accrued to the landowner.
6. Environmental Checklist—This document functions as the initial study for the project. Its completion, according to the California Environmental Quality Act Guidelines and the VMP Handbook, is mandatory.

Why Aren't We Doing More?

This is a deceptively simple question which requires a complicated answer. The complications arise not only from the extremely diverse biological, environmental, and physical conditions that exist in California, but also from administrative, political, and social differences.

Most of the administrative complications arise from program staff within the Department and are differences of opinion about how program requirements are interpreted. From the viewpoint of a program manager, whose duties include trying to ensure that projects meet the requirements and intent of both law and policy, I offer the following comments. Frequently those of us who work in the program at Sacramento Headquarters are perceived to be much too detail oriented. This description is most frequently applied soon after additional information or clarification of issues is requested. I have heard on several occasions that program staff should be inventing ways to approve projects, not to stop them. Since I cannot arbitrarily choose to ignore or modify either the law or CDF policy, I must require compliance which can sometimes result in delayed implementation: therefore, I am part of the problem.

The political issues–and I include "interagency cooperation" as part of this–are also a factor. These issues include working cooperatively with many agencies to address impacts of prescribed fire upon archaeological and cultural resources, fisheries and wildlife habitats, air quality, vegetation communities, and, last but certainly not least, impacts on rare and endangered species of both plants and animals. I have been told by some that agencies with responsibility for managing or protecting these items are not receptive to prescribed fire. That may well be true, but a methodical, educational process that focuses on the benefits that can be provided might change opinions and is preferable to one that is by nature confrontational. As a result of this type of controversy during the southern California fires late last fall, many people are looking at the use of prescribed fire as well as how to improve the political climate and interagency cooperation.

What I perceive to be social issues are those that are not usually founded on the physical impacts of prescribed fire, but are based upon some individual's desire to participate in, and thus influence, the decision-making process. In most of the cases I have dealt with, the people had their own ideas about what they wanted done, and more often than not, they wanted the project stopped. This can complicate the process and that is what I choose to deal with here. Examples include: neighbors who do not really believe that there is a significant risk associated with unmanaged fuels around homes and developments, people who believe that all fuel treatment will result in significantly accelerated erosion, and probably the most common view that wildfires happen "somewhere else" so we do not really need this here. I see this as a need to educate people who live adjacent to project areas. In those cases where individuals cannot be convinced the project is valid, there are mechanisms to go around them. Unfortunately, this means more work, not less. Furthermore, we will not win all of our battles. In most cases, however, the time spent on developing a project will not be wasted.

It appears to me that the answer to the question "Why aren't we doing more?" depends entirely on the experience of the person who provides the answer. In an effort to address the issues, the California Department of Forestry and Fire Protection is exploring ways to simplify the paper flow, increase program flexibility, and improve our working relationships with other agencies. The product of this effort should provide a strong foundation for a dynamic, stable, and functional Vegetation Management Program.

Prescribed Fire: Why Aren't We Doing More? A National Perspective[1]

Jerry T. Williams[2]

USDA Forest Service and fire and aviation management decisions are commonly made in a context of biological, technological, social, legal, and economic considerations. These considerations ultimately define the latitude in which we operate to achieve multiple-use objectives, and they help us answer the question, "Why aren't we doing more?"

These factors are also important in the context of prescribed fire (*fig.1*). We use prescribed fire to meet specific resource objectives—despite that, prescribed fire problems have traditionally focused on prescribed fire practices and policies, but rarely on the primary objectives.

A good example of means becoming confused with ends is illustrated by the prescribed natural fire situation experienced in 1988. After fire problems surfaced, virtually all of the focus centered on the application of prescribed natural fire policy. Few scrutinized the objectives on which the prescribed fire activity was predicated. We did not examine the larger issues attached to the overarching objectives for wilderness and the meaning of those objectives in terms of expected benefits, risks, and consequences.

Underlying the question of "why aren't we doing more" is the larger question of "to what purpose?" Fundamentally, whatever we do must be viewed as worthwhile. The benefits must be worth the risks. This notion becomes especially important to the resource manager because potential benefits may not be clear to the affected public. The risks that inherently surround prescribed fire and the consequences that can result make it imperative that the public have a full understanding of our objectives. If our objective is to sustain short interval fire-adapted ecosystems, why aren't we doing more?

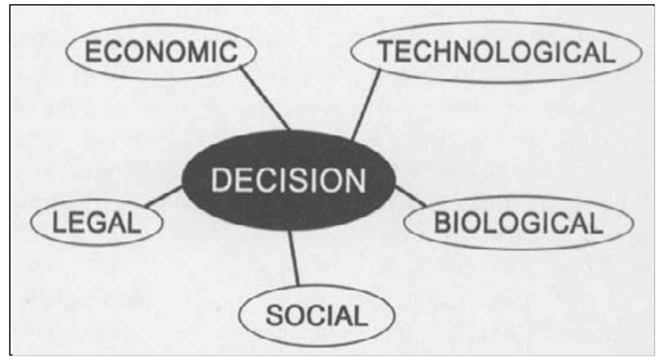


Figure 1–A variety of considerations surround fire management decisions.

Discussion

Biologically, prescribed fire must be included as a management tool in sustaining fire-adapted ecosystems; fire regulates the biotic productivity and stability of fire-adapted ecosystems that cannot be fully emulated by mechanical or chemical means. Prescribed fire is especially important in short interval fire-adapted systems in which the absence of periodic, low-intensity burning causes stands to undergo relatively rapid changes in species composition and structure, which in turn often results in predisposing factors to epidemic insect and disease outbreak and severe stand replacement wildfire. Among conifers, the long-needle pines are a common example of short interval fire-adapted species. Notably, these species account for nearly 30 percent of the suitable timber base on National Forest lands.

Technologically, in most short interval fire-adapted ecosystems, and particularly in the long-needle pine types, the opportunities to use prescribed fire on meaningful scales is limited by narrow prescription windows. Risk and smoke are commonly cited as factors that inhibit more prescribed burning. However, in short interval fire-adapted ecosystems, in the prolonged absence of fire, high fuel loadings, unnatural volumes of biomass, and multi-storied canopies are the fundamental reasons more burning does not take place. These underlying causal factors significantly impede the ability of field practitioners to conduct prescribed burns within acceptable limits of risk. Not to be overlooked, these factors also preclude burning within ecologically appropriate ranges of fire intensity. Before we do more prescribed burning in these situations, we need to give serious consideration to managing understory vegetation and mechanically reducing fuels.

In the social arena, the public does not always understand the rationale for prescribed burning. In fact, much of the country is culturally averse to fire. An exception, of course, is the south and southeastern United States. There, perhaps because long-needle pine forests have the shortest fire return intervals anywhere, cause–and–effect relationships are manifest most rapidly and, therefore, are most obvious. In that part of the country, in the absence of fire, undesirable effects develop quickly. In only a few years, flammability can increase significantly and the habitat for many game animals can diminish rapidly.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interfaced and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Assistant Director—Fire Operations, Fire and Aviation Management Staff, USDA Forest Service, Washington DC 20250.

Misperceptions about fire and culturally imbedded fears about fire have a significant effect on the prescribed burning program. People who do not understand the long-term ecological benefits of fire or are unable to see or somehow benefit from the positive cause–and–effect relationships that result from fire are not likely to tolerate the short-term consequences that invariably accompany prescribed burning. A compounding obstacle is the very nature of prescribed burning. We usually do not notice the ones that go well. We almost always notice the ones that do not. In the planning stages, proposed prescribed burn projects are typically affected by the social impacts that may have resulted from remembered smoke incursions and escapes. Risk is a part of prescribed burning. Because failures command scrutiny while successes go unrewarded, most decision-makers, most managers, and most practitioners are cautious and conservative with the use of fire. Prescribed burning on the scales and over the timeframes that are currently under discussion in some circles will be exceedingly difficult in this social and cultural climate.

The legal arena, however, is perhaps the most contentious. The Forest Service mission is, in large measure, based on the Multiple-Use Sustained Yield Act (1960). Although a great deal of focus has historically centered on the multiple-use aspects of this legislation, sustainability is becoming the growing concern. Nowhere is the issue more acute than in short interval fire-adapted ecosystems. Biologically, we know that a successful management strategy aimed at sustaining these ecosystems must rely on prescribed fire. However, whether concern centers on air quality for a community, cover for large game, critical habitat for endangered species, or the desire for seclusion among people living in a wildland subdivision, the growing trend toward single-resource emphasis will preclude the use of prescribed fire. As long as we are legally mandated to manage for discrete components of the ecosystem, we will be unable to manage for the larger whole ecosystem.

Last but certainly not least, economics will also play a significant role in our ability to sustain fire-adapted ecosystems, particularly when we consider the cost of restoration that now confronts us. We should not think that dollars will become available to fund these treatments unless a compelling argument can be made that the cost of restoration and maintenance is worthwhile. The competition for dollars is intense and it is getting more intense. Entitlements, health care, education, and urban infrastructure needs are among the few that will compete for the dollars available to treat fire-adapted ecosystems. In the final analysis, restoration treatments will need to demonstrate a savings, in terms of the costs that are likely to result in attempting to manage under existing forest conditions and the losses that are likely to accrue in the absence of treatment.

Summary

Perhaps the important question is not so much “why aren’t we doing more,” but rather “what is the reason for needing to do more?” Before we do more prescribed burning, we need to develop a better basis from which to operate. If our objective is to sustain short interval fire-adapted ecosystems, prescribed fire will be a part of that and so will smoke and escapes and expense. We can mitigate potential adverse effects by mechanically pre-treating stands to reduce emissions and escapes. In some areas, before we use prescribed fire, we must make preceding mechanical entries in order to burn within appropriate ecological amplitudes. Treating stands is one thing, but treating landscapes will be difficult and costly.

Nobody likes the idea of the smoke or the escapes or the expense that is a part of sustaining fire-adapted ecosystems with prescribed fire. But, as fire management professionals, we have realized that our suppression capabilities are limited and, although consequences come with using fire, opting to avoid the use of fire carries serious consequences also. In the past decade, under the influence of drought, catastrophic wildfires have consumed what prescribed burning was unable to treat, protect, and sustain.

We are at a crossroads in our ability to sustain fire-adapted ecosystems. This may be the single most important resource issue facing the Forest Service. We are stalled in our efforts to do more prescribed burning. I believe, at this point—because we do not have an adequate anchor, a basis from which to operate—it is less important for our fire managers to advocate the use of prescribed fire than it is for them to know and display the biological, technological, social, legal, and economic tradeoffs and limitations that are involved from among our alternatives. Ultimately, the public will determine what latitudes we are allowed in using prescribed fire. We need to put our energies in providing them with the knowledge they will need to make informed decisions.

Institutionalizing Fire Safety in Making Land Use and Development Decisions[1]

Marie-Annette Johnson[2] and Marc Mullenix[2]

Because of three major wildland fires in the past 5 years along the Front Range of the Boulder County area in Colorado, current and potential residents should be told of steps that can reduce the risks of these fire hazards. The Wildfire Hazard Identification and Mitigation System (WHIMS) is used by the county and city to assist in the identification and mitigation of wildfire hazards in their wildland and urban interface areas. This system combines available expertise in forestry, wildfire behavior, hazard assessment, and fire suppression with a geographic information system (GIS). The county uses WHIMS to combine all the components of wildfire mitigation (i.e., information, education, cooperation, community involvement, planning, and preparedness), and provides motivation for homeowners and residents to actively participate. The development of this system depends entirely on the excellent interagency and cross-jurisdictional cooperation, experience, and knowledge of individuals and various agencies. Fire safety is institutionalized into land use and development decisions in several ways. They include attempts at strengthening local zoning and building codes (as well as state legislation); creating a Natural Hazards Element for the county's comprehensive plan; requesting a Wildfire Mitigation Plan (which operates on a point system) under the county's Site Plan Review (which is required for all new development in the mountains); linking design with the degree of wildfire hazards for new subdivisions in the city; examining alternatives to fuel management from a solid waste perspective; providing information for open space planners and land managers as more land is acquired; and distributing brochures and videos to new residents as well as the builders and designers of new construction in the mountains. Much has been learned about institutionalizing fire safety and ensuring that it is an integral part of the planning process. This includes the critical importance of interagency cooperation (as well as the involvement of citizens' groups and homeowners' associations), the necessity of public education and awareness; the importance of using all available resources, personnel and funding; and the value of sharing information from other areas. All managers should be prepared to act immediately after a disaster during the relatively short "window" of heightened citizen awareness that is present in the aftermath.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Long Range Planner, Boulder County Land Use Department, P.O.Box 471, Boulder, CO 80306, and Wildland Fire Mitigation Coordinator, City of Boulder Fire Department, Boulder, CO 80306

A Synopsis of Large or Disastrous Wildland Fires[1]

Robert E. Martin[2] **David B. Sapsis**[3]

Abstract: Wildland fires have occurred for centuries in North America and other selected countries and can be segregated into three periods: prehistoric (presuppression) fires, suppression period fires, and fire management period fires. Prehistoric fires varied in size and damage but were probably viewed fatalistically. Suppression period fires were based on policy that excluded fire from many ecosystems where it played an important role; the view of fire as an undesirable wildland disturbance was fostered during this period. Recognition of fire's roles led to a managed use of fire; however, large and disastrous fires still occur because of large fuel accumulations during the fire suppression period.

Fires burning in vegetation have been termed "forest" fires, or, more recently, "wildland" fires. If these fires also involve structures, they have been termed "urban," "interface," or "intermix;" i.e., "urban/wildland" fires. Although these types of fires are not new, in the past 30 years we have begun to consider these fires as a separate and very important group of fires—fires that require a great deal of energy to suppress, and from which property and human lives have been lost.

Despite these disastrous fires, we must consider that in natural systems fire is generally neither good nor bad; it just occurs. We might consider that the extinction of a species caused by fire would be a bad or disastrous event. However, is it a disastrous event or merely part of the natural progression of systems? The decision to term an event "good," "bad," or "disastrous" means that human values have been attached to it.

Our concepts of wildfires as bad or disastrous probably result from both our association with the loss of structures to fire, and the Northern European education of the leaders of the conservation movement in North America. Our association with urban fires was always that of loss of values and life. When the conservation movement began in North America in the late 1800's, fire was considered the number-one enemy, and more than 90 percent of the early forestry practices in the early 1900's excluded fire from wildland systems. This approach completely ignored the role of fire in these systems and the use of fire by Native Americans to manipulate their environment.

This paper summarizes the history of large and disastrous fires, in the United States and other nations—from the prehistoric fire regimes, to the suppression period (1910-1960) to the fire management period (1960 to the present).

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Professor Emeritus, Department of Environmental Science and Policy Management, 145 Mulford Hall, University of California, Berkeley, CA 94720.

[3]Graduate Student, Department of Environmental Science and Policy Management, 145 Mulford Hall, University of California, Berkeley, CA 94720.

Prehistoric Period

Fires were started primarily by humans and lightning in the prehistoric period, although other sources such as volcanism were temporally and spatially important. Friction, sparks, or refraction were also possible as fire sources. The first fires probably began shortly after plants first produced terrestrial biomass, or when aquatic biomass dried and was susceptible to burning. Ignitions by humans or our predecessors are relatively recent in geologic time, and especially recent in locations such as North America.

Ignitions caused by our early predecessors would normally result in a fire regime modified to a shorter period between, and reduce the variability of, a fire season and its severity, as the fires set for any given purpose would better accomplish this if set for a predetermined prescription. When fires were ignited by non-human sources, the conditions for spread could have varied widely.

For California, it has been estimated that prehistoric fires covered an average of 5.5 to more than 13 percent of the State every year (Martin and Sapsis 1992). Fires also have covered substantial areas of other parts of North America, Australia, and Africa ignited by both lightning and humans.

Settlement Fires

Fires during the settlement period were the largest and often involved the largest loss of lives of any recorded fires (*table 1*). During this period attitudes about wildland fires were complacent or even fatalistic. Logging created large areas of undecayed slash, and fires were started indiscreetly to burn slash or make land attractive to homesteading. Without any means to control fires, settlers were at the mercy of the weather once fires began to spread.

Suppression Period Fires

The disastrous fires of the late 1800's and early 1900's led to the feeling of a need to control the fires. Thus, when the 1910 fires of northern Idaho, western Montana, and eastern Washington occurred, a skeleton force of firefighters attempted to control them. Tools and equipment were simple, and knowledge of fire behavior primitive. Nevertheless, this was the beginning of the fire suppression period that lasted about 50 years (*table 2*).

Along with the suppression effort was a strong fire prevention effort. Fire was labeled as evil, and the campaign against fire often took on the aspects of a religious crusade. Although some spoke in favor of a moderate policy, and even the use of fire as a tool in wildland management, they were

Table 1—*Major-settlement period fires, before 1910.*

Fire Name	Location	Date	Size and Losses[1]	Comments[2]
Miramichi	Maine	1825	1.2 MM Ha; Lives	Many fires, undetermined drought; wind
Black Thursday	Victoria, Australia	1851	10 killed	
Peshtigo/Michigan	northeast Wisconsin Upper Michigan	1871	1.6 MM Ha; 1,200 to 1,500 killed	Many fires, drought,wind
Michigan	primarily northeast (“thumb”) area of southern Michigan	1881	400 M Ha; 169 killed	Many fires, drought, hot
Hinckley	Minnesota	1894	418 killed	Many fires, drought, hot
Far West	Yacoult, Washington	1902	>500 M Ha; 38 killed low relative humidity	Dry summer; hot, windy,
Adirondack	New York	1903	258 M Ha; none killed	Dry winter, strong winds

[1]M = 1,000; MM = 1,000,000

[2] Haines and others (1986) present evidence that many of these fires occurred without drought or severe weather preceding the fire, based on historical weather records. (Brown and Davis 1973, Forest Fire: Control and Use; Australia, C. Trevitt and P. Cheney 1973).

Table 2—*Suppression-period fires, 1910 to 1960.*

Fire Name	Location	Date	Size and Losses[1]	Comments[2]
Great Idaho	northern Idaho, western Montana, eastern Washington	1910	1.2 MM Ha; 85 killed	Hot, dry, windy; spring and summer
Cloquet	Minnesota	1918	551 killed	Hot, dry, windy
Victoria	Australia	1919	3 killed	Fires burned for 6 weeks.
Berkeley	Berkeley, California	1923	584 structures destroyed	East winds
New South Wales and Victoria	Australia	1926	31 killed, 2,000 homeless	
Mill Valley	N. California	1929	117 homes lost	
Tillamook	Oregon	1933	126 M Ha	Dry, hot summer, east winds
New South Wales and Victoria	Australia	1939	1.37 MM Ha, 71 killed, over 1,000 homes destroyed	
Marshfield	Massachusetts	1941	450 homes lost	
Southern California (series)	southern California	1943	200 homes lost	
Maine Forest Fire Disaster (series)	Maine	1947	1200 homes; 16 lives lost	
New South Wales	Australia	1951	3.5 MM Ha; 6 killed	
Manchuria	China	1956	400 M Ha	

[1]M = 1,000; MM = 1,000,000

[2]Sources: Brown and Davis 1973; Trevitt and Cheney 1973.

overruled by those in favor of fire exclusion (Pyne 1984). Although scientific evidence supported the use of fire, the political accidents of gaining control in Washington, DC, led to a policy of fire exclusion.

Urban Interface and Fire Management Period

During the urban interface and fire management period, wildland fires began to involve structures again, and the idea of fire management began to evolve. Wildland fires had not been involved with structure losses in the United States since the 1923 Berkeley fire. Suddenly, because of the Harlow and Bel Air Fires of 1961, wildland fire threats to urban areas were again a reality. Although many in the fire service and those in the academic community such as Harold Biswell recognized the potential threat of wildland fires to urban areas, many years passed before a broader awareness of the problem evolved.

Table 3—*Fires of the urban interface and fire management period, 1961 to the present.*[1]

Fire Name	Location	Date	Size and Losses[2]
Harlow	central California	1961	106 homes; 2 lives lost
Bel Air	southern California	1961	505 homes lost
Dwellingup	western Australia	1961	146M Ha; 140 bldgs lost
New Jersey Fires (series)	New Jersey	1963	458 homes; 7 lives lost
Staten Island	New York	1963	100 homes lost
Parana	Brazil	1963	2 MM Ha; 5000 homes; 110 lives lost
Hanley, Nuns Canyon Fires	northern California	1964	295 homes lost
Coyote	southern California	1964	106 homes lost; 2 lives lost
Tasmania	Australia	1967	263 M Ha; 1246 buildings; 62 lives lost
Wright, Los Angeles	southern California	1970	103 homes lost
Laguna, San Diego	southern California	1970	382 homes; 5 lives lost
Sycamore, Santa Barbara	southern California	1977	234 homes lost
Kanan, Los Angeles	southern California	1978	224 homes; 1 life lost
Panorama, San Bernardino	southern California	1980	325 homes; 4 lives lost
Ash Wednesday Fires	Victoria and South Australia	1983	392M Ha; 2545 bldgs; 75 lives lost
Black Dragon	northern China	1988	>2 MM Ha
49er	northern California	1988	148 homes lost
Paint, Santa Barbara	southern California	1990	479 homes; 1 life lost
Tunnel, Oakland/Berkeley	northern California	1991	2103 structures, (2475 living units); 25(26) lives lost
Fountain, Redding	northern California	1992	450 homes lost
Altadena, Los Angeles	southern California	1993	118 homes lost
Laguna, Orange County	southern California	1993	366 homes lost
Malibu, Los Angeles	southern California	1993	350 homes; 3 lives lost
New South Wales	Australia	1994	1.2 MM Ha; 185 homes plus other bldgs; 3 lives lost

[1]Sources: California, Reports of the California Department of Forestry and Fire Protection; Australian, P.Cheney, and C.Trevitt ; Brazil, R.Soares. United States fires from Brown and Davis, 1973, Forest Fire: Control and Use; Australia, C. Trevitt and P. Cheney. Eleven Fires from United States are from Brown and Davis, 1973, Forest Fire: Control and Use; Australian, C. Trevitt and P. Cheney; California, Reports of the California Department of Forestry and Fire Protection.

[2] M = 1,000; MM = 1,000,000

Although the list of fires for this period (*table 3*) is not complete, it illustrates that large and disastrous wildland or urban/wildland fires have not diminished; if anything, they have continued to increase in frequency. Numbers of structures lost has increased. In California, as many as 3,500 homes were lost to urban/wildland fires in the 7 decades from 1920 to 1989. In the early 1990's, about 4,200 homes were lost. Although the numbers of human lives lost to wildland fires has decreased since the settlement period, during the last 70 years, loss of life continues because of wildland fires.

Summary

Fire has been part of many terrestrial vegetation communities, and the use of fire as a powerful tool by many native peoples around the world was an important factor in their survival or extinction. Fire was foreign to the land management philosophy during expansion of the conservation movement. This fact, in addition to the large fires that had occurred, led to a policy of fire suppression and exclusion.

Large wildland fires usually are described as "disastrous" when large losses of human life or property occur, as with the "disastrous" 1988 Yellowstone fires. Yet in terms of effects on natural systems, the fires were not disastrous.

Losses of homes or structures increased during the fire management period. This is probably because of more people living near vegetation without the advantage of livestock or other means to manage fuels near structures. The fire management period itself, which advocates fuels management, is not responsible for the increase in acreage and homes lost. Rather, it is the long-term fuel accumulation from the suppression period that has contributed to the fire problem. Today, even with the recognition of the need for fuels management in both vegetation and structures, the most ecologically sound tool for managing fuels—prescribed burning—is severely underused because of human inertia and air quality constraints. Some local programs are vigorously attacking vegetation and fuels management, but we can continue to expect large fires and large losses of structures because of the immensity of the urban/wildland fire problem.

References

Brown, A. A.; Davis, K. P. 1973. **Forest fire: control and use**. New York: McGraw-Hill; 686 p.

Haines, D.A.; Johnson, V. J.; Main, W.A. 1976. **An assessment of three measures of long-term moisture deficiency before critical fire periods**. Res. Paper NC-131. St. Paul, MN: North Central Forest Experiment Station, Forest Service, U.S. Department of Agriculture; 13 p.

Martin, R. E.; Sapsis, D. B. 1992. **Fires as agents of biodiversity: pyrodiversity promotes biodiversity**. Proceedings of the conference on biodiversity of northwest California ecosystems. Cooperative Extension, University of California, Berkeley.

Pyne, S. J. 1984. **Fire in America**. New York: Wiley and Sons; 520 p.

Schiff. A. L. 1962. **Fire and water: scientific heresy in the Forest Service**. Boston, MA: Harvard University Press; 225 p.

Cooperative Efforts in Fuels Management[1]

Gerald L. Adams[2]

Abstract: Our forests have been neglected or protected to death, creating an extreme wildfire risk in wildland urban intermix communities. We as agencies and organizations are just now beginning to understand that the fuel problems we have across the western states are not a single agency problem, but "our problem." Wildfires do not respect boundaries, be they political, jurisdictional, or private. Our fuels problem must be dealt with from a cooperative effort by all individuals who reside and work in the wildland urban intermix communities.

Forests in Nevada have suffered the same decline in health that many forests in the western states are now experiencing. According to Fire Ecologist Professor Bob Sweeney: "we have built structures and now live in the forest. Additionally, we have not allowed nature to manage itself, primarily through normal fire cycles."

If we as Europeans had not intervened, would natural events have produced a healthier forest than we now reside in? Have we mismanaged or "overprotected" our natural resources, and, in doing so, placed our communities at extreme fire risk? I believe so.

Through decades of aggressive fire suppression, the normal fire regime has been altered, stands of trees and understories have become overgrown, drought has stressed the current stands, and now epidemic levels of insects and diseases have come together to produce extensive forest mortality. To the wildland urban intermix, or interface communities, this poses an extreme fire risk.

Because wildfires do not respect political, jurisdictional, or private boundaries, the fire issue becomes "our problem." No one agency or organization can effectively deal with the magnitude of the problem, pre- or post-fire.

For this reason, we in the North Lake Tahoe Fire Protection District, at the beginning of the 7-year drought, began laying the groundwork for an intensive Defensible Space vegetation management project.

In the major fires in recent history, we as incident commanders were waiting for either the weather to change, or the fire to run out of fuel. How successful are we at suppressing fires in these unmanaged fuel accumulations? If recent history is an indication, we are failing miserably, in lives lost, property damaged, and extreme natural resource losses.

Our fire problem is multidimensional, including the components of responsibility, accountability, economics, and the environmental consequences of doing something, or in most cases, nothing. There are major problems in attempting to deal with the primary issues of reducing the fire risk. These are the very issues that I believe we must work on the hardest, to bring about a solution to "our fuel problems." It will take a cooperative effort from many agencies and organizations to finally provide solutions that are drastically needed, in our wildland urban intermix communities.

We as fire suppression agencies have learned to develop excellent "Mutual Aid" pacts. We can gather virtual armies and air forces to attack these notable wildland urban intermix fires, which we have been dealing with since the early 1970's, and so which aptly have been called "the Fires of the Future."

The question must be asked: "Why have we not been able to develop a financial commitment to fuels management, similar to that we have in fire suppression?"

Thomas Watson, the founder of IBM, said, "The way to succeed is to double the failure rate." Have we doubled the failure rate on our wildland urban intermix fires in the past decade? Must we experience more failures before we begin to manage our fuels to a level that will allow us to effectively deal with the wildfire issue? What will it ultimately take to get us on track?

The Beginnings of a Cooperative Effort

When our fire district began recognizing the reality of the fuels problem our community faced, my office began a multi-year project of bringing about a fuels reduction program, or "risk reduction on the ground" program, called Defensible Space. No one within my fire agency had the benefit of an education or background in forestry, biology, or ecology. We did have a "firefighter's" knowledge that our community was at serious risk from any uncontrolled wildfire, and that our daily resources to deal with the problem would be extremely limited.

For many decades we had successfully combated all fires within our community, and had begun to recognize that our many successes would some day cause our most devastating failures. We had been excluding the forest's natural management process, fire, and had not taken the responsibility of managing the fuels any other way, such as reduction or removal.

Our "cooperative effort in fuels management" was based on the following premise. On a daily basis my fire prevention office operates in the area of "responsibility": individual

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Fire Marshall, North Lake Tahoe Fire Protection District, P.O. Box 385, Crystal Bay, NV 89402.

property owners have an obligation to maintain their property at a reasonably safe level.

We make sure that when you as the general public meet in a building, and an emergency occurs, your expectation to "get out alive" is met. When your next-door neighbor exposes your home to an unreasonable risk, there is an expectation that we can reduce that risk through some action on the fire prevention office's part. That's the premise of "individual responsibility."

When we looked at the fuels problem, we addressed it from the same standpoint. Each individual property owner had a shared responsibility to the community as a whole.

We looked at the problem from a worst-case fire behavior standpoint and recognized that even if all 12,000+ (parcels) property owners bought into the Defensible Space program, they would still be at serious risk from larger property owners like the USDA Forest Service and the Incline Village General Improvement District (I.V.G.I.D.). The General Improvement District owned the most hazardous drainages that intersected our community, and the Forest Service owned steep sensitive lands (Burton Santini lots) within and surrounding the community.

We additionally have an environmental regulatory agency called the Tahoe Regional Planning Agency (T.R.P.A.) that, when we began our program, had a reputation for "not touching anything green."

As we began to meet with all the political and regulatory agencies and the regional fire and forestry agencies, we all found a common ground of concern, which was wildfire.

It was observed by all concerned that uncontrolled wildfires could, and most likely would, impact all of the differing agencies and organizations in some way. For example, T.R.P.A.'s main concern would be the possible impact to "water quality" following a high intensity wildfire, and the associated erosion potential from damage to the forest floor.

From my fire district's standpoint, the potential losses to lives and property within the community are the main concern.

The individual property owners are concerned about the losses of homes and the long-term impact on today's scenic beauty, which would not return within their lifetime.

To say that all the agencies and organizations immediately jumped into a cooperative effort in fuels management would be an overstatement. We had disagreements, we struggled, we built bridges and relationships over a long period of time. We worked through "turf" battles, funding problems, general apathy, and denial that we did not even have a fuels problem. Eventually we developed a respect and trust for each other's points of view.

What got us to the present was the belief that the fuels problem was "our problem" and that one agency could not effectively deal with it alone. Other factors were my personal commitment and determination to provide a better level of fire protection to my community. I have been accused of using a "bull dog approach" to reach that objective.

The cooperative effort began with my office joining together with the University of Nevada, Reno Cooperative Extension, in Incline Village. Ed Smith and I recognized a need for a multi-agency approach. With fuels reduction as a goal, one concern was how or why could or would the agencies and organizations keep us from "reducing the fire risk to our community?"

We had to inform, sell, and educate each agency and organization that the common fire problem would affect us all. We eventually were able to accomplish that objective.

Cooperators

Who were the key agencies, organizations, groups, and individuals that have made our community-based program a success?

Organizations and Agencies

- University of Nevada, Reno, Cooperative Extension.
- Sierra Front Wildfire Cooperators, Fire Prevention Committee.
- Lake Tahoe Regional Fire Chiefs' Association.
- Nevada Division of Forestry.
- USDA Forest Service Lake Tahoe Basin Management Unit.
- Tahoe Regional Planning Agency (T.R.P.A.).
- Incline Village General Improvement District.

Groups

- Neighbors for Defensible Space, Our Grass Roots Community Group.
- Incline Village, Crystal Bay Chamber of Commerce.
- Incline Village Board of Realtors.
- Nevada Forest Stewardship Program.
- South Lake Tahoe Kiwanis (Dick Thomas).

Individuals

- Doug Clifford, and the Neighbors for a Defensible Space Executive Board.
- Ann Johnson, Executive Director, Chamber of Commerce, Incline Village.
- Nevada State Legislative Representatives.
- Nevada U.S. Congressional Representatives.
- Many Concerned and Involved Private Property Owners in the Community.
- And many others, too numerous to mention.

Legal Issues

Cooperative efforts have resulted in adoption of two important legislative acts that will allow the State of Nevada to move forward in the area of fuels management. These submittals were generated by my office, but would not have been adopted without the cooperation and support of many individuals and different agencies.

In the 1991 legislative session, the adoption of a "Hazard Reduction" statute, N.R.S. 474.160, allowed my office to require private property owners to remove hazards in a timely manner, or we could remove the hazards and lien the property. My primary problem was that under currently adopted fire codes, I could not issue citations across state lines. The major problem was that our community has many out-of-state, absentee property owners.

In the 1993 legislative session, we were successful in getting "Prescribed Burning" legislation passed. Prior to this legislation, prescribed burning was not even mentioned in the State of Nevada fire and forestry laws.

Summary

Cooperative efforts are what have made our community's Defensible Space program a regional role model. We would not have accomplished what we have, to date (and we are not finished yet), without cooperation from many agencies, organizations, and individuals.

We at this conference all know and understand the dangers that we face in the future for having tinkered with the ecological system that poses the wildfire risk to our forests and communities.

Each of the guest speakers and all of us at this conference seem to be like the "preacher, preaching to the choir." The main goal of these conferences is to share ideas and methods in fuels management and the latest technology to manage them, but in order to do so, we all need to accomplish more results in the fuels problem area. Each year improvements are made in the fuels management area in our agencies and organizations, but they seem very slow when contrasted with the accumulating losses in lives, property, and natural resources each heavy fire season.

We as organizations need to make use of all the tremendous amount of individual knowledge and brilliant people that I meet at these conferences each year and join forces to "educate the budgetary, policy and decision makers" that fuels management is the more cost- efficient way to deal with the mounting wildfire problem.

Let me close with an example of "recorded total losses" in the Cleveland Fire, Eldorado National Forest, September 1992. High winds, low humidity, steep terrain, and heavy concentrations of forest fuels with extremely low fuel moisture content, contributed to problems with long-range spotting. The fire's final size was 24,500 acres.

In 1992, the Cleveland fire caused the nation's largest wildland fire loss (Sullivan 1993).The recorded loss totaled at $245,325,000, which does not include the $16.5 million in suppression costs and the loss of two lives (air tanker pilots).

The breakdown is as follows:

41 homes and structures	$3,500,000
Private/timber stand losses	230,000,000
Marketable bio-mass	1,000,000
Revegetation/slope stabilization	2,000,000
Pacific Gas & Electric, utilities	7,000,000
Sacramento Municipal Utilities Dist. (SMUD)	175,000
Caltrans, roads, signs, infrastructure	250,000
D.C. Air Tanker	1,000,000
(missing item)	400,000
Total:	$245,325,000

Additionally there were 72 injuries with no recorded costs associated to them. These losses plus the suppression costs average out to approximately $10,683 per acre.

In these days of cutbacks, budget reductions, and doing more for less, can we afford these "fires of the future"? Should we not be reviewing the past to learn and better define a strategy for the future, looking for the best approach for the protection of lives, reducing the escalating costs in property damage, and attempting to reduce the wildfire impacts to our natural resources?

References

Sullivan, Michael J. 1993. **Large loss wildland fires in 1992 by listed $ loss: wildland fires**. In: The National Fire Protection Association (N.F.P.A.) Journal, Nov./Dec. 1993: 88.

PANEL DISCUSSION: Barriers to Fuel Management

One of the traditional roles that prescribed fire has played in the fire management arena is reduction of hazardous fuel buildups under controlled, well-defined environmental conditions. However, our ability to use this tool effectively is blocked by many barriers. The preceding panel discussion about the causes of limited success in implementing prescribed burning programs addressed some of the barriers encountered by various types of governmental agencies. This panel discussion focussed on three specific barriers to implementing fuel management programs incorporating prescribed burning.

Mr. Kenneth Blonski of the USDA Forest Service described organizational barriers to implementation. Although the specific examples are linked to the Forest Service, many of the same barriers exist in other organizations. Ms. Anita Ruud of the U.S. Office of the General Counsel described legal barriers, particularly those related to liability issues. Federal disaster assistance programs are viewed by some as disincentives to proactive hazard reduction programs. Mr. William Patterson addressed this issue and described new Federal assistance programs. The following three papers summarize the comments of the panel.

Organizational Barriers to Fuel Management[1]

Kenneth S. Blonski[2]

Numerous obstacles to fuels management, such as limited funding and inadequate staffing, result from programmatic conflict within the fire management mission of the USDA Forest Service. Traditional focus on fire suppression and the political realities of an extremely competitive climate for available public funds underlie this situation. As the Forest Service shifts its focus to the holistic concept of ecosystem management that includes fire and fuels management, agency leaders and resource managers may develop an economic basis for that strategy. Developing a sustained management strategy that embraces and enhances the fire-prone wildlands requires protection from the erratic, political winds of change. The rhetoric of politically correct environmental policy must be tempered with a realistic view of the traditional fire suppression mission. Successful future fuel management strategies must complement protection needs and provide a smooth transition to sustained ecosystem management.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Director of Fuels Management, Pacific Southwest Region, USDA Forest Service, 630 Sansome St., San Francisco, CA 94111

Legal Barriers to Fuel Management[1]

Anita E. Ruud[2]

The law is a strict master regarding any kind of deliberately set fires. The value of natural resources and resource management is low on the list of priorities for this state's lawmakers. BEWARE is the key word for those who dare to challenge the traditional notion that all fires must be extinguished immediately, except those within the safe confines of your fireplace or backyard barbecue. In order for fuel management with fire to be more easily utilized, the laws regarding fire management and resource protection will need to be amended to include the value of fuel management as a resource protection tool.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Deputy Attorney General in the Office of the Regional Attorney General, 455 Golden Gate Ave., Rm. 6200, California Department of Justice, San Francisco, CA 94102.

Federal Disaster Assistance Programs[1]

William J. Patterson[2]

The Robert T. Stafford Disaster Relief and Emergency Assistance Act—Public Law 93-288, as amended—is designed to provide support and assistance to citizens, state, and local government from catastrophic disasters and emergencies. The law provides support in three distinct phases, including preparedness in avoiding or minimizing the effect of a disaster, response support during the disaster, and recovery from the emergency. This law has several interesting and unique features relating to fire disasters. Although most disaster assistance requires a presidential declaration, fire is recognized as a special type of disaster. If fire threatens to become a disaster, assistance can be provided to prevent such a disaster. Special rules relate to these predisaster fire emergencies. Some provisions of the law have led to questions regarding its effectiveness in mitigating fire problems. The hazard mitigation provision of the law provides the opportunity to raise critical issues and funding support to address many important areas. Whether the mitigation provisions of the law are being used most effectively in meeting the continuing threat of wildfire in California and the nation as a whole needs to be studied.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Fire and Hazardous Materials Program Manager, Region 9, Federal Emergency Management Agency, San Francisco, CA 94129.

CONCURRENT SESSION I—Wildland Ecosystem Topics

Fire in Wildland Ecosystems—Opening Comments[1]

Tom Nichols[2]

More than 25 years ago, the pioneering work in fire ecology by Harold Biswell and others encouraged the incorporation of prescribed fire into fire management policies. However, the use in California of prescribed fire in fuels treatment, wilderness management, or ecosystem maintenance programs has not been particularly extensive. Only a fraction of wilderness areas, for example, have a prescribed natural fire program. In forests and brushlands around the State, natural and activity fuels continue to accumulate, and wildfires are becoming increasingly difficult, if not impossible in some situations, to suppress. Reasons for the gap between land management objectives and results with regard to prescribed fire include lack of interagency planning and communication, internal agency differences in resource management objectives, limitations on funding availability, and estimating the behavior of long-term prescribed fires, particularly those occurring in wilderness areas. Prescribed fire remains an important land management tool. The activity, however, of prescribed fire programs will depend on the solution of many issues that constrain its application. The ideas of the various speakers and the discussion that is stimulated should provide much food for thought.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Prescribed Fire Specialist, Western Region, USDI National Park Service, 600 Harrison, Suite 600, San Francisco, CA 94107.

Interagency Wilderness Fire Management[1]

Jim Desmond[2]

Abstract: Wilderness fire managers are often confronted with natural fire ignitions that start and/or burn near an adjoining agency's wilderness area boundary. Management strategies for prescribed natural fires (PNF) are often developed using the adjoining agency's wilderness boundary as the maximum allowable perimeter (control line) for the PNF. When this occurs, fire's natural role in the wilderness ecosystem may be restricted. The difficulty of burning near another agency's jurisdictional boundary can be overcome by strong planning, close communications, and timely coordination between the two affected agencies. Communications and coordination can be achieved only through developing and maintaining a strong working relationship with the fire manager of the adjoining agency. Keys to good interagency coordination are (1) investing time, (2) understanding the policies and procedures of the adjoining agency, (3) developing and maintaining open communications, and (4) having a commitment to see it succeed.

Interagency management of prescribed natural fire (PNF) in federally managed wilderness areas is not new. It has occurred on a limited basis in several areas of the country between adjoining agencies for many years, often with very successful results. But there are many areas where PNF has not been attempted because of the complexities of planning and managing a PNF that may cross interagency boundaries. One of the recommendations of the 1988 Fire Policy review was that the federal agencies needed to do a much better job of planning and coordinating their efforts during actual fire management activities, including prescribed natural fire. This paper is meant to share some observations on the subject of interagency cooperation and coordination in the management of prescribed fire in federally managed wilderness areas. I acquired experience while serving as team leader for developing a complex Wilderness Fire Plan, in which a PNF may be allowed to burn adjacent to administrative boundaries, and/or in which a PNF may be allowed to cross an administrative boundary from one agency's lands to another.

In this paper, I will be addressing my experiences in planning for PNFs that may occur close to the administrative boundaries that exist between the USDA Forest Service (Sierra, Inyo, and Sequoia National Forests) and the USDI National Park Service (Sequoia-Kings Canyon and Yosemite National Parks). This is a federally managed wilderness area that encompasses more than one million continuous acres in the Sierra Nevada.

In the Central Sierra Nevada, National Forest wilderness areas and National Parks adjoin along common boundaries. These boundaries were established for a variety of administrative reasons and may or may not make sense when managing a prescribed natural fire. In this area, the National Park Service currently operates with approved Fire Management Plans allowing for PNF in wilderness areas. The Forest Service is in the plan development stage. In this current situation, park fire managers have to manage natural ignitions according to current agency procedures and restrictions if the natural ignition is close to the park/forest boundary. Generally, this includes taking full control actions before the PNF threatens the boundary.

Once the Forest Service Wilderness Fire Plan is implemented and the Park Service's Fire Management Plans are amended, the ability to manage PNF across administrative boundaries will be greatly enhanced. Management of prescribed natural fire across the entire Sierra Nevada wilderness ecosystem will become a reality.

Principles for Successful Interagency Planning

There are several important elements in planning for a successful wilderness prescribed natural fire program that transcends agency and administrative boundaries. These keys to success are common to any successful relationship, whether interagency, interdepartmental, or interpersonal. They work in a variety of situations, at any level, where people cooperate to achieve a common goal.

To develop a successful, unified PNF program, a considerable personal time commitment by the fire manager is required. This personal commitment requires regular visits between line officers, staff officers, and fire managers in both agencies. Successful personal interaction should be more than just an occasional telephone call or messages sent via electronic mail. This interaction must be face to face. Personal visits must be made with consistency, with the goal of getting to know and understand each other and each other's agency policies and procedures. This commitment is time well spent, with rewards and dividends in successful interagency coordination in the wilderness fire program.

After establishing a strong professional relationship with the adjoining agency's fire staff, the fire manager must make a concerted effort to learn and understand land management and fire policies, procedures, and goals of the neighboring

[1] An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17,1994, Walnut Creek, California.

[2]Fire Management Officer, USDI National Park Service, Ozarks National Scenic Riverways, P.O. Box 490, Van Buren, MO 63965.

agency. Not only must fire managers understand written policy and procedures, they must seek to understand the management style and philosophy of the adjoining line officers (i.e., Park Superintendent or Forest Supervisor) and their fire staff. All line officers and fire managers bring a certain amount of their own philosophy, values, and ideas into managing the wilderness resource, and it is very important to identify these early. Knowing and understanding the policies, procedures, and personalities of the adjoining agency is very important to successful interagency coordination.

Another key to success is to establish and maintain strong communications with the adjoining land management agency. "Communications" is defined as more than just talking; it is expressing oneself effectively. Communications must be open, truthful, and unselfish. An effective communicator is not only a good speaker, but also a good listener.

Probably the most important key to success in developing interagency cooperation in PNF is making the personal commitment to see it succeed. The fire manager has to eliminate the "us versus them" attitude and establish a "teamwork" philosophy. The fire manager must be selfless in his concerns for the success of the overall wilderness PNF program. The fire manager must give 100 percent effort. Personal and agency pride and even "agency arrogance" must be set aside in order for interagency cooperation to succeed. The fire manager must believe from the outset that the interagency wilderness fire program will succeed.

These four keys to success can be easily used in planning a cooperative interagency PNF program. Planning requires a time investment, an understanding of each other's policies, open communications, and a commitment to success.

Implementing Principles into PNF Planning

Early on in the development of the Wilderness Fire Plan for the John Muir, Ansel Adams, Dinkey Lakes, and Monarch Wilderness areas, it was recognized that adjoining National Parks (Yosemite and Sequoia-Kings Canyon) had a vested interest in what the Forest Service was planning in their wilderness fire plan. A representative from the USDI National Park Service was invited to become an active participant and adviser to the USDA Forest Service Wilderness Fire Planning Team. This Park Service representative attended all planning sessions and had the opportunity to review and comment on all proposals to the plan. This interagency coordination effort was able to spot potential problems in the plan early in the draft process. Other small procedural problems, terminology changes, and/or policy conflicts were addressed during this planning phase. As a result of this interagency planning team, many of the following procedures were developed to manage the complexities of PNF's that occurred adjacent to or across administrative boundaries.

During the development of the Forest Wilderness Plan, it was determined that each central Sierra Nevada forest (Inyo, Sierra, and Sequoia) and each park (Yosemite and Sequoia-Kings Canyon) will appoint one person to serve as a Unit/Agency PNF coordinator. This group of five forest/park liaison representatives will form the Unit/Agency PNF coordinators group. These PNF coordinators will be the primary interagency/intra-agency contacts in all matters relating to PNFs once the John Muir, Dinkey Lakes, Ansel Adams, and Monarch Fire Plan has been approved. (Note: Both parks currently have approved Fire Management Plans allowing PNF in their Wilderness Fire Zones). Once the plan is operational, the PNF coordinator will serve as liaison between ranger units, forests, and parks.

The Unit/Agency PNF coordinators group's duties and responsibilities will include attending pre-season planning and post-evaluation of the area-wide PNF program. The forest PNF coordinator will coordinate funding needs and requests before placing natural ignitions in PNF status. The coordinators may assist individual ranger units in ordering equipment, crews, and qualified personnel to manage PNF's. They will monitor forest-wide PNF activity and may serve as advisers to the district fire managers. The Unit/Agency PNF coordinator will serve as the interagency/intra-agency contact on any boundary fire between either two ranger units, two forests, or between a forest and a park. The Unit/Agency PNF coordinator will be the chief adviser to the appropriate line officer and forest management team.

Interagency coordination is of critical importance in natural ignitions or fires that are close to administrative boundaries. Any natural ignition or fire that is within 2 miles of the administrative boundary will be called a "boundary fire." The agency on which the fire is burning is called the "lead agency." The agency across the boundary will be known as the "adjoining agency." Any potential PNF within the boundary zone will require the following: (1) "lead agency" notifies "adjoining agency" of situation, (2) "lead agency" provides copy of PNF assessment and Burn Plan including map of maximum allowable perimeter (MAP) to "adjoining agency," (3) allows the "adjoining agency" to provide input to management and strategy of the boundary PNF. This initial coordination should take place within 24-36 hours.

A second classification for a "boundary fire" is one in which the ignition or PNF is of "immediate threat" to the administrative boundary. This is generally considered within 0.25 mile of the boundary line. When an ignition is within this zone, both agency coordinators will perform the above procedures, plus set up the framework for a unified management team for the PNF, if it crosses the boundary.

At this point, we anticipated that there would be exceptions to the above policy and procedures. Examples of these exceptions are: when the ignition or fire is a "single tree in the rocks," or when the PNF has little potential to cross the boundary because of significant natural barriers. Unit/Agency PNF coordinators are required to come to a mutual agreement on the strategy and tactics on any ignitions or fires within the boundary zone. Again, the key is timely coordination and good communications between the Unit/Agency PNF coordinators.

Several other procedures concerning "boundary fires" were adopted by the planning team and incorporated into the Forest Service Wilderness Fire Plan. The following are examples of a few.

If any circumstance (i.e., political concerns, lack of funding, shortage of qualified personnel, etc.) occurs in which the "adjoining agency" feels uncomfortable in allowing the PNF to burn within the boundary zone, the "boundary fire" will be managed in appropriate suppression response (confine, contain, or control). Both agencies must be unified in their willingness to proceed in allowing a "boundary fire" to burn naturally within the confines of the plan.

Boundary PNF's that burn on both agencies' lands simultaneously may require separate documentation and record-keeping systems. Each unit will maintain its own PNF file. This file will contain documents that are specific to agency needs and requirements. Agencies are encouraged to share maps, observations, and other forms of intelligence gathered.

Daily revalidation of "boundary fires" will require line officer signatures. If the PNF is burning on both agencies' lands at once, line officers of both agencies will be required to sign off each day as agency policy requires. Each agency will use its own forms and procedures for this daily requirement.

The utilization and coordinated use of aircraft, organized crews, and miscellaneous resources for monitoring and/or holding may be negotiated during the preliminary decision analysis of the PNF. Unit/Agency PNF coordinators will share in formulating these agreements.

Conclusion

The time investment, an understanding of others' policies and procedures, strong communications, and a commitment to see interagency coordination succeed do not end when the Fire Management Plan is approved. Planning is a process that makes land management decisions and outlines how those decisions are to be implemented. Good planning can be rendered useless by poor execution.

The wilderness fire manager must maintain a close relationship with neighbors by continuing a strong commitment to interagency cooperation and coordination. As stewards of the wilderness resource we should strive for no less.

FARSITE: A Fire Area Simulator for Fire Managers[1]

Mark A. Finney[2]

Abstract: A fire growth model (FARSITE) has been developed for use on personal computers (PC's). Because PC's are commonly used by land and fire managers, this portable platform would be an accustomed means to bring fire growth modeling technology to management applications. The FARSITE model is intended for use in projecting the growth of prescribed natural fires for wilderness areas. The PC model requires the support of a geographic information system (GIS) to manage and provide landscape data. FARSITE currently uses a stream of weather and wind changes along with landscape data downloaded from the GIS to model fire growth.

Computerized fire growth models have been the subject of research for about 20 years. Despite numerous management applications (Andrews 1989), these models still remain largely in the realm of research. Some obstacles to implementing a fire growth model for management purposes have been technological; different approaches to developing a realistic model for simulating wildland fire spread and behavior have different technical problems to overcome. Practical limitations have also created obstacles, mainly with the availability of computer hardware and software as well as landscape data. Until recently, computers and geographic information systems (GIS) with adequate spatial coverage of the themes necessary for running a fire growth model have not been widely available to potential users.

Many of these difficulties are no longer limiting. Advances in computer technology and increasing prevalence of GIS no longer impede the transfer of fire growth modeling technology to user applications. Personal computers are now commonplace and a familiar tool for most managers. These computers are thus a logical platform for a fire growth model that can be easily accepted in an accustomed environment.

This paper briefly describes an implementation of the FARSITE Fire Area Simulator designed for fire management uses on a personal computer.

Fire Growth Models

The FARSITE model uses Huygens' principle of wave propagation (Richards 1990) to expand fire fronts. This method, named for the 17th century Dutch mathematician who studied light waves, treats fire as a wave that spreads using points on its edge as independent sources of new wavelets. The approach was first used by Sanderlin and Sunderson (1975) and Sanderlin and Van Gelder (1977) to model fire growth (other methods using Huygens' principle in fire modeling were described by Anderson and others 1982, Beer 1990, French and others 1990, Richards 1990, Knight and Coleman 1993, Wallace 1993). The Huygens' approach differs from models based on "cellular automata" that spread fire as a contagion process between cells of a regular grid (Green 1983, Green and others 1983, Kourtz and O'Reagan 1971, Kourtz and others 1977). The cellular automata approach has been pursued by many researchers, too numerous to mention here. Models based on Huygens' principle are well suited to the relatively limited resources of personal computers. Huygens' principle requires information only from points on the fire edge. This makes efficient use of computer time and memory compared to cellular models. In cellular models, distortions to the fire shape resulting from the grid must be minimized by calculating fire spread to unburned cells within a wide radius of each active cell (French 1992).

The applicability of Huygens' principle to fire growth modeling has been demonstrated by a number of studies. Although they have not been comprehensively validated, fire spread patterns predicted by models using Huygen's principle have generally agreed with those observed (Anderson 1982, Finney 1994, French 1992, Sanderlin and Sunderson 1975). Many validations will eventually be needed for defining the strengths and weaknesses of these models.

Features of FARSITE

In general, Huygens' principle enables a logical implementation of existing fire behavior models. Each point on the fire front contains information on the time, direction, and rate of fire spread. These are essential components of existing models of surface fire spread, fire acceleration, crown fire and transition to crown fire, as well as spotting. FARSITE incorporates models for surface fire spread (Andrews 1986, Rothermel 1972) as well as transition to crown fire and crown fire spread (Rothermel 1991, Van Wagner 1977, 1993) and spotting distances.

A user interface for the FARSITE model has been developed for the Microsoft WINDOWS operating environment. This graphical interface allows considerable device independence among the widely varying hardware capabilities of personal computers. The FARSITE model requires the user to identify the data files (containing landscape, weather, and wind data). The mouse control

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Research Scientist, Systems for Environmental Management, P.O. Box 8868, Missoula, MT 59807.

mechanism is then used to input ignitions on the displayed landscape. These ignitions can be points, lines, or existing fire shapes (drawn as a series of line segments). In a similar fashion, users can make minor modifications to the landscape including control lines or fuel type changes. The duration of the simulation is determined by the desired ending date and time. Fire maps and area and perimeter data and graphs can be output to files or printed. Current plans are to test the preliminary version of FARSITE written for 32-bit WINDOWS (WIN32s) during the 1994 fire season at Yosemite and Sequoia and Kings Canyon National Parks in California. The primary purpose of the test phase will be to incorporate management suggestions for interface features. The first general release of FARSITE for the personal computer is scheduled for 1995.

Although fire growth models will likely make some aspects of fire management easier, the true limitations of these models will probably soon become apparent. Weather forecasts along with the absence of 3-dimensional wind fields in complex terrain are likely to be a major source of error for a long time.

Conclusions

The transfer of fire growth modeling to user-applications has recently been encouraged by new demands for managing and researching ecosystem processes across landscapes. The PC version of the FARSITE model should be helpful in managing fire as a landscape process. When implemented on other platforms, it may also be useful for simulating fire as an ecosystem process over larger time and space scales.

Acknowledgments

This research has been funded by the National Interagency Fire Center of the USDI National Park Service (NPS), through a cooperative agreement with the USDA Forest Service, Intermountain Research Station's Fire Behavior Research Work Unit, and the Global Change Program, USDI National Park Service.

References

Anderson, D.H.; Catchpole, E.A.; DeMestre, N.J.; Parkes, T. 1982. **Modeling the spread of grass fires**. J. Austal. Math. Soc. (Ser. B.) 23: 451-466.

Andrews, P.L. 1986. **BEHAVE: fire behavior prediction and fuel modeling system-BURN subsystem, Part 1**. USDA For. Serv. Gen. Tech. Rep. INT-194.

Andrews, P.L. 1989. **Application of fire growth simulation models in fire management**. Proc. 10th Conf. Fire and Forest Meteorology, Ottawa Canada; 317-321.

Beer, T. 1990. **The Australian National Bushfire Model Project**. Mathematical and Computer Modelling 13(12): 49-56.

Finney, M.A. 1994. **Modeling the spread and behavior of prescribed natural fires**. In: Proc. 12th Conf. Fire and Forest Meteorology, Jekyll Island GA. In press.

French, I.A.; Anderson, D.H.; Catchpole, E.A. 1990. **Graphical simulation of bushfire spread**. Mathematical and Computer Modelling 13(12): 67-71.

French, I.A. 1992. **Visualisation techniques for the computer simulation of bushfires in two dimensions**. University of New South Wales, Australian Defence Force Academy. M.S. Thesis.

Green, D.G. 1983. **Shapes of simulated fires in discrete fuels**. Ecological Modelling 20: 21-32.

Green, D.G.; Gill, A.M.; Noble, I. R. 1983. **Fire shapes and the adequacy of fire-spread models**. Ecological Modelling 20: 33-45.

Knight, I.; Coleman, J. 1993. **A fire perimeter expansion algorithm based on Huygen's wavelet propagation**. International Journal of Wildland Fire 3(2): 73-84.

Kourtz, P.; O'Reagan, W.G. 1971. **A model for a small forest fire to simulate burned and burning areas for use in a detection model**. Forest Science 17(2): 163-169.

Kourtz, P.; Nozaki, P; O'Regan, W. 1977. **Forest fires in the computer–A model to predict the perimeter location of a forest fire**. Fisheries and Environment Canada. Inf. Rep. FF-X-65.

Richards, G.D. 1990. **An elliptical growth model of forest fire fronts and its numerical solution**. Int. J. Numer. Meth. Eng. 30: 1163-1179.

Rothermel, R.C. 1972. **A mathematical model for predicting fire spread in wildland fuels**. USDA For. Serv. Res. Pap. INT-115.

Rothermel, R.C. 1991. **Predicting behavior and size of crown fires in the northern Rocky Mountains**. USDA For. Serv. Res. Pap. INT-438.

Sanderlin, J.C.; Sunderson, J.M. 1975. **A simulation for wildland fire management planning support (FIREMAN): Volume II. Prototype models for FIREMAN (PART II): Campaign Fire Evaluation**. Mission Research Corp. Contract No. 231-343, Spec. 222. 249 p.

Sanderlin, J.C.; Van Gelder, R.J. 1977. **A simulation of fire behavior and suppression effectiveness for operation support in wildland fire management**. In: Proc. 1st Int. Conv. on mathematical modeling, St. Louis, MO; 619-630.

Van Wagner, C.E. 1977. **Conditions for the start and spread of crownfire**. Canadian Journal of Forest Research 7: 23-24.

Van Wagner, C.E. 1993. **Prediction of crown fire behavior in two stands of jack pine**. Canadian Journal of Forest Research 23: 442-449.

Wallace, G. 1993. **A numerical fire simulation model**. International Journal of Wildland Fire 3(2): 111-116.

Funding Fuels Management in the National Park Service: Costs and Benefits[1]

Stephen J. Botti[2]

Abstract: Despite a quarter of a century of prescribed burning by the National Park Service (NPS) in California, there is reason to believe that the fuels situation is getting worse rather than better. The area burned in the past 10 years has declined by 42 percent compared to the previous 10 years. The total area burned per year from wildfire and prescribed fire is substantially less than that hypothesized in pre-European settlement times. Fuels within these fire adapted vegetation types are increasing and creating conditions conducive to more high-intensity wildfires. The NPS is failing to meet its ecosystem management and hazardous fuel reduction goals and objectives. Obtaining the funding to treat these fuels with prescribed fire has proven difficult. The NPS has developed a project cost analysis system to ensure the effective use of existing fuels management funding and is developing a comprehensive cost/benefit analysis to help demonstrate the wisdom of investing greater resources in prescribed burning and fuels management.

The National Park Service (NPS) has utilized management-ignited prescribed fire (MIPF) in California for 25 years. During the past 20 years, the NPS has prescribed burned 23,187 hectares (57,271 acres) in California parks, or 2.8 percent of the burnable area in those parks (*fig. 1*). For the most part, these fires are ignited either to restore and maintain natural ecosystems or to reduce hazardous fuels. Hazardous fuels are defined as:

> those which, if ignited, threaten public safety, structures, facilities, cultural and natural resources, natural processes, or permit wildfires to spread across administrative boundaries (USDI National Park Service 1990).

In reference to ecosystem management burns, NPS policies state:

> where fire is an essential component of the ecosystem but cannot be allowed to burn as a natural process because of management constraints, fire is used as a tool to accomplish resource management objectives. These objectives include, but are not limited to, replacing natural fire, maintaining historic scenes, reducing hazardous fuels, eliminating exotic/alien species, and preserving endangered species (USDI National Park Service 1990).

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Fire Program Planning Manager, USDI National Park Service, National Interagency Fire Center, Branch of Fire and Aviation Management, 3833 Development Ave., Boise, ID 83705.

Many of these burns are multi-purpose. A burn to reduce hazardous fuels may also produce ecosystem benefits in vegetative communities adapted to natural fire regimes. Conversely, a burn to maintain the natural fire process will prevent unnatural fuels from accumulating and thus avoid the necessity of a burn to reduce hazardous fuels under more difficult burning conditions. For this reason, the NPS funds both types of burns with fire management funds, as part of an integrated land management program. In an era of declining budgets, different components of fire management compete with each other for scarce funds. For this reason, it has become increasingly important to quantify the relative costs and benefits of the three components of NPS wildland fire management: wildfire suppression, prescribed natural fire (PNF) management, and management-ignited prescribed fire (MIPF).

Liabilities and Handicaps in Fuels Management Investments

Most people believe that wildfires should be suppressed regardless of the cost, and this view has been reflected in Congressional funding authorizations for many years. Since society believes that the benefits of protecting lives, property, and resources from wildfires almost always outweigh the costs, Congress has placed no theoretical limit on expenditures for "emergency" wildfire suppression. Even though the appropriation for Department of Interior and related Federal

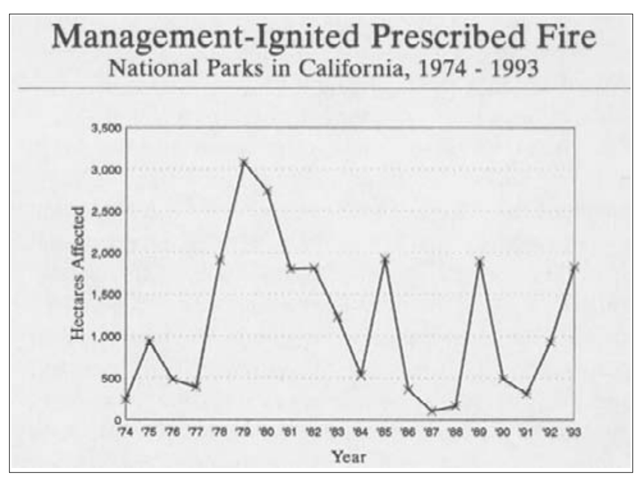


Figure 1–Management-Ignited Prescribed Fire, National Parks in California, 1974-1993.

agencies contains an amount for emergency wildfire suppression, additional funds can be transferred from other appropriations as needed by the Secretary of the Interior. On the other hand, prescribed burning, whether used for ecosystem restoration or as a tool for reducing hazardous fuels, has been faced with a more uncertain funding reality, caused to some degree by ambivalent feelings toward its risks, costs, and benefits. Although prescribed burning has broad support among certain segments of the general population and park visitors, it has rarely been viewed as equally essential to wildfire suppression. The ecosystem benefits are somewhat esoteric to most people and the long-term reduction in wildfire threat may not be immediately apparent to the public or park managers. Some people oppose the program because smoke can affect neighboring communities and park visitors, or because of fear that prescribed fires will escape.

The prescribed fire program is complicated by inherent risk of fire escape and associated liability issues. Even if wildfire suppression efforts fail to save resources and property, there is a general reluctance among the public and the fire management community to criticize suppression organizations and personnel who risk their lives fighting wildfire. The huge government expenditures for wildfire suppression also rarely receive close scrutiny or critical analysis. This same generosity is seldom extended to prescribed burning efforts, however. If prescribed burns escape or smoke impacts become intolerable, reputations can be tarnished quickly, and careers adversely affected. This is one reason that evaluations of the costs and benefits of wildfire suppression and fuels management are not conducted on a level playing field. Prescribed burning and fuels management are planned investments that may not yield rewards for many years. They are not emergency actions. Like most investments in the future, investing in prescribed burning requires discipline, a willingness to take risks, and a long-term perspective.

Status of Current NPS Fuels Management

The Department of the Interior and the National Park Service have invested far more in suppressing destructive wildfires than in managing the fuels that produce destructive wildfires. In fiscal year 1994, the Department budgeted $221.5 million for suppression and suppression preparedness compared to only $12 million for prescribed fire and fuels management. In California last year, the NPS spent $3 million to suppress wildfires on 329 hectares (813 acres) compared to $237,000 to prescribe burn 2,040 hectares (5,039 acres). The relative costs for wildland fire management are $9,115 per hectare ($3,690 per acre) for wildfire suppression compared to $116 per hectare ($47 per acre) for prescribed burning. The total suppression cost was actually considerably higher than NPS finance records indicate because the NPS does not track the costs of firefighting resources contributed by other federal agencies to suppress wildfires on NPS lands. Although the investment in suppression response may look out-of-proportion to that in prescribed fire, a true evaluation of these numbers is not straightforward. It is to be expected that the cost of mobilizing large numbers of suppression resources for an unscheduled incident would be much greater than the cost of staffing a planned and controlled prescribed burn. What is not clear is whether an increased investment in prescribed burning and fuels management would produce a much greater corresponding reduction in suppression costs. Other, more subtle benefits of prescribed burning, such as the decreased probability of catastrophic wildfire threatening resources at risk, remain to be quantified. Managers intuitively believe that these benefits must exist or they would not take the risks, but the lack of data or effective cost/benefit models for prescribed burning diminishes our ability to present a convincing case for increased support.

Are we achieving our fuels and ecosystem management goals with the present level of program funding and accomplishment? The same question can be asked another way. What are the costs of not burning or of not burning enough? To answer this question we must document both the increased costs of wildfire suppression and real property losses, which can be quantified economically, and the intangible costs of natural and cultural resource losses. As stewards of taxpayer dollars, we must also ask, "Is the current prescribed burning program cost effective, or would a greater investment in prescribed burning be more cost effective?"

Before answering these questions, it may be helpful to evaluate the total influence of wildland fire within two representative California National Parks. Wildfires, management-ignited prescribed fires, and prescribed natural fires all contribute to the fuels balance and vegetative community structure in Yosemite, Sequoia and Kings Canyon National Parks. These Parks provide good examples to study because of their long history of prescribed fire management.

The past 20 years of combined wildfire, PNF, and MIPF data from Yosemite reveal that the total area burned is only 36 percent of that hypothesized under natural fire regimes, while at Sequoia and Kings Canyon it is only 22 percent (*figs. 2* and *3*). The hypothesized pristine average annual fire occurrence target is extrapolated from current knowledge of fire return intervals within the vegetative communities in both parks (Caprio and Swetman, in press, Kilgore 1973, Kilgore 1981, Kilgore and Taylor 1979, Parsons 1976, Show and Kotok 1924, Swetnam 1993, USDI National Park Service 1987, Wagener 1961). The continued existence of this gap between pristine and modern fire regimes in vegetative communities adapted to or even dependent upon recurring fires is causing the NPS to drift farther away from its twin goals of protecting people and property and preserving natural ecosystems. As a result of this gap, hazardous fuels are continuing to increase, increasing the costs and difficulty of future prescribed burning projects, along with the cost and destructive power of future wildfires. Analyzing the cost of this gap should be a major focus of future research. The NPS needs to know whether closing that gap would be a cost-effective fire management strategy. At present, parks are

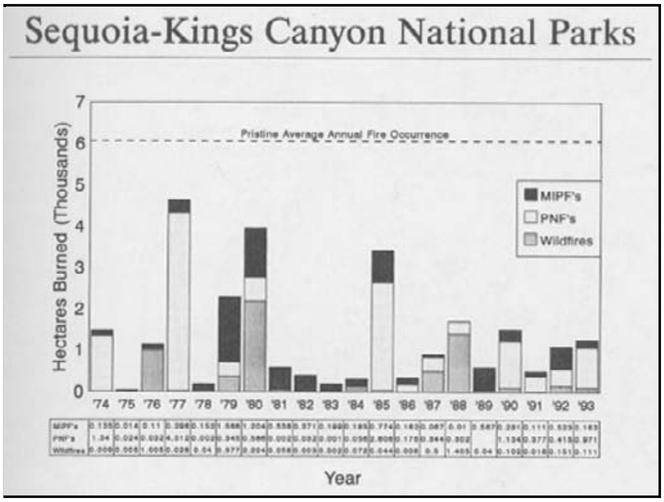


Figure 2–Wildland Fire Occurrence, 1974-1993, Sequoia-Kings Canyon National Parks

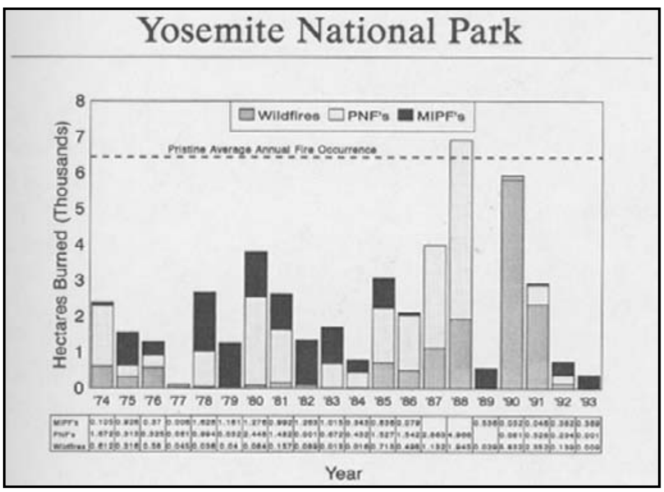


Figure 3–Wildland Fire Occurrence, 1974-1993, Yosemite National Park

proposing to burn less area than is required to close the gap, the NPS is funding less than the parks are proposing, and the parks are carrying out only about half of the projects that are funded.

Fuels Management Analysis Programs

The NPS has never been able to fund all of the fuels management work requested by parks each year. In 1994 the NPS was able to fund only 41 percent of hazard fuel reduction projects requested by parks. In order to allocate scarce funds to the highest priority and most cost-effective projects, the NPS developed three project analysis programs. In the first, parks define projects through an on-line computer program. Projects from all parks are compiled in a central database and assigned priority points by the computer on the basis of fuel type, fire behavior, values at risk, and legislative and administrative mandates and complexity. This program also contains a cost spreadsheet that displays costs stratified by four cost categories and four phases of project development and execution (*figs.4* and *5*). This program produces reports that list all fuels and ecosystem maintenance prescribed burning projects in priority order along with the requested budget for each project. Using these reports, the national fire program manager can easily allocate funds to the highest priority projects according to the funds available in each year.

Under the second program, parks can group projects into multi-project and multi-year plans. This planning tool allows fire managers at the park to define, and those at the regional and national levels to understand, a park's long-term strategy for fuels management and ecosystem management prescribed burning. Multi-year plans that are approved at the regional and national levels receive priority for funding in future years. This planning strategy encourages parks to develop comprehensive fuels management plans and to receive assurance of year-to-year funding continuity for well-designed programs. It also helps fire budget managers to allocate scarce funds to those programs which will achieve the most effective long-term results.

While these programs allow managers in the regional and national fire offices to allocate funds to the highest priority projects, they fail to address the issue of whether the funding requests for high-priority projects are reasonable. Funding itself is not a priority ranking factor and thus must be considered separately. Projects of equal size in similar fuel types with equal values at risk and equal complexity sometimes vary dramatically in cost per hectare. Projects vary from $1.20 to $42,000 per hectare, making it difficult to decide what is reasonable without more detailed knowledge of the factors causing the variation. Some cost variation between projects is to be expected because of size, fuel model, complexity, and other factors, but managers need to quantify how much variation is acceptable for various types of projects.

In order to solve this problem, the NPS contracted with the Department of Forest Sciences at Colorado State University for the development of a cost analysis system (Omi and others 1992). They evaluated all project criteria through a regression analysis to determine which ones contributed most to cost variability, and used the results to develop cost target zones for projects. The regression equation captured 91 percent of the cost variation for hazard fuel reduction projects and 82 percent of the variation for ecosystem maintenance burns. The variables include criteria such as project size, NPS region, fuel model, type of treatment, natural resource values at risk, and the risk of fire escape. The findings were incorporated into a PC-based computer

```
NPS                              Project Definition                           21-OCT-93
HF1000-1-(GDB)                 PROJECT RANKING INQUIRE               Mail      09.29  AM
        ------------------------ PROJECT NUMBER:  9405 -------------------------------
        -      1 TITLE:  WUKSACHI                              2 ACRES:     2,000.0      -
        -         FUND:  U      3 NFDRS FUEL MODEL:  G     4 PROJECT TYPE:  F            -
        ------------------------------------------------------------------------------
    FUEL TYPE/FIRE BEHAVIOR           CONSTRAINTS             DOCUMENTS      COMPLEXITY
  5  FUEL MODEL SCORE..... 5     10 LEGISLATIVE........ 0    15 GMP....      23 ESCAPE...7
  6  BURN INDEX SCORE..... 4     11 ADMINISTRATIVE..... 5    16 MOUS...      24 AT RISK..7
     TOTAL:.............. 9        TOTAL........ .... 5      17 SFM....G     25 FUELS....7
        VALUES AT RISK               MISCELLANEOUS           18 NRMP...G     26 DURATION.9
   7  NATURAL RESOURCES... 5     12 PUBLIC SAFETY...... 5    19 CRMP...      27 AIR QUAL.7
   8  CULTURAL RESOURSES.. 5     13 PHYSICAL FACILITIES 5    20 SUPS...      28 IGN METH.3
   9  NATURAL PROCESSES... 5     14 EXTERNAL CONSIDER'N 9    21 EA/EIS.G     29 TEAM SIZ.3
    TOTAL................ 15        TOTAL............ 19     22 DCP....      30 OBJECTIV.7

        TOTAL RANKING SCORE:  048     31   PARK PRIORITY:     6   32 REMARKS
            TOTAL COMPLEXITY: 0336   36 REGIONAL PRIORITY:   0
    33 PROJECTED START DATE:  10/01/93      34  PROJECTED DATE COMPLETED:  09/30/94

  APLPHA CODE:  SEKI  35  FISCAL YR:  94  SEQUOIA AND KINGS CANYON NATIONAL PARKS
                          DISPLAY REMARKS:  (Y/N/E):      Y
                    ENTER KEYPAD (,) TO EXIT OR KEYPAD (-) TO BACKUP
```

Figure 4–National Park Service Hazard Fuel Project Ranking Program

```
NPS                              Project Definition                          21-OCT-93
HF1010-1-(GDC)                  Project Cost Estimate               Mail      09:29  AM

      FISCAL YEAR:  94     FUND:  U     ACRES:   2,000.00     TOTAL COST:  34,100
    PROJECT NUMBER:  9405  WUKSACHI                            COST/ACRE.      17.05
                                                              COMPLEXITY:    0336

                 PLANNING            PREPARATION          EXECUTION          EVALUATION
              HOURS    TOTAL       HOURS    TOTAL       HOURS    TOTAL       HOURS   TOTAL
             REG PREM  COST       REG PREM  COST       REG PREM  COST       REG PREM  COST
              A    B     C         D    E     F         G    H     I         J    K      L
1 PERSONNEL  100   0   1,000     300    0   3,000    1200  300  16,500    200    0   2,000
2 EQUIPMENT              100                  100                  500                  100
3 AIRCRAFT               500                1,000                7,000                  300
4 MISC                   100                  200                1,500                  200
   PHASE COSTS:        1,700                4,300               25,500                2,600
                                                                  REG     PREM    COST
  M1 ADDITIONAL FTE REQUESTED:  0.8       TOTAL PERSONNEL          1800    300   22,400
      ADDITIONAL FTE APPROVED:  0.0       TOTAL EQUIPMENT                           800
  M2 FIREPRO FUNDS REQUESTED:   9,800     TOTAL AIRCRAFT                          8,800
      FIREPRO FUNDS APPROVED:       0     TOTAL MISC                              2,000
                  ALPHA CODE:  SEKI SEQUOIA AND KINGS CANYON NATION PARKS
                               ENTER FIELD NUMBER TO CHANGE:
              ENTER ROW NUMBER/COLUMN LETTER TO CHANGE OR RETURN TO UPDATE
```

Figure 5–National Park Service Hazard Fuel Project Cost Estimate Program

program used to screen all NPS fuels management and ecosystem maintenance projects.

This screening program is just one tool for deciding whether to fund a project. Projects falling within the 95 percent confidence range for costs of similar projects are considered to be reasonable from a cost standpoint, but may still be rejected on the basis of ranking score, regional office recommendation, a park's track record for project accomplishment, or for other reasons. Projects rejected by the screening program can still be funded if a park can justify why the costs are unusually high.

The existence of the screening program has forced parks to improve their estimates of project costs and to become more cost efficient in order to stay within the target ranges. Since the target ranges are unknown to parks, they cannot manipulate the system by either reducing their estimates to just inside the upper end of the range or allowing costs for an otherwise inexpensive project to escalate to the upper end of a range.

Although these three analysis programs provide useful tools for screening and ranking fuels management projects, they do not provide a quantitative evaluation of programmatic fuels management costs and benefits. A fourth analysis tool is being developed to model the effectiveness of incremental increases in prescribed burn funding in protecting resources at risk, reducing suppression costs, and restoring natural ecosystems. The model will identify the value of resources protected, the long-term costs of the various alternative fuels treatment programs, and the cost of projected suppression response under various treatment scenarios.

By simulating wildfire suppression scenarios under a variety of fuels treatment strategies, managers will be able to determine which strategy will be most effective in achieving the desired reduction in risk to resources and real property. First managers will establish wildfire risk reduction and ecosystem protection targets. For example, managers may be willing to accept a 5 percent probability that wildfires will destroy a value at risk. By modeling fire spread and suppression response under alternative fuels treatment methods, managers will be able to determine which method will produce a fuels complex in which there is only a 5 percent probability that a wildfire will exceed suppression capabilities and destroy resources at risk. The prescribed burning projects necessary to achieve the target fuel complex will be defined under a preferred alternative for the fire management program. Subsequently, budget targets for park, regional, and national hazard fuels treatment can be determined by aggregating the projects identified in the preferred alternatives for all programs. The simulation will also display probable net savings in fire management costs by comparing wildfire suppression expenditures to hazard fuels treatment costs under various treatment alternatives.

Although the simulation and cost analysis have yet to be designed, some of the possible tools they will utilize may include:

• Data that monitor fire effects, indicating the changes in the fuels complex and vegetative community structure from prescribed burns under varying prescriptions. These data can be used to identify the prescription needed to achieve ecosystem management objectives and to provide fuel inputs for a large fire growth model.

• Existing data in the current NPS fire program analysis software that assess the degree of wildfire risk to natural and cultural resources and real property in hazard fuel reduction units.

• Data on wildfires originating inside and adjacent to National Parks that could burn through hazardous fuels and destroy values at risk inside a park.

• Programs to simulate the spread of wildfires under a variety of hazard fuel treatments utilizing geographic information systems and large fire growth models. These programs will display the likelihood that such fires can be successfully suppressed with the current levels of suppression resources.

• Databases on resources outside parks at risk from wildfires originating inside parks. The decreased risk to these resources from fuels management programs will need to be considered in the comparison of total benefits to costs.

Conclusion

The completion of all four phases of the NPS management-ignited prescribed fire analysis system will provide managers with powerful tools for identifying optimum program funding needs, formulating and defending a fire management budget request that reflects those needs, and allocating scarce funds to the highest priority needs. Although there is ample scientific work identifying the benefits of prescribed burning within fire adapted ecosystems, further work is needed to monitor fire effects and model how well the current and projected burning programs will achieve goals and objectives. The comprehensive fuels management analysis system being developed by the NPS will help quantify the relative costs and benefits of wildfire suppression and prescribed fire management programs. This will help define true prescribed fire program needs, and ensure the most efficient use of scarce taxpayer dollars.

References

Caprio, A.C.; Swetman, Thomas W. **Historic fire regimes along an elevational gradient on the west slope of the Sierra Nevada, California**. In: Proceedings of the symposium on fire in wilderness and park management: past lessons and future opportunities; 1993 March 30-April 1; The University of Montana, Missoula, Montana. USDA Forest Service, GTR 000, Intermountain Experiment Station, Ogden, Utah [In press].

Kilgore, B.M. 1973. **The ecological role of fire in Sierran conifer forests: its application to national park management**. Quaternary Research 3(3): 496-513.

Kilgore, B.M. 1981. **Fire in ecosystem distribution and structure: western forests and scrublands**. In: Proceedings of the conference: Fire regimes and ecosystem properties: 1978 December 11-15; Honolulu, HI. Gen. Tech. Rep. WO-26. Washington, DC: Forest Service, U.S. Department of Agriculture; 55-89.

Kilgore, B.M.; Taylor, Dan. 1979. **Fire history of a sequoia mixed conifer forest**. Ecology 60: 129-142.

Omi, P.N.; Rideout, Douglas B.; Stone, Jenna S. 1992. **Final report: cost controls in NPS prescribed fire management**. Prepared for the U.S. National Park Service, Branch of Fire and Aviation Management, Boise, ID.

Parsons, D.J. 1976. **The role of fire in natural communities: an example from the southern Sierra Nevada**. California Environmental Conservation 3 (2): 91-99.

Show, S.B.; Kotok, E.I. 1924. **The role of fire in California pine forests**. USDA Bulletin 1295; 80 p.

Swetnam, T.W. 1993. **Fire history and climate change in giant sequoia groves**. Science 262: 813-960.

U.S. Department of the Interior, National Park Service. 1987. **Fire management plan**. Yosemite National Park, National Park Service, U.S. Department of the Interior; 131 p.

U.S. Department of the Interior, National Park Service. 1990. **Wildland fire management guideline: NPS-18**. Washington, DC: National Park Service; U.S. Department of the Interior.

Wagener, W.W. 1961. **Past fire incidence in Sierra Nevada forests**. Journal of Forestry 59 (9): 739-747.

Ecosystem Management Issues[1]

Jim Boynton[2]

Although recognized as an important tool for ecosystem maintenance, fuels management, and a variety of other purposes, the prescribed fire program in the Pacific Southwest Region of the USDA Forest Service has been constrained by several factors. These range from funding availability, to debates on the effect of fire on the habitat of sensitive species, to competition for resources with fire suppression activities, to the lack of awareness at various levels in the organization of the need for prescribed fire as a land management tool. The Advisory Group for Fire in Ecosystem Management (AGFEM) was established in 1992 to facilitate the use of prescribed fire in the Region. Members of the group were selected from a variety of backgrounds, such as wildlife, fuels management, timber, fire management, air quality, soils, and hydrology. The group has also worked closely with the California Fuels Committee. The interdisciplinary approach allows a fuller discussion of the various concerns about the use of fire. These concerns have been expanded into a list of action items that have also been developed into an annual program of work. The work items are expected to break down barriers to implementing a prescribed fire program. For 1994, these included the development of a fire awareness presentation to the Regional Management Team. If supported by the Team, similar presentations will be made at line officers' and specialists' workshops. Each member on the AGFEM is a key contact for such presentations within his or her own professional community. Other topics recommended by the AGFEM include Minimum Impact Suppression Guidelines for wilderness, a guide for developing wilderness fire programs, review of proposed standards for prescribed fire qualifications and training, and development of an annotated fire effects bibliography.

---

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17,1994, Walnut Creek, California.

[2]Forest Supervisor, Sierra National Forest, USDA Forest Service, 1600 Tollhouse Rd., Clovis, CA 93612.

Panel Discussion: Prescribed Burning in the 21st Century

Even though many legal, social, and organizational constraints affect prescribed fire programs, the ecological and social benefits of such programs encourage their continued existence (with or without modification). The form of these programs in the next 10 to 50 years is pure speculation; but we must speculate and project the programs, as well as associated benefits and costs, since the ecosystems we manage respond to fire on several time scales.

A panel chaired by Dr. Ron Wakimoto of the University of Montana was convened to discuss projections about the role and form of prescribed burning in the next century. The five panelists were Mr. Jerry Hurley, Plumas National Forest, Mr. Ishmael Messer, Santa Monica Mountains National Recreation Area, Mr. Stephen Botti, National Interagency Fire Center, Mr. Jay Perkins, Klamath National Forest, and Mr. L. Dean Clark, Chiricahua National Monument. Several current problems associated with prescribed fire as well as future opportunities were presented, such as prescribed fire as a landscape phenomenon involving multiple jurisdictions. The following five papers present a summary of this panel discussion.

Prescribed Burning in the 21st Century[1]

Jerry Hurley[2]

Abstract: Past experiences in prescribed burning are described, as well as important factors for the continuation and expansion of prescribed burning in California. These factors include: a) gaining public acceptance by better identifying, managing, and communicating risks, especially the risk of attempting to exclude fire from all ecosystems and the increasing risks associated with fires that escape initial attack and affect air and water quality, forest health and sustainability, habitats, costs, and firefighter safety; b) making operational improvements by learning from past mistakes and showing that we have learned to recognize and understand factors that are common to escapes; c) better prioritizing of areas in which to burn and broadening our views on project scale and focusing on landscape; and d) more communication, education, training, prioritizing, and burning.

Natural fire is an ecosystem component, and prescribed fire, often emulating natural fire, is a management tool to meet resource objectives. However, in the current state of some ecosystems, prescribed fire may be the worst tool to solve resource problems. Tools used in combination are best, especially thinning with underburning. Once agreements are reached on desired future conditions, tool selection becomes easier. In addition, fire suppression will also become easier if fire is considered part of the ecosystem, to reduce the damage from eventual wildfires, thereby allowing better use of resources.

The Fuel Problem

In 1989, on the east side of the Plumas National Forest, the cumulative effects of past timber management practices and fire exclusion policies became apparent, with consecutive water deficit years, resulting in large areas of insect-created mortality. Thousands of acres of dense, overstocked, dead, and dying white fir stands now exist where open pine stands existed at the turn of the century. Stand examinations showed mortality varying from 50 to 80 percent in an area that is the epicenter for lightning caused fires in California (Court 1960).

These dense and dying stands are now highly flammable, prone to torching and crowning, and the creation and reception of embers generate more spotfires, making fire suppression more difficult. With more fuel for constructing fireline, higher fire intensities keeping firefighters further back, and more fires to contain or control, acres burned will only increase. Fire modeling projections for areas with the mortality problem show resistance to suppression will become 3 times greater, acres per hour burned will increase 25 times, and spotting distances will be 1.2 times greater (Page and others 1991). This has been validated with two fires on the Forest in 1989 and 1990 in which both fires burned from 500 to 1,000 acres per hour during peak periods with extensive crowning and spotting. Demand for suppression resources is further compounded by urban-rural interfaces in which suppression strategies have changed from perimeter control that minimizes acres burned, to exposure protection focusing on structures.

A Partial Solution

Because of the mortality rates, capturing the merchantable timber value and reduction potential for catastrophic fire became the objectives for the Plumas National Forest. The USDA Forest Service began aggressive salvage actions to remove the rapidly accumulating fuels and capture a merchantable product. However, salvage operations alone would not reduce the potential for catastrophic fire because not all the dead and dying material would be removed. In many cases it was less than 30 percent of the boles removed with salvage. Areas and trees without merchantable sawlog salvage did not require removal. Complete removal of dead trees would not occur for reasons of economic viability, access, equipment limitations, resource constraints, low volumes per acre, large acre involvement, and rapid deterioration of wood value. In fact, based on our projections, fire potential was not reduced when salvage logging was the only fuel treatment (Page and others 1991).

To treat more of the fuel problem and to reintroduce fire into ecosystems, we proposed underburning as the preferred treatment following salvage. Underburning also treats the most acres for the dollar. We currently have about 80,000 acres covered by environmental documentation, including surveys for archaeology and wildlife, authorizing salvage logging and underburning. Of this, we currently have about 20,000 acres with approved burn plans.

In 1991 we began our fire reintroduction program. We have since burned more than 2,000 acres, getting nearly 1,000 acres per year and working towards a target of 3,000 to 5,000 acres per year. We have burned from the road to ridgetop on a southwest-facing slope for 7.5 miles along a road that parallels a major recreational lake. We begin ignition

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Zone Fire Management Officer, Quincy Ranger District, Plumas National Forest, USDA Forest Service, 39696 Highway 70, Quincy, CA 95971-9607.

in the spring, as the snow melts off the south slopes, working from the ridges down slope. On one occasion we were able to carry 1.5 miles of fire down the hill by using the workforce of only six people.

Burning Into the Next Century—Gaining Public Acceptance

So how do we continue to expand prescribed fire programs into the next century, especially as our society becomes more pyrophobic and the struggle to clean up California's air becomes more difficult? Most importantly we must gain public acceptance and support. To accomplish this we need to learn from our mistakes, and initiate a number of concurrent actions, such as improving operations to reduce risk of adverse events, working on a larger scale, and better prioritizing projects for overall fire management effectiveness.

Gaining social acceptance of intensive fuels management with large scale burning as an alternative is crucial to reducing the number of catastrophic wildfires. Public perceptions ultimately drive public land management. This should be extremely clear to us in forest management after the controversial clearcutting issue. To help facilitate public acceptance we need to better identify, manage, and communicate risks to homeowners, air quality regulators, and legislators. In particular, we should emphasize the risk of attempting to exclude all fire from all ecosystems. The increasing risks associated with fires escaping initial attack and their effects on air and water quality, forest health and sustainability, habitats, costs, and firefighter safety must be emphasized. We can only expect fires to continue escaping initial attack, burning more acres and causing more damage. The reasons are clear: higher fuel loads create increased fire intensities causing more damage and lessening suppression effectiveness. We need to change the public's thinking from acres burned to damage incurred. Are 10 acres of non-renewable eastside forests equal to 10 acres of fast-growing, easily-regenerated westside forest, or 10 acres of great basin grass and sage? Do we care how many acres are burned, or are we more concerned about how many acres are damaged?

When we overcome the air quality hurdle, major opportunities will open up. I believe we can affect public perceptions through information and education. I think the public is smart enough to accept the differences between smoke management and smoke prevention. Not only has smoke been part of the ecosystem, but the volume and duration can be managed with prescribed fire. Wildfires, on the other hand, create more unplanned smoke because they burn much more area and fuel. Toxic pollutants are also generated and carried into convection columns when structures and their contents are involved. The public needs to know that wildfire smoke can be managed through fuels management.

Similarly we need to educate the public about wildfire effects on water quality, forest health and sustainability, and wildlife habitats. The public should not have to see these effects for themselves to make logical choices about forest health.

The public must understand the total costs of wildfires and alternatives to suppression and their costs. In 1989, the Layman Fire, on the Plumas National Forest, burned over 5,800 acres, most of which burned in the first 5 hours. It cost about $8 million for suppression, emergency rehabilitation, and reforestation, and about 30 percent of the timbered land became incapable of regeneration because of site degradation. For $8 million we could have easily burned all the high- priority ground on the Beckwourth Ranger District at least once.

The public should be aware of increased threats to firefighters. As our forests generate more dead trees and snags, the potential for loss of life from these silent killers will only rise. Today there is a higher threat for loss of life by firefighters from snags than from the threat of burnovers. Contrary to what we sometimes hear on television, we can predict fire spread direction and behavior. We can see buildups and changes in the weather and fire. We cannot predict where or when a snag will fall. At night we cannot even see them. In these forests, if you construct line, eat lunch, or take a drink of water, you may not even see, much less be safe from a falling snag. There is no black, or safety, zone as there is in a fire. How many acres will be burned if we cease to suppress fires at night (usually the most effective time), because of potential for firefighter fatalities from snags?

Thus, fire suppression—as represented in the figure of Smokey the Bear—and a driptorch are not mutually exclusive. They are both fire management tools to reduce loss and damage of property and forest resources to catastrophic wildfire. Just as we need Smokey the Bear for the fire prevention program to reduce ignitions, we need prescribed fire for the fuel management program to reduce damage caused by ignitions that escape initial attack and that we cannot eliminate. I think the public is capable of understanding "good fire versus bad fire." We have a responsibility to help educate them about the options, costs, and effects; and they should participate in risk decisions, because we cannot forget that public land managers work for the public.

Operational Improvements

We will have to make operational improvements that demonstrate we have learned from the past and from our mistakes. Some indicators common to prescribed burn escapes include:

- Planning Breakdowns—burn bosses should participate in burn plan participation and in planning firelines.
- Target Fixation—the pressure to blacken acres, to get trees in the ground, or to light because the crews are anxious, are reasons that burns have been ignited and have contributed to escapes. We must develop good resource and burn objectives

and good prescriptions and follow them. Just "black" is not an objective.

- Lack of Weather Information and Knowledge—We need to maximize use of remote weather stations and provide that information to our forecasting services. Burning has been performed without on-site weather from general forecasts and no consultation with fire weather forecasters, or worse, decisions were made by a person with little fire behavior or weather training.
- Lack of Planning for Wind Events—Although long-range weather forecasting is still an inexact science, we know that during certain times of the year we are prone to undesirable wind events, including frontal and foehn winds. With some experience and knowledge, we can generally predict when and where these events will occur. We can use that information in planning ignitions and follow-up actions.
- Complacency—This has been a factor in the planning, ignition, patrol, and monitoring phases. When we fail to follow the basics with test burns, or blacklines, or are complacent about patrolling or weather monitoring, the potential for escapes increases. Escapes, like fire fatalities, are not only the result of one breakdown, but a combination of events.

The application of prescribed fire is both art and science. The decision to burn is inherently risky. Agencies must provide the training, direction, and demonstrated support for their personnel who have followed that direction, followed approved burn plans, and made the decision with the best information they had, even when the undesirable occurs. I have never met a prescribed fire manager or burn boss who wants an escape, or undesirable event. Similarly, agency managers need to give equal emphasis to training and resource allocations for prescribed burning.

The value of tenure can be very important to lessen risks—not only tenure on the part of program managers, but also with agency managers. High turnover is often associated with a lack of skill, knowledge, or trust. Tenured managers can provide program continuity. Tenure can provide better local knowledge of weather and fire problems. Productivity can increase and costs decrease as personnel become more comfortable with prescriptions, ecosystems, and weather patterns. Agency managers may also require fewer constraints as their comfort and understanding increase with program personnel. Escapes, undesirable events, and consequential litigation can be reduced and risks lessened through information sharing, training, mentoring, and tenure.

Scale

We need to broaden our views on project scale and to better prioritize areas in which to burn through strategic planning. We should set priorities based on fire regimes, fire occurrence, and potential for catastrophic fire by watersheds so that the the dollars we are allocated protect the highest risk ground. My experience in fire management has shown me that pouring millions of dollars into small timber sale units for fuel treatment, or building non-strategically placed fuelbreaks to keep suppression forces funded has done little to affect large-scale fire. These small units did not alter the wildfire behavior or reduce fire intensities, and stands still suffered extensive damage. We need to develop projects that are cost competitive, allowing us to treat the most acres and the highest priority land.

Summary

The commemorative video took an important step with its message for Smokey's 50th anniversary by mentioning "that the absence of fire is (sometimes) bad; that fire needs to be part of the ecosystem." Smokey and prescribed burning are not mutually exclusive. Fire and fuel management were once the street sweeper in the timber volume parade, but have become the grand marshal of the forest ecosystem parade, because land management agencies and society are beginning to accept that fire and its related effects are components of the ecosystem.

We must better display the alternatives and effects. Although some air degradation may not be desirable, at least when it is over we still have a forest or a home. If we do not use all the fire management tools available to us, can we continue to accept the increases in costs, damage, and losses—including loss of firefighters—associated with wildfires? Can we ignore the dynamics of ecosystems by trying to manage them as if they were static; or by attempting to manage for a single species to the extinction of their habitat or the extinction of other species?

We have the information and the experienced personnel to learn from our past mistakes. If we are going to affect large-scale fires, we have to implement large-scale projects in the right places. Numerous case examples show that stands have survived loss to catastrophic fire when thinned and underburned before the wildfire. We must begin communicating, educating, training, prioritizing and burning. We have a tool—prescribed fire—that is economically and ecologically sound, and in some areas the public is demanding we use it. As Franklin D. Roosevelt said, "the only limit to our realization of tomorrow will be our doubts of today."

References

Court, Arnold. 1960. **Lightning fire incidence in northeastern California, 1945-1956**. Technical paper No. 47 - May 1960. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, USDA Forest Service, U.S. Department of Agriculture; 21 p.

Page, James; Harrell, Dick; Hurley, Jerry; Deeming, John. 1991. **Drought mortality-measuring effects**. A 1990 study of drought mortality on the Plumas National Forest. Unpublished.

USDA Forest Service Smokey's 50th Commemorative video. 1994.

Prescribed Burning in the 21st Century[1]

Ishmael Messer[2]

Multijurisdictional prescribed burning programs are the future of fuels management for numerous areas. Many agencies or departments have different mandates and policies. Burn programs are carried out according to these policies. These policies are often outdated and do not consider the current urban/interface mix issues. Without a complete understanding of the mission of our cooperators and assisting agencies, fire managers will never be able to burn the acres that need burning, including both the number of acres and strategic locations of the burn sites. Why is a particular burn project important? Will it truly protect natural resources or downstream values? Will the project make a significant difference in our protection program? Building resource data bases, specifically accurate field-based vegetation maps using satellite imagery, aerial photography, groundtruthing, and other sources of data should be a priority for any interagency ecosystem management plan. By combining resource data, resource management programs, land-use planning, development practices, and public education, opportunities exist to promote environmentally sensitive land use, while protecting resource values. For example, vegetation information combined with fire history data can be used to develop a more effective fire management and prescribed burning program to better meet ecological and property protection needs.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Santa Monica Mountains National Recreation Area, USDI National Park Service, 30401 Agoura Road, Suite 100, Agoura Hills, CA 91301.

Prescribed Burning in the 21st Century[1]

Stephen J. Botti[2]

Prescribed burning programs are likely to experience changes in the next 20 years as revolutionary as those experienced in the past 20 years. During the initial phase of developing prescribed burning programs for forested areas, researchers and managers generally believed that prescribed burning should be restricted to low-intensity surface fires, and that such fires could reestablish natural conditions while also reducing hazardous fuels to acceptable levels. It was only after managers started implementing long-duration prescribed burns covering several thousand hectares that they started to understand the degree of variability in fire behavior and effects that were both inevitable and desirable in trying to reestablish natural fire regimes. That variability increased the risks and potential liability of burning, and has produced a growing conflict between hazard fuel reduction goals and ecological prescribed burning goals. How this conflict is resolved will strongly influence the future course of prescribed burning programs. It could become increasingly popular to minimize risks by implementing hazard fuel reduction programs that do not promote a natural role for fire in Parks, and may produce permanent, unnatural ecosystem changes. This can be done by concentrating on the fuel complex without regard for the ecological consequences of the treatment. Constraints on prescribed burning, imposed to minimize smoke impacts, impacts to cultural resources, impacts to visitor use in wildlands, and impacts to wildfire suppression readiness, are likely to continue to increase, especially as the population continues to move into the wildland-urban interface and parks become increasingly isolated ecosystem remnants.

[1] An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2] Fire Program Planning Manager, USDI National Park Service, National Interagency Fire Center, Branch of Fire and Aviation Management, 3833 Development Ave., Boise, ID 83705.

Prescribed Burning in the 21st Century: The Role of Fire Planning[1]

Jay Perkins[2]

Abstract: Planning is an essential step in the process of getting fire "back into the ecosystem." The public needs to understand that fire is necessary for a healthy ecosystem and an essential ingredient in ecosystem management. The hazard of high fuel accumulations coupled with risk of fire starts must be portrayed so that the public understands what will happen when the next wildfire burns in our backyard. Decisions will need to be made so that the hazards will be mitigated and areas prioritized for treatment, despite limited budgets. All professionals, and the public, too, who are working to find the answers to healthy forests must work together to understand the role of the disturbance processes at work. Fire is a key disturbance that must be considered in practically every landscape.

The future is now. We must plan to obtain funding to implement the ecosystem management projects. Conceptually, we have made tremendous progress. Before ecosystem management became the current management operating norm for the USDA Forest Service, pioneers in the use and importance of fire blazed the trail. Those of us who will carry the ecosystem management torch must give thanks to the pioneers, such as Dr. Harold Biswell for his work in the California Sierras and Bob Mutch for his work on prescribed natural fire in the White Cap Wilderness in the Bitterroot mountains of Idaho and Montana.

Recently, the Klamath National Forest committed itself to determining the meaning of ecosystem management and preparing the Forest for the 21st century. Landscape Analysis and Design is the process that was developed because fire analysis fits comfortably within it. The key to fire's future success is the incorporation of fire planning processes within the context of ecosystem management—not as a separate process.

Predicting or projecting the future is a tremendous challenge. The technology age is expanding rapidly. Current research in modeling stand dynamics in conjunction with different fire scenarios will strengthen our ability to understand complex systems. The fire analysis used by the Klamath is part of the Landscape Analysis and Design process. The Klamath is confident that this approach will be useful in the future and can adapt to changing science.

This paper will discuss the use of the Landscape Analysis and Design process used on the Klamath National Forest.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Fire Planning Specialist, Klamath National Forest, USDA Forest Service, 1312 Fairlane Road, Yreka, CA 96097.

Landscape Analysis and Design

The purpose of the Landscape Analysis and Design (LAD) process is to provide a means by which forest landscapes can be understood as ecological systems, and to use this knowledge to help shape the landscape patterns created through National Forest land management activities. Fire is recognized as an essential component of the Klamath; hence, fire is a primary element in the planning process.

The process is intended as a vehicle for implementation of forest planning direction while ensuring the ecological health of the resources. It provides the link between the National Forest Management Act (NFMA) and the National Environmental Policy Act (NEPA), by providing a method for defining the desired condition of a landscape and identifying opportunities to achieve and perpetuate the desired landscape character as portrayed in the Land Management Planning (LMP) document.

Summary of the LAD Process Steps

The first two steps in the process are designed so that the landscape is described in the context of ecological structures and functions. In the first step, the landscape elements are described in terms of the vegetative matrix, patches, corridors, and patterns. In the second step, the ecological phenomena (referred to as flows) that move across, or interact with, landscapes are identified. Fire, wildlife, humans, and water are some examples of flow phenomena that operate at a landscape scale.

Step three provides a sense of the complexity of the landscape by describing the interactions of the flows with the individual landscape elements, as well as the landscape patterns. Individual flow phenomena have a specific way of interacting with the landscape elements, and the landscape pattern in aggregate. This interaction provides insight into how the landscape functions as an ecological system.

Step four provides a framework for defining sustainability. Landscapes are not static; disturbance processes are an integral factor in ecosystem sustainability. Characterizing past conditions, processes that have created the present conditions, and processes likely to affect future conditions provides a sense of the range of variability.

In step five the desired condition is defined by first establishing the landscape patterns and objectives found in the Forest Plan. The applicable standards and guidelines are evaluated in the context of the historic range of variability defined in the previous step. The resulting desired condition encompasses understanding of ecological processes at work, as well as management direction.

Finally, step six identifies possible management opportunities, by contrasting the existing condition to the desired condition. Potential opportunities that achieve desired condition objectives are delineated. The outcome of the process provides a purpose and need for implementation of individual projects designed to achieve, or maintain, the desired condition of the landscape. This process can serve as a catalyst to identify a full range of resource opportunities; by reducing functionalism, planning efforts are better integrated to provide a balance of resource outputs.

Scale of the Landscape Analysis

Because the analysis process encompasses areas roughly between 10,000 and 100,000 acres, the level of detail will be general in nature but considerably more detailed than the analysis that led up to the Land Management Planning document. This assessment of the landscape conditions serves to refine the desired condition from the LMP, while defining management concerns and issues before initiating the NEPA process.

The analysis record serves as a source document for general characterization of landscape conditions and interactions. It can be used during the NEPA process to provide a framework for the generation of alternatives, and may make recommendations where additional information and data are needed to assess environmental consequences. Although a more detailed analysis may be necessary for NEPA sufficiency, that analysis can be focused on project- specific issues and potential effects in subsequent NEPA documents.

Basic Information Needs

For every landscape, baseline information is necessary to perform the analysis. Additional information that is needed will depend on the flows, uses, and functions characteristic of each individual landscape. The baseline information includes:

- Land Management Plan map—Defines spatially the management area allocations in each landscape. General knowledge of land allocations for adjacent landscapes is also necessary.
- Topographic map with transportation system—Serves as a point of reference for unique features or areas of concern, as well as general orientation of the landscape.
- Aerial photos—Serve as useful aids that show the latest flight lines as well as earliest photos; also show obliques, orthophotos, SPOT images, and flight lines taken just before and after major events.
- Vegetation map—(may be derived from timber type or ecological type data).
- Fuel Model map—(forest crosswalk based on timber strata characteristics).
- Fire Risk/Occurrence map—Based on Forest or District information from fire history atlas.
- Fire Hazard/Fire Behavior map—Developed from the fuel model map after initial field review; combines fuel model with topographic features of slope and aspect to show hazard potential.

Additional maps that will be of use throughout the process include:

- Geohazard map—An LMP product or district product in areas where additional field review has been accomplished.
- Order 2 Soils—Particularly helpful if regenerability or productivity is a concern; LMP information could be useful in a gross scale for identifying unsuitable or incapable grounds.
- Plantation map—In landscapes with higher proportions of managed plantations, silviculture background information is a useful tool.

The initial planning meeting should identify resource concerns specific to a landscape; including wildlife use, unique features or habitats, human use patterns, or sensitive resources (i.e., sensitive plants, soils, or cultural resources). Additional needed map layers will be determined from this initial meeting. This meeting should be scheduled well in advance of the analysis process to provide sufficient lead time for data and map preparation. This meeting is crucial also so that the first steps in validation of map outputs can occur.

Team Composition and Function

The Forest has identified the need to provide consistency to the process; hence, the formation of a core group. The core group is composed of five people: a team leader, a writer/editor, and three writers/specialists. This team goes to all of the meetings irrespective of the Ranger District/landscape.

Key to the process is the Districts' involvement. In brief, they are the owners of the process and need to be intimately involved in the process. Much of their project funding will hinge on the outcomes of this process. The Districts provide the ground specialization and "resource" area familiarization. They also provide a key District liaison to ensure the Districts' needs are being met from the initiation of NEPA through project implementation.

Fire Analysis

The fundamental information that is needed to analyze wildfire susceptibility is an understanding of the fire occurrence and the fuels (vegetation) situation on the landscape. With these two elements, plus a sense of the historic role of fire in pre-fire suppression, we can gain an understanding of the susceptibility of the landscape to fire and the likelihood of the severity of a wildfire when it does occur.

The elements of this fire analysis within the Landscape Analysis and Design process will center around the Klamath's most recent project, the Humbug landscape.

The Humbug landscape is situated due west of Yreka, California and is administered by the Oak Knoll Ranger District.

Fuel Modeling

The very first step is to characterize the fuels on the landscape. As mentioned previously, one of the very first LAD products is the preliminary fuel modeling map. This is built from the timber strata map from the LMP database through a geographic information system (GIS). A first approximation fuel map is created relating timber strata to fire behavior fuel models. Ground verification is the first task by the LAD team because the resolution of the timber strata is not always sufficient for the analysis. The fire behavior fuel models characterize surface fires. If the fires reach the forest canopy, then the understory needs to be analyzed so that surface fires that reach the forest canopy are better understood.

The dominant fuel models in Humbug include:

- Fuel Model 1 (grass)—Globally changed to fuel model 2, this model is still one of grass fuel but with a tree or brush overstory. It mostly occurs along the ridges of the landscape boundary. Fires typically burn quickly in late summer.
- Fuel Model 5 (brush)—Globally changed to fuel model 6, these fuel models are difficult to discern from the timber strata information. It becomes imperative to field verify as these two fuel models burn differently. Overall decadence in the brush types indicate model 6 would be the best descriptor. The brush patches would require more detailed assessment before implementation of a prescribed burning project. Fire can be fast and intense.
- NCF (non commercial forest)—Without being given a fuel model from the crosswalk, fuel model 6 best characterizes the NCF lands in this landscape.
- Fuel Model 11 (slash)—Attributed to older plantations (>30 years), this fuel model has fuel on the ground—probably from management activities. These had to be attributed on a polygon by polygon basis through use of the stand record card system or field verification.

General assumptions are:

- Thinned stands—Remained as fuel model 11 because thinning slash in untreated stands creates a slash fuel model.
- Poorly stocked stands—Combined with fuel model 6 because the assumption is the brush component is the fire carrier. For the most part these stands are >30 years old, presumed brush with decadence.
- Adequately stocked stands—Combined with fuel model 9 because we assumed the litter accumulation is the fire carrier. Stands went into fuel model 9 rather than 8 because the majority of area had a high component of ponderosa pine.
- Timber fuel models (models 8, 9, and 10)—These were left unchanged because they are highly variable and no consistent assumption could be applied to make changes. Stands will require further refinement to develop burning prescriptions that will successfully achieve objectives of cleaning up ground fuels or understory regeneration without exceeding acceptable levels of mortality in the overstory component.

Other Fuels Characteristics

A factor not tracked in Humbug is development of understory. Presence of an understory component in sufficient quantities would create ladder fuels that contribute to crown fire potential. This would place moderate hazard fuels (such as 8 and 9) into higher hazard classes. This is an essential piece of information that needs collecting. Many current systems do not adequately portray the understory situation. This item must be improved in the future. Crown fires are the most destructive and have a serious impact on many wildlife species that are currently protected by the Threatened and Endangered Species Act.

Fire Hazard/Fire Behavior

Fire hazard/fire behavior is a derived GIS layer that uses a slope map, fuel model map, and fuel model to crosswalk a fire hazard. The crosswalk is a way of entering a look-up table for the GIS database. This crosswalk and subsequent crosswalks will be used for building GIS layers.

Three slope classes are used, consistent with the slope classes used in the LMP geologic hazard classification (0 to 34 percent, 35 to 65 percent, and >65 percent). The Digital Elevation Model (DEM) information could be used to make different slope breaks if necessary.

Each fuel model/slope combination found on the landscape is run through the BEHAVE fire behavior program. This is a modeling program that uses fuel model, slope, and weather parameters to predict fire behavior and resistance to control for suppression purposes. The 90th percentile weather from district records are used to model late summer afternoons typical of late August and early September. These late summer parameters are used because they are the ones that cause the most intense problems, burn the most acres, and have the most significant consequences to firefighting capability and dramatic fire effects to other resources.

The final product is another crosswalk created within the GIS database in which flame lengths and rate of spread are evaluated to determine resistance to control. BEHAVE is used to build this crosswalk outside of the GIS system because this capability is not yet available. The output is a rating of low, moderate, or high fire hazard/fire behavior:

- Low—Flame lengths less than 4 feet and capable of direct attack fire suppression with hand crews.
- Moderate—Flame lengths of 4 to 8 feet and capable of direct-attack suppression efforts with equipment, dozers or engines. Hand crews are not effective for direct attack suppression efforts. Rates of spread greater than those that the handcrews can contain in the low category.

• High—Flame lengths greater than 8 feet and require air support or an indirect attack method of fire suppression.

Although flame lengths are generally used to define hazard, some fuel models will have low flame lengths but extremely rapid rates of spread, which will place them into a higher hazard class. For example, in Humbug, fuel model 2 is a grass/low brush fuel model that never exceeds 4 feet flame lengths, but the rate of spread is 114 chains per hour. This exceeds the ability of hand crews, or equipment, for direct attack without air support.

The derived layer incorporates the information into a spatial display of hazard assessment for the landscape providing the link to risk and the resource values.

Fire Risk/Occurrence

This map is based on Ranger District and National Forest fire atlas information. We are still working on getting this fire history process totally automated. The map displays location of starts over a 60 year period for the Humbug landscape.

Fire risk is based on the number of fire starts per 1,000 acres. Included in the calculation are the number of fire starts, number of years of historical information, and number of acres involved. The value derived corresponds to a likelihood of fire starts per 1,000 acres. The risk ratings and range of values used in the assessment include:

• Low Risk = 0 to 0.49—at least one fire expected every 20 or more years per thousand acres.

• Moderate Risk = 0.5 to 0.99—at least one fire expected in 11to 20 years per thousand acres.

• High Risk = >1.0—at least one fire expected in 0 to 10 years per thousand acres.

Potential Wildfire Susceptibility

This is the end product of the assessment. By incorporating hazard and risk, a matrix is developed that displays the likelihood an area will be affected by wildfire. The output is a tabular report identifying the number of acres in each category, and a spatial display generated by a GIS:

Potential Wildfire Susceptibility Matrix

Hazard	Risk		
	Low	Moderate	High
Low	1	1	2
Moderate	1	2	3
High	2	3	4

What Is Next

Evaluation of the various resource values and objectives along with the wildfire susceptibility matrix can be used to develop a fuels management plan that can best achieve the desired condition for the landscape. Because all areas cannot be treated at once, efforts may be focused on areas of greatest risk to wildfire. The fire maps can also be overlaid with other resource concern areas for the line officer to evaluate priority areas.

Other uses of these resources include:

• Budgeting and identifying needs for priority work, especially those that can meet several objectives in one treatment.

• Using the products of the system for educational purposes to display the importance of incorporating fire into the ecosystem.

• Demonstrating that more firefighting resources will not provide the desired output. Fire needs to be an ally in the management of ecosystems.

Summary

In addition to the fire planning process, we need to address other issues as well. For instance, budgeting processes must align themselves with the task of implementing ecosystem management. If Forest Service budgets remain resource-oriented, our publics may not be convinced that we intend to change our way of doing business.

In addition, dynamic fuel modeling will need to be integrated with temporal vegetation modeling. Traditional fuel modeling will have to change concurrently because of the greater need to study fuels vertically as well as horizontally.

Planning processes must follow the intent of NEPA and be implemented in an interdisciplinary fashion. Fire planners must share their knowledge of fire effects and fire dynamics so that we can have a better understanding of all of the interrelations that occur on a landscape. The search for knowledge must continue and that knowledge must be shared.

References

Diaz, Nancy; Apostol, Dean. 1992. **Forest landscape analysis and design: a process for developing and implementing land management objectives for landscape patterns**. USDA Forest Service: Pacific Northwest Region; R6 ECO-TP-043-92; 94 p.

USDA Forest Service. 1992. **Our approach to sustaining ecological systems**. USDA Forest Service: Northern Region; R1-92-23; 26 p.

Prescribed Burning in the 21st Century[1]

L. Dean Clark[2]

Abstract: General Helmut Von Moltke defined strategy as "the practical adaptation of the means placed at a general's disposal to the attainment of the object in view." Three strategies are needed for a proactive posture of fire management in the 21st century. The first is to improve positional defenses of human values at direct risk of fire loss. This strategy addresses primarily fuels management at the interface. A second strategy is to improve safety and cost effectiveness of fire management activities on the exterior lines where rural and resources economics are the human values at risk. The third strategy involves the dilemna of cost effective wilderness fire management programs faced by land managers to improve command, planning, logistics, and financing of interior line prescribed fires (within administrative boundaries of public lands).

I met Professor Biswell at Pinnacles National Monument after he had written a USDI National Park Service (NPS) prescribed fire plan for that unit (Biswell 1976). My job was to implement that plan. Professor Biswell gave me a little advice at the Pinnacles before doing the controlled burning there: "Talk with the local ranchers—listen to what they have to say." My attention was turned to the winds (Schroeder 1961).

I presume to speak for those whose tongues are still. For I have followed their paths and the ancient paths before them. These words you may regard as an echo. An echo of what the winds have whispered to me. Because to understand the essential nature of fire, you must *feel* the winds. For it is by such means that fire will return to where you stand and listen. The "Cat-faced" trees are also a clue in my woods (Swetnam and others 1989).

Our cultural focus with fields and fire is that we will stop the fire if we do not want it or prescribe it as a treatment. We prescribe a fire. An interesting story is the one that the ancients of this land held, that Fire is in the Wood (Clark 1953). At the right time, by and by, it was let out. It went on and on that way for a long time. The fires started one way or another. The fact is fire was here, is here, and so are we.

What should be the form of these fires? Currently, we have two choices. Our direct defensive strategy (Clar and Chatten 1966) is to keep to a minimum the number of acres burned and the extent of property and human losses. The chances of success for our indirect offensive strategy depend on control of the timing and rate of progressive ignitions, or firing. Fire as a tool is used only as a last resort.

Our transformation of this landscape compels a redefinition of our prescribed fire strategies. Suppression alone is a defensive strategy. For fire suppression we must confine, contain, and control them (NPS 1991a). For prescribed burning we depend on either management or natural ignition. If tactics derive from strategy, then how do we reconcile our actions to our policies?

Fire suppression works most of the time, but does not work all of the time, particularly during the dry and windy extremes of a site's environmental range of conditions. During these times fire is the enemy; it can become the fire demon. We often must abandon exterior attacks upon fire flanks and must defend positions of developed properties. We are duty-bound to do so. The reassignment of firefighting resources to the protection of human life and property further complicates the control problems by an ever-widening perimeter of uncontrolled fire. The command and operational difficulties in these tactics are a recurring problem (Phillips 1971, USDA-USDI Task Force 1989).

We lack unified strategies to focus our uses of fire in other than suppression modes. General Helmut Von Moltke defined strategy as "the practical adaptation of the means placed at a general's disposal to the attainment of the object in view." Our lack is coordinated prescribed fire action on the offensive end. We can take the initiative and use time to our advantage. The firefighting tools and equipment we can buy are stronger, and more powerful than ever before. Our tools, and therefore our tactics, are evolving. But even with limited resources we can at least apply a limited aim strategy: for example, fuels management on key geographic positions when the weather elements align to our favor. The principle is to change weak fire defensive positions into strong (or anchor) points at times of advantage to a site's fire potential, such as doing "off-season" controlled burning. As General Patton used to say, "A good plan in time is better than a perfect plan that is too late."

The integrated STRATEGY I propose is a simple synthesis of three common strategies for prescribed fire management application. The use of these three strategic profiles can provide priority and essential flexibility for any jurisdiction to integrate with the suppression and prevention programs for more effective wildland fire management. The strategies serve equally well for suppression or for prescribed fires.

[1] An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2] Chief Ranger, Chiricahua National Monument, USDI National Park Service, Dos Cabezas Rt., Box 6500, Wilcox, AZ 85643.

Positional Defenses

This strategy directly protects life and property from fire. Tactics for this strategy are the most varied, and by the topography of most human developments, machine-accessible. The objective is to reduce fire hazards near properties that are at risk to fire loss. The California Public Resources Code 4291 specifies a vegetation clearance around structures in the wildlands. The rule is 30 feet or more and if uniformly enforced, it would work to reduce wildfire losses. This tactic can be done by anyone or by any public entity on owned lands, not just in California.

Many common problems of wildland fire protection occur on a small scale that can be solved before a wildfire (Moore 1981). The image of a design of concentric circles, or ellipses, can be applied to fuel reduction areas around structures, or developments, as fire protection buffer strips. This protection concept can apply to timber plantations, recreation sites, historic, natural or cultural resources as well. The widest, or deepest, strips of modified vegetation would be in the upwind, or to the downslope sides of the values at risk to fire.

The limited aim of this strategy is to turn the most vulnerable flanks of wildland exposures into positions of defensible space under the worst case conditions expected for a site. Use of public labor crews may be an option for some areas.

Exterior Lines

Perimeter fire control is the basic tenet for effective wildland fire suppression (Brown and Davis 1973). It is a lawful assumption for controlled burns. The basic principle to this direct strategy on the exterior line is to contain a fire. Wildfire losses will be held to the minimum through timely and effective suppression action consistent with values at risk (USDI 1990). This strategy generally protects life and property indirectly by stopping the spread of a fire.

The defined perimeter of each prescribed burn is the line of "control" beyond which the fire is no longer controlled. Currently, therefore, each controlled burn is an exterior line action with all of the associated expenses.

Cooperation between neighboring agencies to agree upon joint project areas on mutual boundaries can serve to "dissolve" administrative boundary lines. An example of this planning concept is the joint NPS-USDA Forest Service Lassen Park-Caribou Wilderness Fire Management Plan recently re-approved by Lassen National Forest and Lassen National Park. Others are in development throughout the west.

Convergence of planning for wildfires and prescribed fires can use existing escaped fire situation analysis (EFSA) format as a basis for safer, more cost-effective resources decisions. For multi-jurisdictional situations, the documents must reflect the unified command structure of the planned incident, and thereby provide strategic agreement in advance of the inevitable need. These are "pre-attack" fire presuppression plans and can be prepared as contingency for planned or even on-going prescribed fires of concern to managers. Powerful new tools using remote sensing technology can help managers identify realistic fire management planning units based on fuels and projected fire behavior.

The concept of fuelbreaks as a pre-attack measure for area fire protection can be beneficial (Green 1977). Fuelbreaks emplaced upon geographic features such as ridges, particularly along administrative unit boundaries, serve dual purposes. The access to fires is at least safer for firefighters, as well as being a clearly defined edge of a management unit or a jurisdiction such as at Whiskeytown National Recreation Area, and on the Stanislaus, Sequoia, and Sierra National Forests. A successful example of this principle working in practice was on the "Powerhouse" fire on the Sierra National Forest in 1989. A flank of that fire was contained when it burned into Jose Basin, a part of of the "Sugarloaf" type-conversion project from the 1960's.

Area conflagration control and wildfire reduction on an area could be improved by treating the areas contained within the fuelbreak perimeters with controlled burning such as on the "Grindstone" project on the Mendocino National Forest. There are a multitude of resource benefits from such programs on public lands in addition to fire hazard reduction.

Interior Lines

Interior lines as a strategic concept applies primarily to large blocks of public lands. Areas that have few high-value economic elements, and have high ecological significance, such as wildernesses, parks, and monuments, are logical for applications of large-scale prescribed fires. Indeed, both Sequoia-Kings Canyon and Yosemite National Parks have been at the vanguard of the use of fire as a tool in ecosystem restoration and maintenance. Several Forest Service wildernesses such as the Selway-Bitterroot, and the White Cap in Montana are active with prescribed natural fire (PNF).

Wilderness should permit the role of natural processes to the fullest extent possible without interference from man. Yet each wilderness fire must be guided by a plan! We should plan the fires to our capacities, for instance, scheduling the ignitions in certain areas, at certain times where natural ignitions and suppression activities have resulted in unprecedented fuel accumulations. The strategy of the interior line has a broad scope of application in the medium sized and smaller units of the public lands. The use of an interior line strategy will work, but some objectives and procedures need to be refined. On the interior lines of remote areas, the ecological processes may be served within the span-of-control of modest-sized forces, by using moderate burning conditions, with some time allowed to do the job patiently and carefully.

Formation of mobile tactical teams of specialized fire management resources able to move from job to job as reinforcement (but *not* replacement) to local fire forces could enable this work. Simplified command, operational, and administrative procedures could empower the field fire commanders. Most of the NPS areas in the western United States have comprehensive fire management plans prepared and on file (NPS 1992). Working strategies are lacking, however, as well as essential resources and field flexibility. Many opportunities exist for human-ignited prescribed fire programs in smaller wildernesses. Thus, many of the present difficulties with naturally occurring prescribed fires may be resolved. Smoke management can be a protracted problem for small areas, too.

Point/Counter-Point

Legal issues surround the use of prescribed fire in the next century. Guidance in the form of United States Code (18 USC 1855, 1856) covers issues such as fires kindled, left unattended, or unextinguished by Federal agencies (U.S. Code 1982). The internal administrative discussion about prescribed fires, the external regulatory climate, and interagency distrust following Yellowstone 88 all combine to deflect attention from the focus of the IC/burn boss to the forces that make or break successful fires on the fire ground. Land managers are well-advised to await a wildfire rather than bother with all of the prescribed burn risks and headaches. Individual commitment must be to a shared responsibility (Mutch 1977) for total fire management.

"Mobile Tactical Teams" that are specially trained and equipped to initiate and see through prescribed burning projects (USDA-USDI 1989) may encounter several barriers. Most are fiscal and administrative concerns.

Dr. Biswell once stated that fire control agencies should balance the money used in the fire program in thirds: suppression, prevention, and controlled burning. This idea did not really work. Perhaps the concept could be applied in reverse. "Base" fire management funds "saved" by efficient operations could be designated for prescribed fire operations, if such operations have been targeted in a plan. This approach is an incentive to save funds to get more fuels/vegetation work done.

We do need sensible and sustainable funding sources to pay for the integrity of natural processes. A potential source is a percentage of the Land and Water Conservation Fund (P.L.88-578, September 3, 1964, and as amended) in proportion to wilderness use for the NPS, the USDI Bureau of Land Management (BLM), and the USDI Fish and Wildlife Service (FWS). The Forest Service might assess a special user fee permit for each wilderness entry.

My thesis is that tactics derive from strategy and our strategies are deficient. I have proposed an integrated strategy for prescribed fire management actions. Interior line actions await refinements of strategic interagency cooperation, and our resolve to act. I have the patience to wait, but the problems are not going away. And the fire is still in the wood. The decisions must be on the ground and in time to work well. We must do fire work like we walk, a step at a time. For the winds will return where I walk. It is not if, but when, the fire shall return, and return once again.

References

Brown, A.A.; Davis, K.P. 1973 **Forest fire: control and use**. New York: McGraw-Hill Book Co.; 686 p.

Biswell, H.H. 1976. **A management plan for restoring fire in chaparral at the Pinnacles National Monument**. San Francisco, CA: USDI National Park Service; 32 p.

Clar, R.C.; Chatten, R.L. 1966. **Principles of forest fire management**: Sacramento, CA: State of California; 272 p.

Clark, E.E. 1953. **Indian legends of the Pacific Northwest: How coyote brought fire to the people, and how beaver stole the fire**. Berkeley, CA: University of California Press; 187-192.

Green, L.R. 1977. **Fuelbreaks and other fuel modification for wildland fire control**. Agric. Handb. 499. Washington, DC: U.S Department of Agriculture; 79 p.

Moore, H. E. 1981. **Protecting residences from wildfires: a guide for homeowners, lawmakers, and planners**. Gen. Tech. Rep. PSW-50. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 44 p.

Mutch, R.W. 1977. **Fire management and land use planning today: tradition and change in the Forest Service**. In: Western Wildlands, Vol 4 (1). Missoula, Mt: School of Forestry, University of Montana; 37-43.

Phillips, C.B. 1971. **California aflame!** Sacramento, CA: California Division of Forestry, 1970 September 22-October 4; 73 p.

Schroeder, M.J. 1961. **Down-canyon afternoon winds**. Bull. Amer. Meteor. Soc. 42 (8): 527-542.

Swetnam, T.W.; Baisan, C.H.; Brown, P.M.; Caprio, A.C. 1989. **Fire history of rhyolite canyon, Chiricahua National Monument**. Final Report, Chiricahua National Monument; Tucson, AZ: University of Arizona, Laboratory of Tree-Ring Research; 38 p.

United States Codes. 1982. Office of the Law Revision Counsel of the House of Representatives Containing the General and Permanent Laws of the United States, effective January 14, 1983. Title 16 Conservation and Title 18 Crimes and Criminal Procedure, and Appendix. 679 p. Washington, DC: Government Printing Office.

USDA-USDI Task Force. 1989. Interagency Fire Policy Review Team Report, Washington Offices, Washington D.C.

USDI Bureau of Land Management. 1990. 910 DM 1 Wildland Fire Suppression and Management Program; 1990 March 29; Washington, D.C.: Government Printing Office.

USDI National Park Service. 1991a NPS-18. **Guideline: Wildland fire management**. Washington D.C.

USDI National Park Service. 1992 **Wildland fire management plan: Chiricahua National Monument**. Wilcox, AZ; 91 p.

Concurrent Session II—Urban Interface Topics

Use of Class A Foams on Structures and Wildlands[1]

Paul Schlobohm [2]

Abstract: The increase of homes in wildlands indicates a significant change. The build-up of fuels around homes and in wildlands over time also indicates change. Resistance to change, however, remains the norm. Fires get worse, but plain water continues to be used for fire suppression and property protection. With Class A foam, the objectives of protection are to wet the exposure rapidly, creating a heat sink, and then leave or apply elsewhere while the foam remains behind. This foam can be generated in low-, medium-, and high-expansion forms. Class A foam can be applied from pump-and-roll monitors, large water capacity structure protection engines, small home protection units, aircraft and conventional hose lines. Foam has been successfully applied to save structures threatened by wildfire and to contain prescribed fires near valuable resources. As developed at this time, durable foam is capable of remaining in place as a barrier to fire for 24 to 48 hours. Class A foam technology offers an effective tool to improve the use of water for structure and resource protection.

Change is constant. For instance, the landscape has changed, and in rural areas, homes have been built, increasing the fire protection problem for these areas.

In suburban and rural areas, canopy trees grow, the understory and brush grows, limbs and leaves fall, and fuels continue to build up. Residents prefer the ambiance of thick vegetation surrounding their property rather than an occasional blackened slope from a fuels-reducing prescribed fire. Fuel loading and fuel models continue to change.

In forests and rangelands, prescribed fire is increasingly restricted by impacts of smoke emissions and resource protection. Burn opportunities are fewer and, when they occur, sensitive resources, such as snags, often must be saved. The regulations by which we conduct prescribed fire have changed.

Each of these changes has increased the burden on our fire suppression and protection technologies. Our job keeps getting more difficult to perform. The only thing that does not change in the fire service is our resistance to change. For centuries, plain water has been accepted as the primary fire-extinguishing tool for all Class A or natural fuel fires. Perhaps some time ago this practice was sufficient. Given the annual parade of wildland-urban interface examples of how the fire service has not kept up with the fire problem, it is time to re-examine how we do business.

Presuppression measures, such as creating defensible space and fireproofing exposures, are significant steps to protecting structures from wildland fire. But, once a fire is rapidly approaching and embers are flying everywhere, there is only time for protection activities.

The fact is suppression and protection are relied upon for every wildland-urban interface fire. Certainly, not every structure can be safely defended from fire, but we have to do our job better in the face of ever-worsening situations.

Why Foam?

Possibilities for change begin with that old standard—plain water. The idea is not to replace it—for water has great potential for suppression and protection—but rather to improve it. When a surfactant like liquid dish soap is added to water, water loses its surface tension and gains an emulsifier, allowing rapid wetting of Class A fuels. Without the surfactant, water clings to itself and runs off fuels to the ground. Some fuels, like cedar shingles, naturally shed plain water. Wetting fuels with plain water requires time and large quantities of water. A traditional way to counter this dilemma while protecting structures is to maintain a stream of water on the exposure while it is threatened.

The combination of water and a Class A foam surfactant is called “foam solution” and acts like a high-performance wet water. All of the water in the solution is immediately available for wetting. However, most wood fuels are not able to absorb water all at once. The problem with applications of foam solution is that they are short-lived. Wetting occurs at the fuel surface, but no solution is left for further and continued wetting. And the solution that cannot be absorbed immediately runs off.

The rapid run-off of foam solution can be slowed by adding air and creating a foam. Foam can hold the solution in place until it is absorbed by the treated fuel.

Foam also provides a visual reference for an application. A specific depth of foam can be applied. With foam solution, it is difficult to know if any has been applied and if that amount is sufficient. As long as foam is visible, the fuel below the foam is not drying out. Fuels wetted by non-aerated foam solution begin to dry immediately.

Structure Protection

The spread of fire from house to house is primarily because of wind-borne fire brands and radiation. A fire that starts on a roof begins as one or more very small fires. The structural protection objective with Class A foam is to sufficiently wet exposures to withstand these ignition sources.

[1] An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Fire Management Specialist, USDI Bureau of Land Management, National Interagency Fire Center, 3833 S. Development Ave., Boise, ID 83705.

A wet house becomes a heat sink, effectively forcing brands and flames to spend their energy on drying rather than igniting the house. An application of foam buys time while the fire front burns around and past the structure. And it does this without the need for continuous application.

Because foam is effective well after application, the fire apparatus and crew can move on and treat other structures or leave the area if necessary. The opportunity for multiple-structure applications has led to the development of apparatus designed for rapid and continuous foam discharge. These wildland/urban interface foam engines carry 1,000 to 3,000 gallons of water and at least 40 gallons of foam concentrate. They are plumbed to deliver compressed air foam through monitors or side ports. During pump-and-roll they can deliver the water flow at which the pump is rated. Using the compressed air foam system this type of engine can discharge at least 100 gallons per minute of water as foam for exposure protection a distance of 200 feet. The large water capacity and the flow-conserving use of compressed air foam means these engines often will be pumping off the same water load long after conventional Type 1 engines have run out of water and hydrants have lost pressure.

Although this type of apparatus has been in great demand for structure protection over the last few years, such an engine is not necessary for success with foam. Anything that can deliver water can also deliver foam. The common fertilizer canister filled with dish soap and attached to a garden hose can be effective. Several commercial home protection units are designed for foam use. On fire apparatus, foam concentrate can be added from a proportioner plumbed into the water line or dumped into the engine water tank. Aspirating nozzles will make foam at the end of the hose. Compressed air foam systems will pump foam through the hose and increase discharge distance with the energy from the air compressor. Rotor- and fixed-wing aircraft create foam by dropping foam solution through the air.

Extinguishment

For those structures that become involved and for gaining control over the adjacent wildland fire, foam is again an improvement over plain water. Water is primarily effective at suppressing open flame by cooling. Foam solution changes the structure of water so that water is more completely used for heat absorption. The thin films of foam solution, which are the bubbles in foam, expose a greater surface area of water for absorbing heat than solid streams or drops of water. The amount of water in the extinguishing foam can be adjusted to meet the heat output of the fire, also known as the critical application flow rate. Flame knockdown is often immediate. The clinging nature of the foam structure works to suppress vapors and eliminate smoke. Improved penetration of water reduces hold-over fires. More complete utilization of water results in reduced water damage inside structures.

Prescribed Fire

Foam is making water a more effective tool for prescribed fire. Foam is used to create fuel breaks and burn unit boundaries, to protect important resources within the unit, and to reduce secondary smoke emissions. The objective of fuel break and resource protection applications is similar to that of structure protection: to raise fuel moisture and create a heat sink until the ignition threat passes. With smoke reduction, the objective is to turn black to white, to cover the entire burn area as quickly as possible.

In many fuel types, foam is being used as a fuel break, sometimes as a "light hand on the land" approach in place of fire trail cut by machine or hand crew. A single foam trail, made from a hoselay or during pump-and-roll, becomes an anchor or boundary from which to ignite a prescribed fire area. Wide holding lines are created by firing out between two foam trails. High– (over 200:1) and medium– (20:1 to 200:1) expansion foams are being used to create fire trail downhill from ridgetop to draw. No long hoselay plumbing is necessary to create the barrier; a river of foam slides downslope from the nozzle.

Special resources, such as wildlife corridors, are being protected from prescribed fire with appropriate foam applications and ignition techniques. Low-expansion (compressed air or aspirated) foam is applied to tree trunks, canopies, and other long-distance exposures. Medium- and high-expansion foams are applied to the surface and ground fuels around the exposed resource. Ignition is timed to the effective lifetime of the foam.

After ignition, foam is being used to suppress smoke with a tactic called Rapid Mop-up. Rapid Mop-up is the application of a blanket of foam over the entire burn area as soon after ignition as possible. The blanket of foam effectively smothers the residual fire, cutting off secondary smoke production. Solution draining from the foam works to extinguish the fire before the fire becomes deep-seated. Smoke venting through the foam blanket indicates areas of heat that will require more firefighter attention. This technique has been effective at reducing smoke emissions, firefighter smoke exposure, and mop-up costs. The long discharge of compressed air foam and the long downhill flows of medium- and high-expansion aspirated foam have helped make this tactic practical.

Durable Foam

Class A foam products in use today are, in part, synthetic hydrocarbon surfactants. Much like liquid dish soaps, these components produce the rapid drainage and extinguishment properties exhibited by Class A foam. These surfactants are also the reason that Class A foam is short-lived. Relative to other foam, such as protein foam, Class A foam is a poor foaming agent. The longest time one can expect it to be visible in hot, dry conditions is about an hour, and usually much less. The success of Class A foam in structure and resource protection has been largely because of wetting and good timing, not longevity. Sometimes during structure protection, foam must be reapplied because the impending fire has not yet arrived. The limitation for prescribed fire is that the unit may have to be ignited soon after foam is applied. If winds aloft change and the burn must be postponed, the foam applied is wasted.

To address this short-useful-lifetime limitation of Class A foam, products with longevity, generically called Durable Foam, are being developed. These foams will be created with the same equipment currently used to make Class A foam. A durable foam will be able to hold water as a foam for 24 to 48 hours. Prototypes are already capable of these lifetimes.

Durable Foam will enable one application per structure, well in advance of the fire. It will allow for one application as the prescribed fire unit boundary, even if the ignition time is delayed 1 or 2 days.

A Foam Use Strategy

Foam use can be as simple as buying concentrate, pouring it into the watertank, and applying foam solution with conventional water nozzles. This is a good place to start. However, foam may be formed from a variety of methods and each one has a place in a foam use strategy. Low-expansion foam is needed to reach long distances. Compressed air foam offers lighter hose weights, and medium- or high-expansion aspirated foam quickly covers ground fuels. Durable foam holds water in place for a 12-hour shift. The ability to adapt water into the most appropriate form of foam for the situation is important to successful foam use.

A flexible air strategy with foam is also possible, but needs more development.The use of foam from rotor- and fixed-wing aircraft shares the same advantages as ground-applied foam in comparison to plain water for protection and suppression in the wildland-urban interface. Development of tactics to coordinate air and ground foam apparatus/resources can lead to improved utilization of the technology.

Conclusion

Fire protection responsibilities are growing more difficult. It may be time to change strategies to keep pace with the changing fire scenario. One strategy for structure protection and prescribed fire is the use of Class A foam. In a wide variety of application schemes, Class A foam technology unlocks the full potential of plain water for fire suppression and protection.

Structure Ignition Assessment Model (SIAM)[1]

Jack D. Cohen[2]

Abstract: Major wildland/urban interface fire losses, principally residences, continue to occur. Although the problem is not new, the specific mechanisms are not well known on how structures ignite in association with wildland fires. In response to the need for a better understanding of wildland/urban interface ignition mechanisms and a method of assessing the ignition risk, USDA Forest Service Fire Research is developing the Structure Ignition Assessment Model (SIAM). SIAM uses an analytical approach that relates the potential for sustained structure ignitions to the location and characteristics of adjacent fires and the structure's materials and design. SIAM's ignition risk assessment is based on a worst case estimate of the direct effect of flames leading to ignitions as well as ignitions from burning embers (firebrands). Initial SIAM results indicate that the flames of burning vegetation are not greatly effective in creating sustained ignitions. This suggests that firebrands and adjacent burning structures are significant causes of structure ignitions. Current experimentation is directed toward verifying these SIAM results.

Residential losses associated with wildfires first gained national attention during the 1985 fire season in which about 1,400 homes were lost. This condition has been called the wildland/urban interface (WUI) fire problem and was raised as a critical national issue at the Wildfire Strikes Home conference in 1986 (Laughlin and Page 1987). Since then, the WUI fire problem has remained prominent. "Structures threatened" has typically appeared on fire situation reports. Since 1990, California alone has suffered over $2.5 billion in residential property losses associated with wildfires. These property losses principally occurred in residential areas that were within or adjacent to wildland vegetation. And the number of people who will live in or adjacent to wildland areas has continued to increase, thereby further increasing the WUI problem (Davis 1990). Without mitigation, the WUI fire losses are likely to continue or increase.

The characteristic property losses during WUI fires are very different from the average United States residential fire losses. The 1991 U.S. residential fire loss statistics (including the Oakland fire losses) illustrate the characteristically higher fire losses experienced during WUI fires. Of the 1991 U.S. total fire occurrences, WUI fires account for less than 0.6 percent of the occurrences; however, WUI fire losses account for 27 percent of the 1991 property losses (Karter 1992). This reflects the higher fire losses per residence for a WUI fire than for a typical residential fire. During a WUI fire, ignited structures typically result in a total loss. Recent media coverage of the October 1993 WUI fires in the Laguna Hills of southern California show standing houses adjacent to complete destruction—a sight typical to any WUI fire. The increasing frequency of WUI losses and the intense destruction associated with WUI fires provide compelling reasons to mitigate the problem.

"Wildfire Strikes Home!" the document of the 1986 WUI meeting (Laughlin and Page 1987), recommends needed research for WUI fire problem mitigation. Many of the recommendations continue to be viable:

- Managing hazards in an esthetically acceptable manner
- More knowledge about the relation of building design and clearance to fire hazards
- More knowledge about ignitions from wind transported burning embers
- Techniques to evaluate and identify fire risk.

The Structure Ignition Assessment Model (SIAM) and its associated research specifically address these issues.

Ignition Assessment for Improving Structure Survival

After a WUI fire, structure survival is visible in varying degrees. This outcome can result from a complex, interactive sequence of events involving the ignition and burning of vegetation and structures. It is accompanied by varying efforts on the part of firefighters and homeowners to prevent further burning and extinguish the existing blaze. The development of an assessment method requires an explicit description (at some resolution) of the processes involved.

Structure survival involves factors influencing ignition, and given an ignition, factors influencing the fire suppression. Thus, structure survival assessments also require consideration of the suppression factors. Analysis reveals that the factors influencing suppression are very dependent on the current situation at the time of the fire, thus making a prior description of the suppression factors unrealistic (Cohen 1991). The general process leading to structure survival or loss must "pass" through the occurrence or nonoccurrence of an ignition (*fig. 1*). Therefore, assessing the ignition factors for the purpose of improving ignition resistance can result in an improved chance of survival. SIAM depends on the ability to describe the general factors that influence the potential for ignition.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17,1994, Walnut Creek, California.

[2]Research Physical Scientist, Southern Research Station, USDA Forest Service, Southern Forest Fire Laboratory, Route 1, Box 182A, Dry Branch, GA 31020.

The WUI fire problem can be examined on the premise that structure survival is the essence of the problem, and that structure ignition is the critical element for survival: homes that do not ignite do not burn. SIAM addresses the potential for structure ignitions rather than the potential for structure survival.

The Structure Ignition Assessment Model (SIAM)

SIAM is designed for the purpose of assessing potential structure ignitions during wildfires burning in vegetation and structures. The model uses general descriptions of the structure, the topography at the building site, and the potential fire characteristics around the structure to compute an index of ignition risk. It is designed to provide a flexible approach toward achieving residential fire safety by rating the potential for ignitions based on a structure's ignition resistance characteristics and its potential fire exposure. Thus, homeowners and developers can "trade off" various design features of a building's exterior and its surroundings to meet fire-safe requirements.

SIAM is intended for the facilitation of improved fire safety as well as to identify potential wildland/urban interface fire problems. In its basic form, the model can be adapted to a variety of applications ranging from single home assessments to planned developments. The basic applications can include:

- Establishment of fire safety requirements based on potential ignition risk for a mix of factors.
- Integration of a resident's exterior home design and landscaping interests with fire safety requirements.
- Integration of a developer's home and neighborhood design interests with fire safety requirements.
- Ability of fire agencies to assess wildland/urban interface fire risks for pre-suppression and suppression planning.

To achieve these applications, SIAM uses an analytical approach to establish relationships between the structure design and the fire exposure that results in the assessment of potential ignitions. Because actual fire conditions of a future fire are unknown, worst-case assumptions are used. For example, it is not known how and in what sequence the flammables around a structure will burn; therefore, it is assumed that all flammables adjacent to the structure will burn at the same time. If conditions are not well understood, e.g., firebrand (flying embers) exposure and ignition, judgments based on physical reasoning are used. Because of the various unknowns, SIAM rates only the potential for structure ignition; it does not predict ignition.

A better understanding of the model's processes can be obtained by examining the components of SIAM from the input of information to the output of the resulting ignition risk rating (*fig. 2*).

The SIAM model consists of six principal processing steps (items in the brackets refer to *fig. 2*):

1) [Structure Design, Topography, Fire Weather Severity, Fuels, Expert Designated Fire Behavior]

SIAM inputs require the description of the structure and site conditions, including a fire professional's estimate of flame lengths that are consistent with the chosen potential severe fire weather conditions. The Structure Design inputs relate to the general design, e.g., roof flammability, exterior materials, windows, nooks and crannies, and exterior dimensions. The Topography input refers to the degree of slope and whether it is upslope or downslope from the structure. Also included is the structure/slope set-back, i.e., the horizontal distance between the structure and the slope. The Fire Weather Severity is a selected level of weather conditions for planning WUI fire safety. The inputs explicitly involve windspeed,

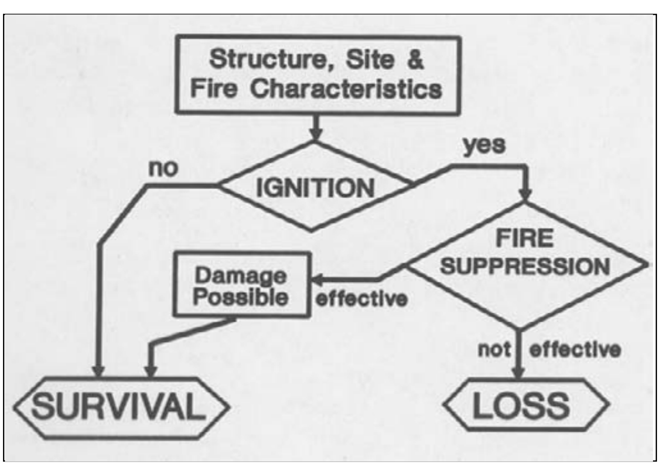


Figure 1—Structure survival depends on factors influencing ignition and factors influencing effective fire suppression. Regardless of the fire suppression effectiveness, survival initially depends on ignition.

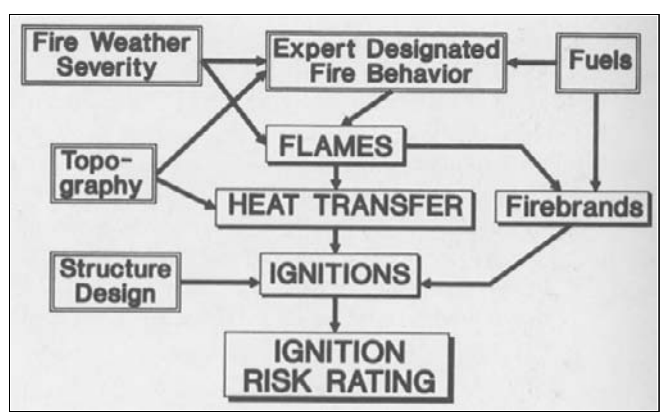


Figure 2—The Structure Ignition Assessment Model (SIAM) uses the inputs (double line boxes) to calculate the potential for ignitions from direct flame exposure (Heat Transfer) and exposure to aerially transported burning embers (Firebrands). SIAM produces a dimensionless ignition risk rating index, not a prediction of outcomes.

temperature, and fine fuel moisture content. Implicitly, the Fire Weather Severity guides the user in designating, and/or calculating, the fire behavior characteristics. The Fuels inputs require the designation of the type of flammable material (e.g., grass, shrubs, trees, wood piles, structures), the dimensions of its area, and its distance from the structure. The Expert Designated Fire Behavior includes flame length and rate of spread if appropriate. These fire behavior inputs can be calculated through the BEHAVE Fire Behavior Prediction System (Andrews 1986, Andrews and Chase 1989) and/or estimated experientially.

2) [Flames]

On the basis of input information of the fuel type, the fuel locations and the fuel length/width dimensions, windspeed, topographic slope, and flame lengths, SIAM calculates flame size, flame angle, burning residence time, and the structure's exposure to flame radiant heating and flame or convection column contact.

3) [Heat transfer]

SIAM uses a physical heat transfer model to relate the calculated flame characteristics to the radiative and convective heat transfer. Worst-case assumptions are used for such items as the flame temperature and the flame/wall geometry.

4) [Firebrands]

The firebrand exposure depends on the amount and size distribution of the firebrands generated. Using physical reasoning and experience, a structure's firebrand exposure corresponds to the type of fuel in the wildland/urban interface area and the general fire intensity. The type of fuel (e.g., grass, shrubs, trees, buildings) relates to the general size of the firebrand, while the fire intensity relates to the fire's lofting capability.

5) [Ignitions]

An empirical ignition model (Tran and others 1992) is used to relate heat transfer to the potential for sustained ignitions of wood. The assessment of the potential for ignition on exterior wood building materials depends on the magnitude of the heat transfer, and the burning time. Using physical reasoning, the potential for ignition by firebrands is subjectively related to the firebrand exposure and the structure's exposed flammable nooks and crannies and roof material. SIAM calculates the influence of firebrands on the ignition potential separately from the direct flame heat transfer influence.

6) [Ignition risk rating]

The assessments for ignition potential from direct flame heat transfer and firebrand exposure are subjectively combined for the entire structure. The final risk rating recognizes the potential interactions between structure heating (without ignitions from flame heat transfer) and firebrand ignition effectiveness. The final rating is a dimensionless quantity, linearly related to potential structure ignition (Cohen and others 1991).

An important procedural change has occurred with regard to the determination of the fire behavior characteristics. Fire behavior characteristics such as flame length and rate of spread are not calculated by SIAM—they are now direct inputs. Through personal expertise and/or fire behavior modeling, the user determines the fire behavior that matches previously chosen fire severity conditions. This change has occurred because the application is largely out of context for available operational fire models. The intent is to produce greater model reliability by involving the user in the determination of the fire behavior characteristics.

Experiments in Support of Ignition Assessment Modeling

Several aspects of ignition require a better understanding before SIAM can reliably rate ignition risk. These issues are being approached through experimental methods. Currently, an experimental examination is being done to better understand the effect of windows (principally window breakage) on potential ignitions. In conjunction with the window experiments, the flame radiation heat transfer model and the ignition model are being examined for their reliability. The experimental work is not complete, but preliminary results suggest some important considerations.

Window Breakage Tests

Windows often fracture when exposed to a nearby exterior fire. The structural fire problem regarding windows involves the fracture and subsequent collapse, in which an opening is created. In the wildland/urban interface context, firebrands are a very important structure ignition source. Experience indicates that any opening to the interior of the structure increases the potential for ignition. In the context of SIAM, windows are an important factor principally if a fire exposure results in a window fracture and collapse, but without a concurrent exterior ignition, because the only effect of the fire exposure is to create an opening, and thus an entry point for firebrands. The experiments are designed to address the question of window collapse specific to SIAM needs.

The window breakage experiments have been conducted in two phases. The first phase uses relatively small windows exposed to relatively low heat fluxes (heat flux = energy/time/area). The window pane dimensions measure .61 meters by .61 meters by 4.8 millimeters thick. A wooden sash holds the glass panes in a wooden frame. Tests are conducted on both plate and tempered glass types, and in single pane and double pane arrangements. The window heat exposures consist of average total heat fluxes of 9.3 kW/sq m, 13.6 kW/sq m, and 17.7 kW/sq m for 300 seconds (kW/sq m = kilowatts per square meter). The experiments use the USDA Forest Service's Southern Forest Fire Laboratory's wind tunnel facility and a propane fueled flame source.

Phase 1 has been completed. Preliminary results indicate significant differences between plate and tempered glass, and the potential integrity of double pane windows compared with single pane arrangements (*table 1*). The results show that for every test of single pane/plate glass, window breakage

Table 1—*Phase 1 window breakage results*

Glass type and arrangement	Heat flux (kW/m²)		
	9.3	13.6	17.7
Plate glass:			
Single pane	4/4[1]	4/4	4/4
Double pane			
Outer pane	4/4	4/4	4/4
Inner pane	0/4	3/4	3/4
Tempered glass:			
Single pane	0/4	0/4	0/4
Double pane			
Outer pane	0/4	0/4	0/4
Inner pane	0/4	0/4	0/4

[1] Number of tests in which window pane broke per number of tests.

resulted at each heat flux, yielding a ratio of 4/4. For double pane/plate glass at the lowest heat flux, 9.3 kW/sq m, only the outside pane broke in each test (4/4; and 0/4). The higher heat fluxes resulted in inside pane breakage in 3 of 4 tests. However, from observation during the experiments, the degree of fracture to the inside pane, i.e., the number of cracks, was less than for the outside pane. No breakage occurred to tempered glass panes due to the fire exposures.

Although all heat fluxes resulted in plate glass breakage, none of the windows collapsed leaving an opening. In each case, the wooden sash held the glass fragments sufficiently to prevent collapse. This raised the important question if larger windows and higher heat fluxes of shorter duration would result in collapse.

Phase 2 of the study used larger windows and higher heat fluxes. The panes were plate glass, measuring .91 meters wide by 1.5 meters tall, and 6 millimeters thick. The panes were held in a wood frame by a wood sash that was part of a wall section 2.5 meters tall by 3.4 meters wide. Exterior plywood siding (T-111, unpainted) covered the wall during the glass breakage experiments.

The tests were conducted in the USDA Forest Service's Southern Forest Fire Laboratory's combustion facility using precisely constructed, oven-dried wood fuel cribs. The entire crib was simultaneously ignited, resulting in maximum flame dimensions of about 1.3 meters wide, 3.1 meters high, and .8 meters deep. Because heat flux sensors could not be placed at the glass surface, calibration measurements determined the window heat fluxes instead of real time measurements. The heat flux sensors were located in a non-flammable panel that was placed in the window opening. The calibration measurements generally covered the area of highest total heat flux for the wall section. The average highest total heat fluxes were measured during calibration tests performed at two different intensity levels (*fig. 3*). These intensity levels correspond to the different flame-to-wall distances noted in the figure. The highest intensity level exceeded 50 kW/sq m at its peak burning period, compared to 30 kW/sq m for the lower intensity profile.

Although the Phase 2 testing has just begun, significant results have already been observed. The 50 kW/sq m heat flux tests resulted in glass breakage and virtually complete window collapse. Immediately following the window collapse, wall ignition occurred followed by sustained burning. The 30 kW/sq m heat flux test also resulted in glass breakage and virtually complete window collapse, but without wall ignition.

Thus, these initial experiments showed that windows can be a significant factor for potential structure ignitions, by allowing interior firebrand penetration without the occurrence of an exterior structure ignition. Continued window experimentation will better define the differences in window collapse between the Phase 1 and Phase 2 experiments and extend the range of test conditions beyond Phase 1. Questions remain as to whether the large windows will break without collapse, to what extent a double pane arrangement mitigates window collapse, and whether tempered glass in either a single pane or double pane arrangement will prevent window collapse until exterior ignitions occur.

Wall Ignition Tests

It is important to verify that SIAM is consistent with real situations. An initial step in this verification process is to measure total heat flux and observe ignition occurrence at the wall section concurrent to the window breakage tests. By comparing measured observations with model results, these experiments provide a physical test under high heat flux conditions with relatively large flames, and with a heat flux/time relationship similiar to actual vegetation burning (*fig. 3*). Ignition observations can be compared with the ignition model (Tran and others 1992).

Ignition model calculations using heat flux calibration data provide an estimate of sustained ignition occurrence (sustained ignition = continued flaming after the initiating heat source is discontinued). *Figures 4, 5,* and *6* show the heat fluxes with the flux-time ignition calculation superimposed (right axis values). The horizontal line delineates the flux-time value that corresponds to the piloted ignition point (piloted ignition = the presence of a hot spark or small flame that initiates flaming). Inspection of *figure 4* indicates that the flux-time exposure (65 cm distance) should readily result in an ignition. This can be seen by comparing the flux-time curve with the piloted ignition value. The lower heat flux shown in *figure 5* (100 cm distance) results in a much lower flux-time magnitude and indicates a marginal condition for ignition.

The actual tests produced results consistent with the ignition model calculations. At the higher heat flux (65 cm distance), the wood siding readily ignited with sustained flaming. The lower heat flux test (100 cm distance) did not result in ignition. *Figure 6* illustrates the average total heat flux at a location adjacent to the glass pane in the wood window frame. At this location, the flux-time calculation

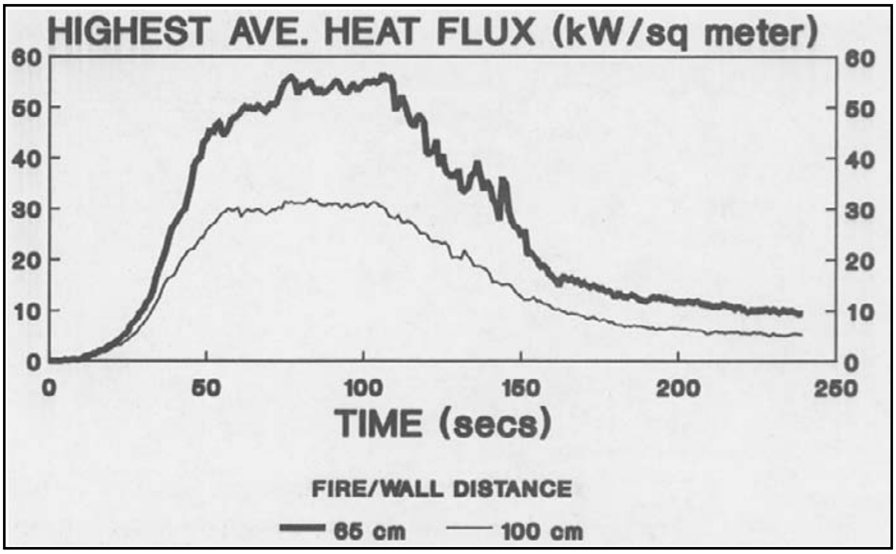


Figure 3—Total incident heat flux and flame distance comparison for the 65-cm and 100-cm calibrations from the Phase 2 portion of SIAM experimentation. Calibration tests such as these indirectly determine the window heat flux exposure.

does not reach the ignition point, which is consistent with the no-ignition occurrence.

Preliminary SIAM Results

Although SIAM is not ready for operational assessments, the component models for heat transfer and ignition can be used. Thus, given constant flame characteristics and distances, estimates of the time required for ignition can be calculated. Preliminary SIAM results can be examined for flame descriptions relevant to burning vegetation and burning structures.

The ignition model (Tran and others 1992) uses incident radiant heat flux (not the net heat flux) to calculate an ignition time. For a given constant heat flux, the ignition model provides a relationship between radiant heat flux and the amount of time for the piloted, sustained ignition of wood (*fig. 7)*. At heat fluxes below 30 kW/sq m, the heat flux/ignition time relation has a high rate of change; therefore, small changes in heat flux can result in large changes to ignition time. Considering that vegetation fuels (without a continuous bed of large stem wood) have flaming residence times generally less than 120 seconds, a small change in heat flux can make the difference between an ignition and no ignition. Also, people are more sensitive than wood to the radiant heat fluxes: at 16 kW/sq m, skin blisters form after 5 seconds (Drysdale 1985), but wood takes 1,200 seconds before piloted ignition.

Because actual fire conditions are not predictable, SIAM calculates the radiation heat transfer for a worst-case situation. The flame is assumed to be a constant, 1,200 degrees Kelvin, gray body emitter over its entire dimensions. And, the radiation view from the wall to the flame is assumed to be that of two parallel surfaces with their centers aligned. Based on these assumptions and given flame dimensions, a relationship exists between the radiant heat flux and the flame-to-wall distance (*fig. 8)*. The given flame dimensions represent possible vegetation fire conditions (e.g., 5 m wide by 2 m high flame = a low flammable hedge row; 5 m wide by 15 m high flame = a fully torching tree). SIAM uses the heat fluxes to calculate the potential for ignition.

The ignition times (*fig. 9*) for a flat wood surface are associated with the heat fluxes of *figure 8*. The ignition time graph shows the minimum time for ignition related to the flame-to-wall distance for the given flame dimensions. The graph is limited to 300 seconds because the burning time of the flame front in vegetation fires is generally less than 5 minutes. Note that with the exception of the two largest flame sizes, the flames have virtually no direct significance beyond 10 meters (33 feet). These preliminary results suggest that vegetation management activities are most effective in the areas immediately surrounding the structure. However, vegetation is not the only potential flame source adjacent to a residence. The neighbor's house may also be a fire threat.

Local agencies often focus on flammable vegetation as a factor in wildland/urban interface fire safety concerns. However, depending on the distance between residences (structure density), neighboring structures can be a very significant ignition source.

The radiant heat flux is a function of distance between structures and structure size (worst-case conditions are assumed) (*fig. 10*). The calculations assume that the entire wall is burning and that the flame is a rectangular, black body emitter at a constant temperature of 1,200 degrees Kelvin. The walls are assumed to be parallel with their centers aligned. Importantly, larger structures produce higher heat fluxes, and thus if burning, larger structures are a greater threat to neighboring structures (*fig. 10*).

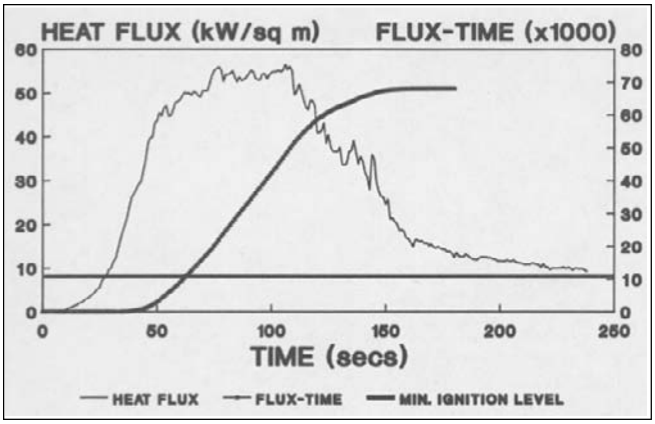


Figure 4—Fire test calibration for the 65-cm flame to wall distance. The flux-time value (right axis reference) is a cumulative quantity that empirically relates to piloted, sustained wood ignition (Tran and others 1992). The flux-time value begins to increase above the critical incident radiant heat flux (greater than 13.1 kW/sq m) and ceases when the heat flux falls below the critical flux. Ignition is expected at a flux-time value of 11,501, which corresponds to the ignition line. The heavy, S-shaped curve is the flux-time curve.

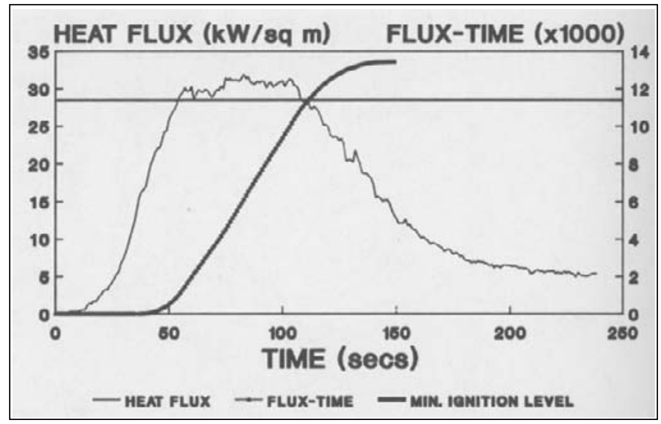


Figure 5—Fire test calibration for the 100-cm flame to wall distance. The flux-time value (right axis reference) is a cumulative quantity that empirically relates to piloted, sustained wood ignition (Tran and others 1992). The flux-time value begins to increase above the critical incident radiant heat flux (greater than 13.1 kW/sq m) and ceases when the heat flux falls below the critical flux. Ignition is expected at a flux-time value of 11,501, which corresponds to the ignition line. The heavy, S-shaped curve is the flux-time curve.

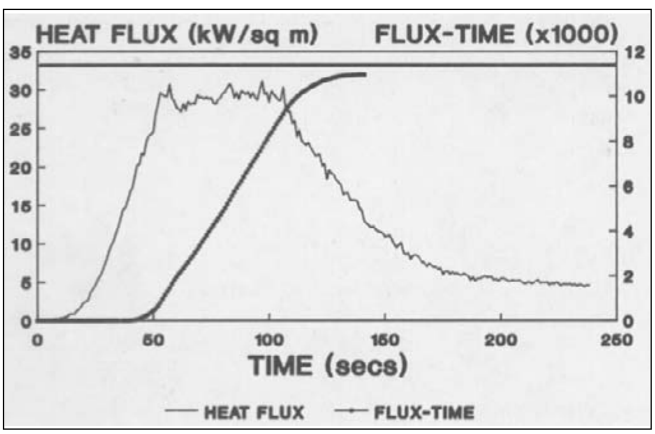


Figure 6—Wall fire test without ignition for the 100 cm flame to wall distance. The flux-time curve (right axis reference) is based on measured heat fluxes of the wood wall panel adjacent to the window. The maximum flux-time quantity did not achieve a value equal to or greater than the critical ignition level.

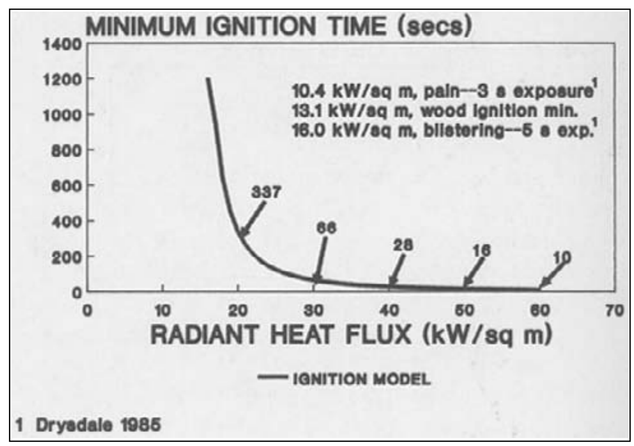


Figure 7—Minimum ignition time vs. radiant heat flux. Given a constant radiant heat flux, the ignition model (SIAM) can be used to estimate the time required for sustained ignition on a flat wood surface. The references to pain and blistering relate to exposed skin at the given radiant heat fluxes.

Figure 11 provides the minimum ignition times based on the heat fluxes shown in *figure 10*. The graph extends to greater ignition times because structures characteristically burn longer than vegetation. Inspection of the ignition times suggests that the clearance between structures should be about 8 meters (26 feet) for the one-story structure and about 12 meters (39 feet) for the two-story structure. Although these examples are hypothetical, past wildland/urban interface fires involving high-density residential neighborhoods (e.g., Oakland, 1991) indicate the importance of structure-to-structure ignition.

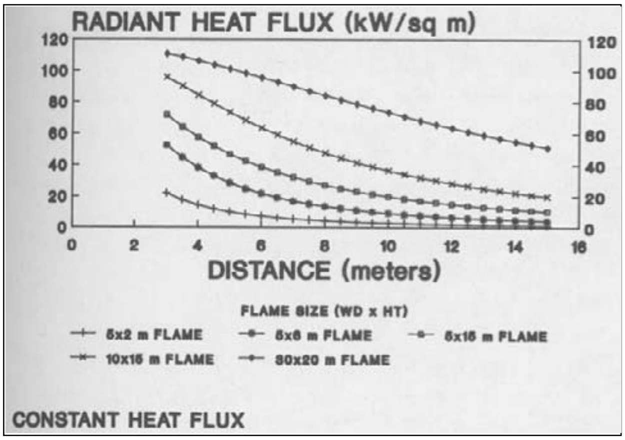


Figure 8—Radiant heat flux vs. distance for burning vegetation. The amount of radiant heat flux and the rate of decrease depends on the flame size. The distance refers to the distance from the flame. Based on these heat fluxes, ignition times are calculated as a function of distance. As the distance increases, it takes longer for sustained ignition to occur.

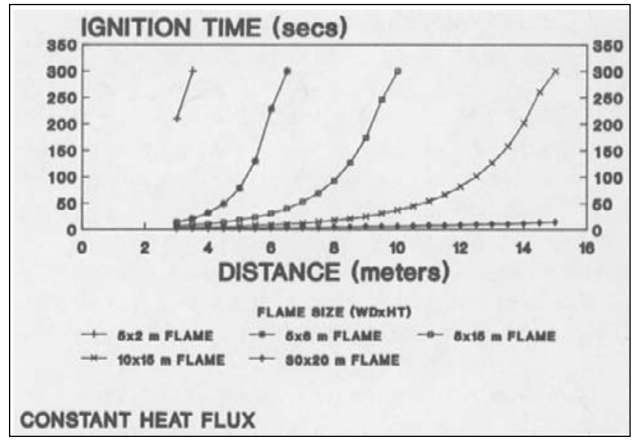


Figure 9—Ignition time vs. distance for burning vegetation. The amount of radiant heat flux and the rate of decrease depends on the flame size. The distance refers to the distance from the flame. Based on these heat fluxes, ignition times are calculated as a function of distance. As the distance increases, it takes longer for sustained ignition to occur.

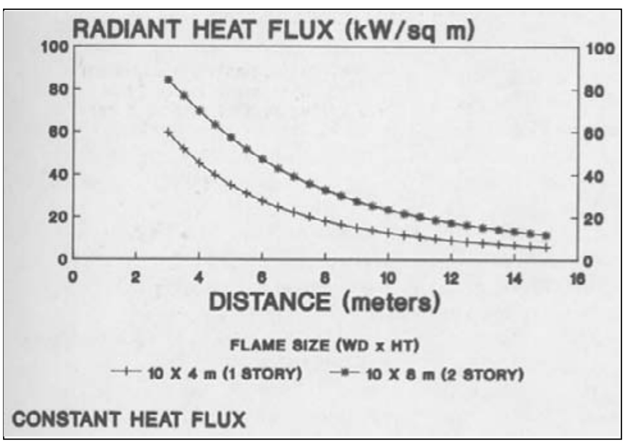


Figure 10—Radiant heat flux vs. distance for an adjacent burning structure. The amount of radiant heat flux and the rate of decrease depends on the flame size. The distance refers to the distance from the flame. Based on these heat fluxes, ignition times are calculated as a function of distance. As the distance increases, it takes longer for sustained ignition to occur.

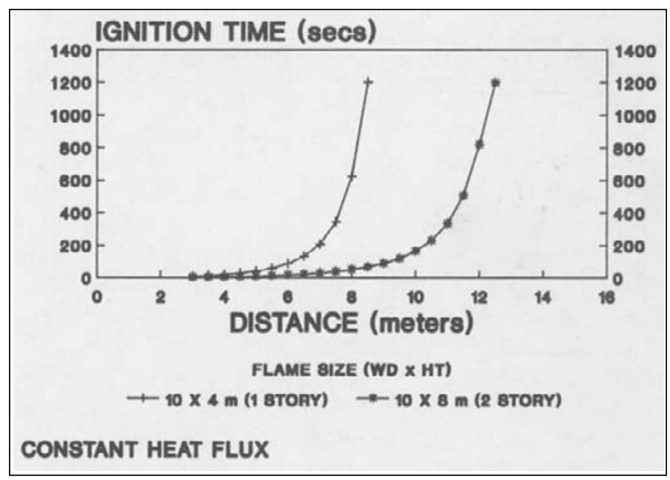


Figure 11—Ignition time vs. distance for an adjacent burning structure. The amount of radiant heat flux and the rate of decrease depends on the flame size. The distance refers to the distance from the flame. Based on these heat fluxes, ignition times are calculated as a function of distance. As the distance increases, it takes longer for sustained ignition to occur. The radiant heat flux from structures is not necessarily greater than from vegetation, but the characteristic burning time is longer; thus the ignition time axis covers a greater range for burning structures.

Conclusions

The Structure Ignition Assessment Model is being developed as a tool for the purpose of reducing high residential fire losses associated with wildland fires. In the context of wildland/urban interface fires, SIAM rates the potential for structure ignitions rather than predicts structure ignitions. SIAM does not address structure survival, but assumes that lowering a structure's ignition risk leads to improved chances for survival.

SIAM development involves experimental work to gain needed understanding and to verify the reliability of SIAM's component models. Current experiments involve determining the significance of windows regarding the potential for structure ignition. Concurrently, these experiments are an initial effort to verify the reliability of SIAM's heat transfer and ignition models. The experimental work is not complete, but it has generated preliminary results regarding the behavior of heated windows and the verification of the ignition model.

Preliminary results of the Phase 1 window experiments produced significant differences between glass types and pane arrangement. These results suggest that for an exterior fire exposure, the double pane arrangement improves window integrity, and significantly, tempered glass is much more thermally resistant than plate glass.

The Phase 2 experiments (not completed) have demonstrated that windows can break and collapse from fire exposure without the occurrence of an exterior structure ignition. This finding has determined that SIAM requires window information in the description of significant design features that contribute to structure ignitions during wildland/ urban interface fires.

Although model verification is just beginning, the observations from the accomplished tests suggest that the preliminary SIAM results are reasonable. The 35-cm fire-to-wall distance change (for the specific fire dimensions) results in the difference between wall ignition versus no ignition. Analysis of the measured heat flux data using the ignition model produces results consistent with the observed ignition occurrence. This suggests that the SIAM ignition model reasonably represents the relationship between incident radiant heat flux and ignition.

Preliminary SIAM results suggest that ignitions from flames (radiant and convective heat transfer) occur from fires within the immediate surroundings of the structure. Except for the case of large flame heights and an extensive fireline, ignitions result from flames within 15 meters (50 feet) of the structure (*fig. 9*). But, ignitions on structures and adjacent vegetation commonly occur while fires burn at distances considerably greater than 15 meters. This finding concurs with personal observations that firebrands are a significant source for structure ignitions.

These results suggest that to reduce ignitions, the distances from a structure for managing vegetation are much smaller than the lofting distances for firebrands. Thus, beyond some relatively short distance from the structure (depending on the vegetation and topography), vegetation management has no significant benefit for reducing flame generated ignitions. Vegetation management, on the other hand, cannot be extensive enough, in a practical sense, to significantly reduce firebrand ignitions. Therefore, the structure and its immediate surroundings should be the focus for activities intended for improving ignition risk.

Neighboring structures are a significant potential ignition source. SIAM results suggest that at distances between structures of less than 5 meters, structures can become the principal source for ignitions (not including the additional effect of firebrands from structures). In high-density residential areas containing highly flammable structures (e.g., residences with flammable roofs), vegetation management may not be sufficient to prevent widespread fire destruction.

References

Andrews, Patricia L. 1986. **BEHAVE: fire behavior prediction and fuel modeling system—BURN subsystem, part 1**. Gen. Tech. Rep. INT-GTR-94. Ogden, UT: Intermountain Research Station, Forest Service, U.S. Department of Agriculture; 130 p.

Andrews, Patricia L.; Chase, Carolyn H. 1989. **BEHAVE: fire behavior prediction and fuel modeling system—BURN subsystem, part 2**. Gen. Tech. Rep. INT-GTR-260. Ogden, UT: Intermountain Research Station, Forest Service, U.S. Department of Agriculture; 93 p.

Cohen, Jack D. 1991. **A site-specific approach for assessing the fire risk to structures at the wildland/urban interface**. In: Nodvin, Stephen C.; Waldrop, Thomas A., editors. Proceedings of the fire and the environment: ecological and cultural perspectives international symposium; 1990 March 20-24; Knoxville, TN. Gen. Tech. Rep. SE-GTR-69. Asheville, NC: Southeastern Experiment Station, Forest Service, U.S. Department of Agriculture; 381-383.

Cohen, Jack D.; Chase, Richard A.; LeVan, Susan L.; Tran, Hao C. 1991. **A model for assessing potential structure ignitions in the wildland/ urban interface**. In: Proceedings of the 11th conference on fire and forest meteorology; 1991 April 16-19; Missoula, MT. Bethesda, MD: Soc. of Am. Foresters; 50-57.

Davis, James B. 1990. **The wildland-urban interface: paradise or battleground?** Journal of Forestry 88(1): 26-31.

Drysdale, Dougal. 1985. **An introduction to fire dynamics**. New York: John Wiley and Sons; 424 p.

Karter, Michael J. 1992. **NFPA reports on 1991 U.S. fire loss**. National Fire Protective Association Journal 86(5): 32-43.

Laughlin, Jerry; Page, Cynthia. 1987. **Wildfire strikes home**. In: Laughlin, Jerry; Page, Cynthia, editors. Report of the national wildland/urban fire protection conference; 1986 September; Denver, CO. NFPA No. SPP-86. Quincy, MA: National Fire Protection Association; 89 p.

Tran, Hao C.; Cohen, Jack D.; Chase, Richard A. 1992. **Modeling ignition of structures in wildland/urban interface fires**. In: Proceedings of the 1st international fire and materials conference; 1992 September 24-25; Arlington, VA. London, UK: Inter Science Communications Limited; 253-262.

Strategies for and Barriers to Public Adoption of Fire Safe Behavior[1]

Ronald W. Hodgson[2]

Abstract: A recent survey of people living in wildland-urban intermix neighborhoods in a portion of the Sierra-Cascade foothills identified perceptions of defensible space that block its rapid and widespread adoption. A companion survey described communication channels used by residents to acquire information about landscaping and identified opinion leadership characteristics. Neither lack of awareness of the wildfire threat, lack of basic knowledge of defensible space, nor skepticism about defensible space effectiveness were a barrier to adoption of wildfire defenses by property owners. Perceived costs and labor requirements, lack of specific knowledge about how to do the required work, lack of time or assistance to do the work, and the difficulty of disposing of large amounts of brush generated in the initial conversion to defensible space were serious barriers. Biomass harvesting was experimented with to dispose of brush and to cover some of the costs of initial conversion. Social marketing and community organization methods were used to promote and carry out the project. The approach proved effective. Results showed excellent promise for the use of biomass harvesting in thickly settled subdivisions.

In spite of years of effort to encourage the adoption of defensible space—a safe zone that protects a structure from fire—only a relatively small proportion of wildland-urban intermix residents have changed their landscapes to help protect their properties from wildfire. Even more rare are entire neighborhoods and communities protected by strategic wildfire defense preparations. The annual drama of flames, ashes, and despair broadcast on California prime-time television and featured on the front pages of newspapers from the smallest weekly to national circulation giants regularly alerts residents to the potential danger. Clearly other barriers must block widespread public adoption of wildfire defenses.

Investigations to identify these barriers began with Survival by Design workshops held at Chico and Pomona, California, in which fire management specialists presented the problem to selected community leaders who then evaluated the potential of defensible space as a "product" that wildland-urban intermix residents might adopt. A pair of surveys of wildland-urban intermix residents in the aftermath of the "49'er Fire" were administered. The workshops and the two surveys together generated information needed to create a neighborhood-based approach to the promotion of wildfire defense preparations. This approach is now being tested in neighborhoods in high fire hazard areas in northern California.

The organization and education elements of the approach were tested on a small scale in Paradise, California with some success. A study of the potential of biomass harvesting on small private ownerships to reduce the fire hazard was proposed in the Shingletown Ridge area. The project was funded, and during the spring and summer 1992, a successful effort at neighborhood organization for hazard reduction and biomass harvesting demonstrated the potential of the neighborhood based approach, but also revealed the need for larger scale operations and planning. A proposal is currently being considered by the California Department of Forestry and Fire Protection (CDF) to prepare a wildfire defense preparations plan for an area of about 40,000 acres on the Shingletown Ridge that can be implemented through community action with assistance from National Forest Stewardship funds and other public conservation programs.

Concurrently, a neighborhood-based hazard reduction program was implemented in the Middle Creek watershed west of Redding. The approach was similar to the Shingletown area study but involved more financial commitment from property owners. The Middle Creek project began as a soil conservation and erosion reduction project designed, in part, to protect the endangered winter run salmon spawning beds. Fire defense preparations for the watershed were undertaken when it was realized that a repeat of the 1972 Swasey Fire would destroy erosion protection investments as well as burn many homes and threaten lives.

These studies showed that strategic defensible space (wildfire defense preparations) can be successfully promoted on a large scale if the idea is marketed using the natural social and communication structure of the communities, perceived barriers are removed, and neighborhood initiatives are supported.

This paper describes the barriers revealed by the survey of residents in wildland-urban intermix neighborhoods, and other barriers that impede the implementation of defensible space promotion projects. The most appropriate approach for marketing community wildfire defense preparations will also be discussed.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2] Professor, Department of Recreation and Parks Management, California State University, Chico, CA 95929.

From Suppression To Integrated Fire Management

One central objective of wildfire management is to minimize the sum of fire losses and costs. That objective applies to prevention and pre-suppression as much as to fire fighting. Prevention and fuels management are (or ought to be) equal partners with suppression in the management of fires to reduce as much as possible the negative impacts on people's lives and their social and economic systems. However, currently our thinking is dominated by suppression even in the case of defensible space design and promotion.

As presently conceived, defensible space is a collection of actions, including vegetation management around structures, that will provide a safe place to defend the structure and reduce the vulnerability of the structure to ignition. Defensible space includes other elements, of course, such as signing, adequate roads, and water supplies, and all are to be provided in an effort to defend individual structures easily, safely, and more effectively. If defensible space were widely adopted, fewer resources from perimeter control would be reassigned to structural defense, allowing quicker containment of the fire.

The unexpressed assumption of this viewpoint is that the values at risk are contained in the structure and that the landscape is expendable. The actual facts are very different. The survey revealed that about one person in five considered protection of the landscape more important than protection of the structures. Those who work with urban-wildland intermix (also known as the "I-zone") residents have been told that if the landscape is lost, people will not want to live in the area anymore. After the 49'er fire, many people whom interviewers looked for within the fire perimeter had sold or moved out since the fire, even if the structures were saved. Other evidence of the importance of the environment is more obvious. For example, people build expensive homes in the I-zone and commute longer distances to work, even when they could live in good suburban neighborhoods closer to their jobs.

Concern for erosion control and water quality (as illustrated by the Middle Creek watershed project) also suggest that the landscape may be more highly valued than the structure. Those who value wildlife and energy management (shade and protection from wind) also suggest this. Homes may be quickly rebuilt, but 100-year-old trees cannot be replaced by insurance.

If fire destruction does result in the departure of many residents, the social structure of the neighborhood will be disrupted. Friends will be separated. Feelings of security and predictability will decline. Uncertainty will increase, and distress and anxiety may follow. The quality of life will be markedly diminished. Recovery from disasters is enhanced if conditions can be returned to near normal as soon as possible (Albrect and Adelman 1987, Drabek 1986, Lindell and Perry 1992). If the setting can be protected or repaired quickly, the familiar pace and flow of neighborhood life may be easier to restore. If so, the important human, non-property losses associated with wildland-urban intermix fires can be reduced.

Ultimately, of course, if the landscape does not burn intensely enough to kill the larger trees and other important vegetation, it is less likely to destroy structures. If the rate of spread is slow enough to permit residents to escape easily and unhurriedly, it will also be easier to bring adequate suppression forces to the attack. Any vegetation management strategy that protects the landscape values at risk will also protect structural values and human life imbedded in that landscape.

A second important, unspoken assumption in our approach to fire protection for the wildland-urban intermix is that the wildfire will burn out of the wildlands into the settlements to threaten lives and destroy homes. Although that often occurs, these fires usually start in or on the perimeter of an I-zone settlement. The risk of ignition in the wildlands, with the exception of lightning, is concentrated in areas of human activity. Human activity with fire potential is most concentrated in wildland-urban intermix settlements. There one finds the greatest potential for children with matches fires, the greatest opportunity for equipment fires, the greatest likelihood for escaped debris fires, and the chance that structure fires will spread to the wildlands.

I-zone fires that threaten lives and homes are those that probably start in a settled area and grow to dangerous proportions because the settlement and its immediate environments have not been treated to reduce the fuels, alter the fuels to make them less flammable, eliminate the fire ladder, and create fuel and fire breaks to contain the risk.

Viewed from this perspective, the usual recommendations of defensible space with the focus on assisting suppression forces with individual structure protection are less sensible than defensible space designed to contain risk by managing vegetation throughout the settlement and its immediate environment and to prevent fires that will inevitably start within the settlement from spreading rapidly, growing to destructive intensities, and burning into the wildlands and then into other settlements.

This risk containment strategy, fortunately, works both ways. It will also reduce the danger from fires burning out of the wildlands into the settlement.

Finally, this shift in perspective requires that prevention not be equated only with Smokey Bear programs for kids and information and education programs for adults. Prevention is not only posters, state fairs, rodeos, parades, exhibits at the mall, team teaching, or television, radio, and newspaper public service announcements (PSA's) , news stories, and features. Of course all of that is an important part of a fire prevention strategy, especially in the wildland-urban intermix. However, the engineering leg of prevention's tripod (engineering - education - enforcement) is just as important. In the I-zone, engineering means, among other things, large-scale vegetation (fuels) management. If prevention seems not to stand on its own today, it is partly because the engineering leg has not been as developed as enforcement, information, and education. Even the information and education leg, although large, is presently weak in its application of modern communication and marketing theory.

In summary, we need to think more about strategies to prevent wildland-urban intermix fires from quickly spreading and growing to destructive power. We must cool the inevitable fires down, slow them down, and keep them on the ground to give suppression forces time to arrive and control them and to limit losses experienced between ignition and mop-up. Fire intensity and rate of spread are functions of topography, weather, and fuels. Only fuels are significantly within our control. We need to shift our thinking from the suppression perspective. We need to shift the way we think of prevention from ignition reduction to include reduction of the potential for fire damage and threat to life through large-scale fuels management within and surrounding settlements. We need to work with whole neighborhoods and settlements instead of targeting only individual property owners to develop and implement a coordinated set of wildfire defense preparations that integrate suppression, fuel management, and prevention in a cost-effective, holistic approach to fire protection.

Landscape for Wildfire Defense Management

If apathy, lack of knowledge of defensible space, or skepticism about the effectiveness of defensible space is not the problem, what has prevented people from protecting themselves and their property from wildfire? Innovation diffusion theory suggests that the problem might lie with public perceptions of defensible space as an innovation. Research has shown that an innovation will earn acceptance slowly unless it is thought to have a relative advantage over alternatives, and is compatible with values and accepted ways of doing things, relatively simple to understand and use, observably beneficial, trialable on a small scale before full scale commitment is required, and adaptable to individual situations without losing effectiveness (Rogers 1983).

To assess public perception of defensible space, samples of residents of selected wildland-urban intermix neighborhoods between Grass Valley and Paradise, California were surveyed. The results make it clear that, at least for these I-zone residents, people know about defensible space and believe that it is effective. They also believe that it is costly, somewhat complex, and potentially incompatible with landscape values. Other perceived characteristics are not entirely positive. It appears that the characteristics of defensible space itself, as perceived by potential users, create barriers to its widespread adoption.

Barriers to Implementation of Defensible Space

Several concepts must be defined to describe how people perceive technology. Observability is the degree to which people can “see” the technology and its positive effects (Rogers 1983). Trialability is the degree to which the technology can be experimented with on a small scale before the decision has to be made to invest in it (Rogers 1983).

Plasticity is another important characteristic of new technology influencing its potential for adoption: it is the degree to which the technology can be modified to fit individual innovator’s situations without adversely affecting its relative advantage. Rogers (1983) does not discuss “plasticity” per se but does describe the role of “reinvention” in adoption.

Relative Advantage

Relative advantage is the degree to which a new technology is perceived to be better than alternatives. Costs, labor requirements, discomfort, and effectiveness for the intended purpose are all part of relative advantage (Rogers 1983). Four out of five people surveyed believed that defensible space would help save their property in the event of a wildfire. For most people, defensible space is perceived to be effective for its intended purposes. Still, one in five does not think it will help save their property. We do not know whether that is because they do not think it will save their homes or because they think of their property in a larger sense to include the landscape.

Lack of defensible space implementation is not because people are fatalistic. Less than one in ten thought that if a house burns it is a matter of luck.

About half of the respondents to the survey believed that defensible space would cost them more money in the long run than the alternative. Less than one in twenty thought defensible space would cost less. Clearly, defensible space is at a relative disadvantage with respect to costs. This is an important barrier to widespread adoption. Increasing the number of people who implement defensible space in the wildland-urban intermix depends heavily on our ability to bring the perceived initial conversion and long-term maintenance costs down.

Almost two thirds thought the work required to maintain defensible space would be about the same as that required by their current landscape. Nearly 30 percent, however, thought it would be harder, and less than one in ten said it would be easier. Defensible space has no labor-saving advantage to make it attractive to wildland-urban intermix residents.

More than half thought it would be difficult to find the time to make the landscape more fire safe, while a quarter thought it would be easy.

Although no question about the perceived discomfort of creating and maintaining defensible space was asked in the survey, later focus groups in Paradise raised concerns over poison oak, snakes, and Lyme disease. Some residents may be reluctant to work on the undeveloped parts of their lots for these reasons. Because of this perceived barrier, finding ways to get the initial conversion work done for residents without requiring them to expose themselves to these perceived dangers could make defensible space more attractive.

Although defensible space is believed by four out of five people surveyed to help protect their property from wildfire, many remain skeptical. Perceived costs, labor, time requirements, and perhaps aversion to snakes, poison oak, and Lyme disease leave defensible space without a clear relative advantage. This, in part, accounts for the low level of implementation in the wildland-urban intermix in spite of sustained promotional efforts. To achieve greater adoption, costs, labor requirements, and time demands must be lowered.

Complexity

Complexity is the degree to which people find the new technology difficult to understand and use (Rogers 1983). Two-thirds of those surveyed believed that they would have to change their landscape to make it fire safe. About 17 percent thought they would have to make many changes.

More than half of those surveyed understood the different kinds of landscape features and how they protect property from wildfire. Only about 15 percent did not understand those features. In fact, we have found that people in the neighborhoods where we have worked learn the basic principles of fire behavior easily and can apply them to their landscaping decisions pretty well.

Less than two-thirds said they would need to learn new things about landscaping to make the changes required for defensible space. The good news is that they would enjoy learning more about landscaping for the most part.

Considerably less than one in five did not know which features in a landscape make it more or less fire safe.

About one-third of the respondents said it would be hard to know which plants grow in a fire safe landscape. Nearly another quarter were uncertain. Increasing the adoption of defensible space will require better and more available information on recommended plant materials and landscape designs that provide wildfire defense and will survive a wildfire. Locations that sell the plants seem difficult to find to about one in five, while another fifth are unsure.

More than a quarter thought a defensible space landscape would be more complicated to maintain. Almost two-thirds thought it would be about the same, and less than one in ten thought it would be less complicated. Of those who thought it would be more complicated, few thought it would be much more complicated. Perceived complexity of maintenance is a barrier for a few but is not a major barrier to adoption.

Although survey data were not obtained about brush disposal in neighborhoods in which defensible space has been promoted, difficulties in disposing of the large amounts of brush produced in the initial conversion to a fire safe landscape add significantly to the perceived complexity at the implementation stage. The amount of brush produced is dangerous to burn, it is costly and difficult to haul, and landfills won’t take it anyway. This is a major barrier to widespread adoption.

Overall, people generally do not find it difficult to understand defensible space and how it works to protect their property. The major sources of complexity are the amount of work needed to make property fire safe, lack of certain how-to-do-it information, and especially, the difficulty of disposing of the brush.

Compatibility

Compatibility is the degree to which the new technology is perceived to fit with existing values and ways of doing things (Rogers 1983). A little more than 40 percent believed that natural landscapes are more beautiful than planted landscapes while an almost equal number disagree.

More than one-third believed that few changes should be made in the natural landscape while more than half are willing to make changes.

Modifying what is seen as the natural landscape and replacing it with a planted landscape is not compatible with attitudes of many of the people who responded to the survey. Defensible space and wildfire defenses in general need to be understood as compatible with natural landscape values. Landscaping for wildfire defense will be more attractive if it can be shown to restore and protect wildlife, watershed, esthetics, air quality, and other values.

Recommendations

Public perception of defensible space was least acceptable in terms of its relative advantage and complexity. That is enough, however, to slow adoption of wildfire defense preparations among I-zone residents. Promotion strategies that increase perceived relative advantage and reduce perceived complexity will accelerate the adoption of defensible space among residents of the wildland-urban intermix.

The establishment and maintenance of defensible space should be made less costly in terms of money, labor, time, and discomfort for the wildland-urban intermix landowner. Biomass harvesting may be one way to do this in certain circumstances. Chipping and scattering the material back on the ground may be another. Use of light under burning after initial mechanical or hand treatment may also work. Better information should be provided on costs and more cost-effective vegetation management equipment for the wildland-urban intermix.

In addition, the complexity of defensible space as perceived by land owners should be reduced. Improved methods of brush disposal and maintenance will help. Education about fire behavior and landscaping is needed. Plant materials and landscaping advice should be more readibly available.

Perceived incompatibility with values for natural landscapes will be a barrier to some. The best way to handle compatibility difficulties is to adopt a marketing perspective. In marketing, one does not "sell" the idea by trying to change attitudes and values. Instead, one attempts to modify the product to fit existing attitudes and values (Kotler 1981, Solomon 1989). Neighbors and opinion leaders are important when compatibility is in question (Rogers 1983). Illustrations of typical neighborhood landscape designs that are fire safe and provide for wildlife, watershed, esthetics, and other values identified during marketing research will help.

Defensible space promotion programs should be targeted at neighborhoods and other relatively homogeneous groups. Resident input into planning and implementation should be extensive and their concerns, interests, and suggestions should be incorporated into the wildfire defense plan. Residents should be involved in the development and implementation process as a community to the greatest extent possible. Marketing is most effective when it is targeted to homogeneous market segments; neighborhoods tend to be socio-economically homogeneous and, in the I-zone, share the same wildfire threat.

Rapid implementation of defensible space in neighborhoods will be facilitated by ensuring that the benefits are observable. In the Shingletown Ridge project, we encouraged neighbors to pile brush for chipping at the roadside. The growing numbers of piles and later, the activity of the chipping operation to dispose of the brush communicated clearly to other people in the neighborhood that fire safe work was being done. Participating lots should be marked with an emblem of some kind showing that hazards have been reduced.

Not everyone is willing to implement landscaping for wildfire defense fully without seeing how it will look on their own property first. By making the neighborhood-based hazard reduction project an annual event, skeptics have the opportunity to try it out on a small part of their property. When they find they like it, they will fully implement fire-safe landscaping at the next opportunity.

Defensible space is adaptable to the requirements of each setting and to the tastes and preferences of most people. Its attractiveness will be enhanced if that flexibility is maintained. Attempts to make specific fire-safe rules and apply those rules to every site will result in less adoption and less effective wildfire protection. By educating people about fire behavior and advising them on applications of hazard management to their particular situation, more people are likely to accept defensible space.

Summary

Fire prevention is more than information and education aimed at reducing the numbers of fire starts. That is part of prevention—a very important part—but fire prevention works best when supported by three legs: information and education, enforcement, and engineering, and integrated with suppression and fuels management. In the wildland-urban intermix, engineering involves hazard management. Hazards are those things that will burn and the characteristics of those things and the topography and weather that cause them to burn intensely.

Fires will start in the wildland-urban intermix. They are most likely to start where human activity is concentrated. Those concentrations are typically settlements. The fire that destroys homes in the wildland-urban intermix probably will start in a settlement and grow to dangerous intensity because available fuels (and weather and topography) allow it to grow rapidly. Suppression forces find they must deal with human safety and structural protection when they arrive and are unable to take direct action on the fire itself. One solution is to contain the risk through a settlement-wide effort at hazard reduction to cool the inevitable fire down, slow it down, and keep it on the ground.

Risk containment requires a community- or neighborhood-based marketing effort. Neighborhoods are good market segments to target with fire prevention education and promotion because the residents are relatively homogeneous in terms of socio-economic characteristics, tastes and preferences for home and environmental characteristics, and they face the same fire threat in the same fuel type. Marketing is not selling. Marketing attempts to discover the sort of "product" the consumer wants and then to produce, price, promote, and deliver the product. With some modification, the marketing approach has been successfully applied to public safety and health campaigns similar to fire prevention.

In the areas studied to date, the slow rate of adoption of wildfire defenses by people living in the wildland-urban intermix is not the result of lack of knowledge, motivation, or skepticism about the effectiveness of defensible space. Instead, a number of barriers have resulted from perceptions of defensible space. Defensible space does not have a clear relative advantage compared to alternatives; it is perceived to be somewhat complex, and has the potential to conflict with important values or established methodologies. Increasing the rate of adoption and use of wildfire defenses in the wildland-urban intermix requires fire prevention officers to be conscious of perceived barriers and work to remove or mitigate those barriers.

Acknowledgments

Ray Stewart of the California Department of Forestry and Fire Protection (CDF) Shasta-Trinity Ranger District encouraged me to propose a study in the Shingletown Ridge area. Mike Jones and Cynthia Reese, of the Western Shasta Resource Conservation District, developed and implemented the Middle Creek Watershed fire protection project. Survival by Design workshops were sponsored by the USDA Forest Service, CDF, and California State Universities at Chico and Pomona. The surveys of I-zone residents were sponsored by the Pacific Southwest Research Station, USDA Forest Service, and the CDF. The Paradise field test was sponsored by the CDF and California State University, Chico, with the cooperation of the Paradise Fire Department. The Shingletown

study was sponsored by the CDF and California State University, Chico, with the cooperation of the Shasta Forest Village Property Owners Association and Water Company.

References

Albrect, Terrance L.; Adelman, Mara B. and Associates. 1987. **Communicating social support**. Beverly Hills, CA: SAGE Publications; 317 p.

Drabek, Thomas E. 1986. **Human system responses to disaster**. New York: Springer-Verlag; 509 p.

Kotler, Philip. 1982. **Marketing for nonprofit organizations**. Englewood Cliffs, NJ: Prentice-Hall; 528 p.

Lindell, Michael K.; Perry, Ronald W. 1992. **Behavioral foundations of community emergency planning**. Washington, DC: Hemisphere Publishing Corp.; 309 p.

Solomon, Douglas S. 1989. **A social marketing perspective on communication campaigns**. In: Rice, Ronald E., Atkin, Charles K., eds. Public Communication Campaigns. 2nd ed. Newbury Park, CA: SAGE Publications; 416 p.

Rogers, Everett M. 1983. **Diffusion of innovations**, 3rd ed. New York: The Free Press; 453 p.

Neighborhood Organization Activities: Evacuation Drills, Clusters, and Fire Safety Awareness[1]

Dick White[2]

Abstract: Emergency preparedness activities of one Berkeley-Oakland Hills neighborhood at the wildland/urban interface include establishing clusters that reduce fire hazards and fuel loads, setting aside emergency supplies, and identifying evacuation routes; taking emergency preparedness courses from the Offices of Emergency Services of Berkeley and Oakland (the CERT and CORE programs); and setting up and exercising a citizen-band radio network. With the cooperation of the Berkeley and Oakland fire and police departments, on-foot evacuation and earthquake drills have been held. Problems discovered relate to liability, absentee ownership of lots, and response time of the official emergency radio system.

The Story

This is the story of one neighborhood's preparations for responding to a major emergency, whether large fire or severe earthquake.

The Setting: The neighborhood contains roughly 235 dwellings, sited densely on a hill on the urban/wildland interface located nearly atop the Hayward earthquake fault. There is just one road for access to the neighborhood, the streets are steep and full of tight curves, and no street is much wider than 15 feet. The utility lines are carried overhead on old poles. Shrubs and trees abound both inside and just outside of the neighborhood.

Political Landscape: The neighborhood lies partly in Berkeley and partly in Oakland. It abuts University of California land on several sides, and it touches East Bay Regional Park land. A neighborhood association was founded in 1926, reportedly in response to the issue of providing better emergency access for fire-fighting equipment. An additional access road has not been built, and the idea of such a road is not popular with residents because it is believed likely to trigger the development of presently undeveloped lots in the neighborhood.

Cast of Characters: The neighborhood is populated by "team-players" and dedicated individualists, homeowners, landlords, tenants, long-term residents, and absentee owners of undeveloped lots, plus unknown transients who camp occasionally in the adjoining woods.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Professor, Department of Electrical Engineering and Computer Sciences, University of California, Berkeley, CA 94720.

Motivations for Emergency Preparedness

Common sense—and the historical record of major fires here—contributed to a background level of concern for engaging in emergency preparations. But most of the activities described here began after the Loma Prieta earthquake of 1989 and were intensified greatly by the occurrence of the Oakland/Berkeley Hills Firestorm in October 1991.

Sources of Information and Help

Although the residents may have conceived of a few novel twists, most of the preparedness actions we have taken were suggested in publications and courses made available by many organizations. Here are some that we have used:

- Berkeley Office of Emergency Services: Disaster First Aid Handbook and Search and Rescue Handbook, plus courses on these topics.
- Oakland Office of Emergency Services: CORE Program (Citizens of Oakland Respond to Emergencies) courses covering individual and group preparations, medical disaster, light search and rescue, and light fire suppression, followed up by a realistic earthquake drill at the Oakland Fire Department Training Center.
- American Red Cross: Your Family Disaster Plan (with FEMA co-sponsorship), and other booklets.
- California Department of Forestry and Fire Protection: Video "Fire Safe — Inside and Out,"pamphlet "Fire Safe, California!," and other publications.
- East Bay Municipal Water District: Firescape: Landscaping to Reduce Fire Hazard.
- Others: KTVU Channel 2 Television: Video, "The Oakland/Berkeley Hills Firestorm, October 20, 1991." University of California emergency preparedness fair. Vendor information.

The Three P's: Preparations, Plusses, Problems

In the hope that our experience might be useful to others, here is a summary of what we have done to increase our readiness for responding to emergencies. The emergencies we foresee—through a veil of denial—are two. One is a massive, fast-moving fire coming from any direction of the compass. The other is a major earthquake that severely damages many of our dwellings and roads, disrupts electricity and water supplies, cripples telephone communications, injures many people, and possibly leaves the neighborhood isolated to take care of itself for at least 72 hours.

While engaging in preparedness activities, we have experienced many positive side benefits—we will refer to them here as “plusses.” And we have identified some problems that we hope can be overcome.

Preparations

We have attempted to learn what needs to be done in case of emergency; we have set up small local groups (clusters) of five to ten dwellings each to cooperate locally in preparing for and dealing with an emergency, and communicating with the neighborhood as a whole; and we have invested in some means for improving our ability to deal with an emergency (*table 1*).

Neighborhood Clusters

We have approximately 15 clusters of five to ten nearby dwellings. Each has a cluster representative and an alternate who help plan activities, such as drills, and communicate to their neighbors about the preparations one should make, the

Table 1—*Neighborhood preparedness activities*

- Fire prevention
  - Awareness through information dissemination.
  - City inspections and followup (spark arrestors, clear zones, etc.).
  - Clearing by individuals (city pickup of clippings, chipper, dumpsters).
  - Roof replacement and tree removal and trimming by individuals.
- Neighborhood organization
  - Cluster formation (use for two-way information transfer):
    - 5-10 households; identify occupant skills and needs; sketch and tag utility shutoff locations.
  - Spreadsheet (each address, names, phone numbers, skills, needs)
  - Neighborhood association
    - Committees—emergency preparedness, etc.
    - Entire neighborhood informational meetings.
- Communications
  - Telephone trees (through clusters)
  - Citizen band radio network
    - • 40-channel, 5-watt; 24 units purchased by individuals
    - • Protocols, practice drills, neighborhood maps
    - • Coverage: “command center” to top and bottom of hill, end-to-end of fire trails, inside house to inside house, AC-DC on standby.
- Courses
  - Berkeley “CERT”:
  - Medical disaster (3 hour).
  - Oakland “CORE”
    - Module 1: individual preparedness (18 people).
    - Module 2: group preparedness (18 people).
    - Module 3: Medical emergency; light search and rescue; light fire suppression; “final exam” drill—simulated earthquake (OFD Training Center).
- Disaster planning and practice
  - Command center identified, storage building stocked.
  - Emergency medical location identified.
  - On-foot escape routes identified and tested.
  - Medevac site discussed (?)
  - Emergency police access paths discussed (?).
  - Practice drills
    - Mar. ’93: on-foot neighborhood evacuation (emphasis: walking out).
    - Oct. ’93: on-site earthquake response (emphasis: learn your local area).
    - Mayday ’94: on-site earthquake response (emphasis: ready for 72 hours?).
- Liaison
  - Interactions throughout with city and university emergency personnel.

emergency supplies to store, the marking of utility shutoff valves and switches, and so on. The cluster representatives also communicate to the chairmen of the neighborhood-wide emergency preparedness committee relevant local information, such as current names and phone numbers of all residents, which residents are usually at home during the day and are willing to provide timely information about conditions in case of emergency, and the locations of residents having special needs that should be promptly dealt with in case of emergency. This information for the entire neighborhood is entered in a spreadsheet (Excel) by the committee chairmen.

Courses

Some 20 residents completed the three-module CORE courses and survived the final drill held at the Oakland Fire Department Training Center, albeit with receipt of withering but helpful criticism. Others have taken Berkeley CERT courses. Several took other courses on similar topics.

Citizen-Band (CB) Radios

About two dozen residents have purchased 5-watt 40-channel CB radios in order to facilitate communicating over the neighborhood in case of emergency. Costs ranged from $60 (on sale) to about $90. A set of protocols has been prepared, and several drills a year are held to familiarize people with the use of this tool — “be brief,” “terminate transmission with ‘over’ even though it seems silly at first,” “start on channel X and move up to channel Y in case of interference,” and so on. We have tested the range of the radio system and located a spot (“Command Central”) to and from which transmissions can be understood regardless of their point of origin.

Some residents also purchased AC-DC converters ($12) and leave their radios always powered (with “Squelch” control set so they are quiet until a local transmission is made). In several cases where actual structure fires occurred in the neighborhood, the network was activated by a call from an alert CB owner, showing that it is not necessary for a given individual to be present to get the network going.

Maps

Residents prepared a number of different kinds of maps, including the following:

- Map of the streets and the trails in the surrounding hills.
- Map of all properties, obtained from Assessor’s office.
- Map showing location and boundaries of all clusters.
- Detailed map of each cluster showing location of all utility valves and shutoffs.
- Maps showing preferred escape paths.
- Map for use by CB radio users to identify origins of transmissions.

Emergency Supply Shed

At a central location, two clusters assembled an 8-foot by 8-foot prefabricated shed to hold cluster supplies and certain neighborhood-wide supplies (maps, logsheets for use in an emergency, etc.). The shed also holds a 12-volt storage battery, which is trickle-charged by a solar panel, to power CB radios for an extended period.

Paths

In addition to the obvious escape routes, we have identified and marked (with inexpensive reflective 2-inch dots) several additional escape paths. One resident constructed at personal expense a bridge over a small creek and a set of steps to create a safe exit from one difficult area.

Drills

In 1993 two neighborhood-wide drills were held:

March 1993: Commencing at noon on a Sunday, about 120 residents walked out of the neighborhood on streets or trails to an assembly point (parking lot of the University of California football stadium). CORE trainees monitored the event, and the CB network was exercised. At the stadium, Berkeley and Oakland Fire and Police Departments had stationed equipment and personnel, providing an instructive and enjoyable social experience for residents who participated.

October 1993: A supposed earthquake brought residents out to interact within their clusters (talking about preparedness, walking from house to house to show where utility valves and shutoffs were located). Simulated problems had been distributed among the clusters: several mannequins (loaned by the Oakland Fire Department Training Center) represented injured people; portable gas shutoff demonstration units (from the Berkeley and Oakland Offices of Emergency Services) were available for practice; and a number of “downed utility wires” were scattered about for residents to find and report using the CBs. About 20 residents later attended a street demonstration and description by an Oakland firefighter of the emergency supplies that he always carries in his personal auto. Afterwards, some clusters held a potluck or picnic.

Plusses

While the goals of these activities were serious, the activities had unexpected positive side benefits. People became much better acquainted with their neighbors. Several residents agreed formally to allow parts of their property to be used for emergency purposes. Residents met emergency personnel for the first time, in relaxed circumstances.

Cooperation among the constituencies involved has been notable. The University of California has funded brush reduction by a herd of 600 goats on land that adjoins the neighborhood; a grass fire that occurred was reportedly much less dangerous than it would otherwise have been. The University also installed two solar-powered emergency call boxes on its lands quite close to the neighborhood. These could be used to relay to the 911 emergency system early warning of a fire, and (being cellular phones) might serve as a needed communication link for the neighborhood after a major earthquake. The East Bay Regional Parks and the University cooperatively used a brush hog to clear fire trails in the area.

In the courses offered, whether a given resident lived in the Berkeley or Oakland part of the neighborhood was of no relevance. Stimulated by prodding from residents, city offices have taken legal means to encourage various property owners to reduce fuel loads on their lots. Another example of cooperation was the completion of one city's installation of reflective blue hydrant markers ("Bott's dots") by the other city, when the first city ran out of reflectors.

Problems

Though we are encouraged by what has happened thus far, we cannot ignore some important problems that we see:

Fuel Loads Remain High

In spite of more vigorous action by city agencies and urging by neighbors, the fuel load in the neighborhood and in the lands immediately adjacent to it remains dangerously high.

Contradictory Advice

Residents have been told that bamboo groves are, and are not, a fire hazard; only fuel on the ground matters, and that the limbs are unimportant; and foam is good for fighting structure fires generally, and that it is not. Most worrisome, some emergency personnel recommend privately that residents obtain fire hose and be ready to use it, but official policy forbids it.

Volunteer Labor Is Not Allowed

Ostensibly because of the fear of legal liability in case of an on-site injury, residents have been unable as yet to find persons in authority willing to let them volunteer their labor to help reduce fuel loads in the lands that surround the neighborhood. At the same time, budget limitations have severely restricted fuel reduction programs that use paid laborers.

Slow Response of Official Emergency Radio Station

The local 1610AM emergency radio station is slow to mount and remove announcements that residents might need to rely upon. For example, the March 1993 drill was supposed to have been started by a broadcast announcement, upon notification by the Berkeley Police, but the announcement was first broadcast twenty minutes after the drill started. Announcement of the October 1993 drill, which was supposed to have been taken off the air at the end of the drill, was still being broadcast two days later. And description of a wildland fire 5 days earlier was still being broadcast 5 days later when another wildland fire in a nearby area occurred. (Our reason for concern about having prompt response of the station will be made clear below.)

Waning Interest

With the fading of memories of Loma Prieta and the firestorm of 1991, the sensed urgency of making emergency preparations fades, and some residents lose interest.

Suggested Solutions

Here are some suggestions regarding these problems. The issue of cost is also discussed below.

Prevention

- To guide residents on what is dangerous, and particularly what conditions on lots under absentee ownership should be corrected, ask high-ranking firefighters from both cities involved to give a 1- to 2-hour walking tour of the neighborhood. City offices that issue citations for cleaning up should also be represented, along with the neighborhood's emergency preparedness committee.
- To reduce fuel loads on adjoining lands, organize a few work parties of volunteers from the neighborhood. This might also help our problem of waning interest. In addition, since the estimated costs of crucial clearing are relatively low (see below), an effort should be made to fund these projects from a source other than the University, in view of their wide benefits.
- The goat brush-clearing program is threatened for budgetary reasons. Its effectiveness has been demonstrated, and it should be continued.
- Provision of dumpsters and the visit of a chipper have convinced many residents to clear their properties, and both should continue to be made available.

Emergency Response

Our CB radio network has already proven useful in emergencies, but we are unable to communicate via that means with the most relevant emergency service, the Berkeley Police Department (BPD). Acquisition of a CB base station for use in BPD headquarters has been requested, but no money has been allocated. Can this small amount of funding ($250) be found elsewhere if necessary?

Telephone trees have proven useful, but they are clearly too cumbersome for use in communicating the urgent need to take a particular emergency action (for example, to evacuate on foot to the south because an as-yet-unseen major fire is approaching from the north). A suggested approach that could provide an early neighborhood-wide warning is outlined in *figure 1*. It relies on the ability of the emergency broadcast station to transmit quickly detailed emergency advice. A modest amount of equipment is also needed. If we can solve the "people" problems associated with getting the radio station to carry really current information and obtain the modest amount of funding required for equipment (around $250), this system could be functioning within weeks.

Financial Issues

Here are the estimated costs of the possible solutions just described:

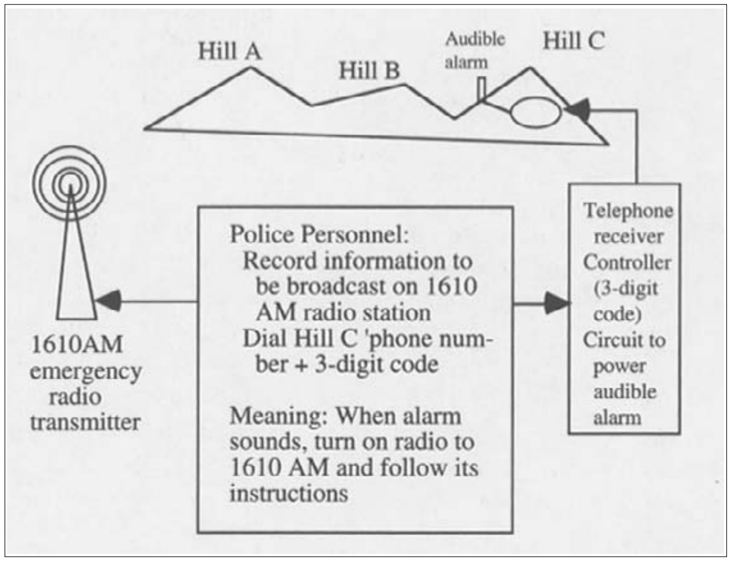


Figure 1– Proposed warning system for neighborhoods: If a specific warning regarding evacuation or the like is to be made to a given neighborhood (Hill C), the police would record the message for broadcast on the emergency radio station, and then dial a telephone located on Hill C. After the phone is "answered" (by the commercially available device), police personnel use their push-button phone keypad to send a 3-digit code that triggers sounding of an audible alarm. The meaning of the alarm is "tune in to the emergency radio station for instructions."

- Acquire and install CB base station at BPD so residents can communicate with police when landlines are down: $250.
- For the local police-activated alarm system, acquire necessary equipment ($200), install at one location ($150), and pay cost of telephone service for one year ($150). Non-recurring costs: $350. Recurring cost: $150 annually.
- Thin the University of California wildland north of neighborhood, leaving it amenable to periodic "touch-ups": $3,000.
- Similarly, thin the University of California wildland east of neighborhood: $4,000.

We have not been able to estimate the costs of some of the other items referred to above. In addition to the items discussed, there are more expensive problems that need correcting. One is the repair of a washout in one of the fire access trails near our neighborhood. Another is replacing old, heavily laden utility poles in neighborhood areas, to which access during an emergency would be vital, with underground utilities. (There is a program for gradual replacement of overhead lines, but the replacement schedule is reportedly "booked up" through the next decade. Emergency considerations should be given priority.)

One may well ask, should not individual residents bear the costs of fire prevention and emergency response? The answer is, to a large measure they have. Many residents have replaced wooden roofs with fire-resistant roofs, have had trees taken down and other growth removed. In addition, in taking the other emergency response steps described above, residents have spent in excess of $5,000 during the past 2 years. In view of this, allocation of public funds for some of the projects listed above seems equitable in view of the enormous cost that would be avoided if another major conflagration were prevented.

Conclusions

We look forward to continuing to work with emergency organizations in order to reduce the seriousness of the emergencies that will inevitably arise in the future. We hope that we can keep our neighborhood actively involved in this effort, through focussed periodic drills, the stimulation of volunteer work to reduce surrounding fuel loads, and through being further trained in emergency procedures.

Acknowledgments

The following neighborhood residents played especially important roles in the activities summarized above: Lindy Hahn, Sydney Kennedy, Penny Rink, and Marianne Tanner. Thanks also go to Debora Reismann, of the CORE Program, and other individuals too numerous to mention by name in the Offices of Emergency Services, Fire Departments, and Police Departments of both Berkeley and Oakland, as well as emergency personnel and other staff members at the University of California, Berkeley.

Conflicts Between Natural Resources and Structural Protection[1]

Stephen Bakken[2]

Abstract: Each parcel of government land carries specific land use constraints and objectives. This is also true of private housing and business developments. When government land, which was acquired to protect the natural or cultural resources, borders private land, which was acquired to build and protect houses or businesses, conflicts arise. The flammable native vegetation on the agency land is both a threat to the adjacent private landowner and the primary resource that the agency is sworn to protect. This paper covers the California Department of Parks and Recreation's response to this conflict.

All of the previous presentations in this concurrent session on the urban-wildland interface have focused on the protection of lives and buildings on the urban side of the fence. I would like to give a different perspective as the manager of land on the other side of the fence: the wildlands.

Most of you know that all government land is not managed the same; each Federal, State, county, or city land management agency has its own missions and objectives for each parcel of land. However, much of the lay public makes no distinction.

The California State Park System, like the National Park System, is a conglomeration of properties that were acquired to protect and manage: historic and archaeologic features, sensitive species of plants and animals, and representative examples of California's spectacular variety of ecosystems. That is the "Parks" part of our name. Its employees, including myself, have the responsibility, by law, to protect these features.

The other part of our name, "Recreation," indicates our mission to provide access so that the general public may enjoy these lands.

All private land is not managed the same, either, yet private property owners do share one goal with the California Department of Parks and Recreation—to protect their investment. Buildings are usually the most important investment for homeowners and business owners. The natural and cultural resources are the most important investment for Parks.

Moving Back to Nature

Protecting one's investment is an illusive concept. People usually move back to nature to escape the problems of the city. Parks provide some of the "nature" that people seek. Yet, in moving to the urban-wildland interface, these people do not wish to give up their lifestyle. Nor do they seem to accept any inherent risk.

Let's not kid ourselves; there is risk. Remember all of the natural disasters this country has experienced recently: fires, floods, hurricanes, earthquakes, mudslides, etc. Every square inch of land carries a degree of risk, some more than others.

People can reduce their losses from natural disasters, but cannot eliminate them completely. For example, they can avoid living in areas of high risk; they can construct buildings or modify the site to withstand the hazard by installing Class A roofing or removing vegetation; they can construct structures to prevent the hazards, such as sea walls to protect bluffs from being eroded by ocean wave action; they can purchase insurance; or they can do nothing and take their chances.

The urban-wildland interface dwellers try in vain to bring all the urban amenities and safeguards with them. The consequences are far more significant than most people realize.

Housing and business developments, at the very most, demolish all remnants of the native ecosystem. At the very least, developments subdivide the ecosystem so it will no longer function as the same system. The effects of these altered areas stretch beyond their physical boundaries.

Fire Management in the Urban-Wildland Interface

Let's put this into a wildfire protection scenario. A county permitting agency grants a developer the right to build on vacant property bordering a state park. Permitting agencies rarely take into consideration that wildfires are an inherent natural hazard of most sites, so many permits are not routinely sent to the fire protection agencies for review.

In order to increase the number of units per acre, there is an incentive for the developer to site buildings close to property lines.

Frequently the developer will scarify the entire development for ease of construction and replant with non-native plants, some of which may invade the adjacent native ecosystem in the park. Time passes, and the plants within and adjacent to the development grow, eventually attracting the attention of the fire protection agencies. The private homeowner or state parks are then put on notice to clear vegetation to create defensible space and weed abatement for the structure.

Either because of this notice, or to reduce his insurance premium, the private landowner may trespass onto park property to clear vegetation, demand that Parks clear their

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Forester, California Department of Parks and Recreation, 1416-9th Street, Sacramento, CA 95814.

property, or notify fire protection agency of the dangerous condition perpetrated by Parks.

The fire protection agency may cite Parks for non-compliance of the ordinances. In some cases, the fire protection agency may elect to clear the park property and bill the Department for the work. To add insult to injury, the Department is asked to pay for a destructive action on its property that is in direct conflict with its mission to manage natural ecosystems.

What is the primary purpose in constructing fire and fuel breaks? According to the newspapers, it is to protect everyone from wildfire. But look at this from Parks' perspective. Like everyone else, Parks is concerned with protection of human life and will evacuate all park visitors and employees' families during a wildfire. The Department has even gone so far as to close a park when the fire danger rating reaches extreme. And yes, like everyone else, Parks is concerned with protection of its facilities and performs the required vegetation clearance around structures. Indeed, some of these structures are irreplaceable historic buildings.

However, the Department is most concerned with the protection of its principal investment—the natural and cultural features. This is why the land was acquired and why each park unit is unique.

Parks usually does not want its native wildlands protected from wildfire; indeed, fire is the most important agent in the management of a dynamic functioning ecosystem in many areas of California.

Sometimes Parks might prefer that fire occur in a more planned fashion (i.e., prescribed burning), such as where long-term fire exclusion has produced an extremely high biomass, but we are usually not concerned that the plants and animal species will be irreparably damaged by an unplanned fire.

Ironically, some of the techniques used to protect lives and structures from fire can be very damaging to the natural and archaeologic features. Parks is most concerned with bulldozer activity, be it for a firebreak made at the beginning of fire season, or for a fire control line made during a wildfire. Firelines accelerate erosion, destroy archaeological artifacts, allow invasive exotic plants to establish, and degrade the visual esthetics of the park. The vegetation usually recovers quickly on burned areas regardless of whether the fire was planned or not, but may not return to dozed firelines for decades because the organic surface soil and stored seed has been removed.

The Department is also concerned with tree felling; it takes a long time to replace an old-growth tree that was dropped to extinguish a smoldering fire high on its trunk.

Most of the bulldozer lines on native wildlands are not to protect the park. They are constructed and maintained to protect the surrounding businesses and homes. This is an example of an indirect impact that stretches far outside of the private ownership boundaries.

I am not here to point fingers at the fire suppression agencies; they are only doing their job—to protect life and property. Indeed, if they do not diligently carry out that duty, they may be sued.

A newspaper editorial during the recent southern California wildfires was entitled "Public Lands Shouldn't Be Allowed to Become Lingering Hazards to Lives and Property." It would seem that Parks is negligent by perpetuating a hazardous condition.

What would be considered best management practices in this simplified example: a 10,000-acre park with one vegetation community, say chaparral? Parks would be remiss in its mission if it attempted to manage all of this community as one homogeneous block. Biological diversity would be better served if Parks were to maintain a mosaic of different age classes of the chaparral. The most ecologically suitable means to accomplish this is to burn scattered plots of the older aged chaparral each year.

Yet even this management scheme leaves more than half of the park in a flammable condition. Given hot, dry, windy conditions, a wildfire could spread in any continuous cover of chaparral and threaten adjacent property owners. This is a paradox. Parks can accomplish its mission using the most suitable ecological tool and successfully reduce wildland fuels, yet be held liable for maintaining a "hazardous" condition.

The political solution to this hazardous condition is frequently unilateral: "Parks needs to construct fire breaks on its land to protect the private landowner," or, if you have been following the Mount Diablo State Park controversy, "Parks needs to put non-native cattle on its land to protect the private homeowner."

Do I sound a little defensive? Well, I fail to see why it is Parks' responsibility to trash some of its most important investments—its natural and archeological resources, in order to protect someone else's investment. Yes, native vegetation will propagate a fire, but as the Oakland Hills wildfire reminded us, so will exotic plants, shake roofs, and redwood decks.

Solutions

It is the coordinators' wish that this conference initiate some concrete change in the way society does business at the urban-wildland interface. From the fire perspective, I would like to see two changes:

First, eliminate all of the barriers to prescription burning. Everyone here is probably aware of how difficult it is to conduct a prescription burn in the urban-wildland interface area given air quality constraints, burn logistics, potential liability, and public sentiment. Yet, this is the only tool that comes close to meeting the needs of my agency in managing natural resources while providing a reasonable degree of protection for the adjacent landowner. The greatest barriers that I see are smoke management constraints and the threat of litigation against the landowner and fire protection agency.

Second, the scope of liability for wildfire damage against land management and fire suppression agencies must be severely limited. As long as managing a native ecosystem using best management practices is determined by the courts to be equivalent to "maintaining a hazardous condition," then there can never be a solution.

The current situation is unworkable for my department. When a wildfire occurs, Parks either accepts significant resource damage from suppression activities or risks litigation. The only acceptable tool available to my department, controlled burning, will never be used to its full extent because of the gauntlet of constraints. When Parks is able to conduct a prescription burn, we still face litigation threat. A prescription burn that escapes is worse from a liability standpoint than an arson or accidental wildfire. Even a successful prescription burn can generate lawsuits. For example, if heavy rainfall, following a controlled burn, produces a mudslide that destroys a home, Parks will likely be sued.

In conclusion, without significant change in the constraints to prescription burning and especially tort liability, Parks will be unable to accomplish its mission in the urban-wildland interface zone.

I should not close without saying that Harold Biswell, or "Doc" as we called him, was instrumental in starting the Department of Parks and Recreation's Prescribed Burn Program. I believe that he would smile if this conference in his honor was instrumental in changing the way society manages fire in the urban-wildland interface.

PANEL DISCUSSION:
Regional Approaches to Urban Interface Problems

Regional Approaches to Urban Interface Problems[1]

Neil R. Honeycutt[2]

The urban and wildland interface (mix) problem exists in many communities in the United States. To effectively deal with these complex issues, cooperative approaches should be used to solve regional problems. This panel discussed the unique programs currently at work in Alameda and Contra Costa Counties in northern California. These programs were designed after the 1991 Oakland hills firestorm to address the specific problems in this predominantly urban intermix locale. The panel discussed the benefits derived from the formation of regional cooperatives that go beyond traditional geopolitical boundaries. The East Bay Fire Chiefs' Consortium and the Vegetation Management Consortium operate as components of the Hills Emergency Forum. The public sector Chief Executive Officers are responsible for ensuring that the lessons from the Firestorm are translated into public policy. The Bay Area Wildfire Forum is a private, nonprofit group of northern California firefighters.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Chief, Fire and Rescue Branch, State of California, Office of Emergency Services, 2800 Meadowview Road, Sacramento, CA 95832.

The East Bay Vegetation Management Consortium: A Subregional Approach to Resource Management and Planning[1]

Tony Acosta[2]

Formed in response to the October 20, 1991, Oakland/Berkeley hills firestorm, the East Bay Vegetation Management Consortium (EBVMC) is a voluntary association of public agencies concerned with vegetation management and planning related to fire hazard reduction in the Oakland/Berkeley hills. To date, a total of nine agencies are participating in the EBVMC, including local cities, park districts, public utilities, and educational and research facilities. Each agency owns or is responsible for significant open-space lands in the East Bay hills. The EBVMC is preparing a Vegetation Management Plan (VMP) oriented toward fire hazard reduction; this planning effort is funded by the Federal Emergency Management Agency (FEMA) through the Hazard Mitigation Grant Program, with FEMA and EBVMC agencies splitting the $330,000 total project cost. The VMP project was initiated in August 1993 and is projected to be completed by September 1994. The VMP has been developed with substantial public input by a team led by Amphion Environmental, Inc., an Oakland-based planning firm. The University of California, Berkeley, is also contracted to the EBVMC to develop a geographic information system (GIS) for the VMP. A Technical Advisory Committee and Citizen's Advisory Committee have been formed to provide review and comment on the VMP as it is developed. Several series of public workshops will also be presented to provide the general public with the opportunity to learn and comment about the VMP. The basic goal of the VMP is to reduce the risk and potential loss from future wildfires in the East Bay hills. This basic goal will be achieved by improving communication and coordination of work planning and activities between local agencies, establishing a resource-based approach to vegetation management (as opposed to a jurisdictional approach), and developing and implementing a consistent set of standards for vegetation management activities (ranging from land management prescriptions to residential parcel inspection criteria). Ultimate success for the EBVMC will depend on public support and political will to change traditional jurisdictional approaches to resource management and program funding.

---

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Parks Service Manager, Oakland Office of Parks and Recreation, 1520 Lakeside Dr., Oakland, CA 94612.

Regional Approaches to Urban Interface Problems: East Bay Fire Chiefs' Consortium [1]

Michael Bradley[2]

The traditional approach to planning for public fire protection has been based on independent actions by each fire department or district. The county fire chiefs' associations, while providing interagency communication, were not adequate to deal with the regional nature of the wildland urban interface problem. The formation of the East Bay Fire Chiefs' Consortium grew out of the need to provide regional solutions to these problems. This group is composed of representatives from all agencies that provide protection in Alameda and Contra Costa Counties in a common urban wildland interface zone more than 30 miles in length. The East Bay Fire Chiefs' Consortium serves as a clearinghouse for issues such as policy development, vegetation management, public education, fire response planning, and coordination of interdepartmental training.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Fire Chief, City of Hayward Fire Department, 25151 Clawiter Rd., Hayward, CA 94545.

Regional Approaches to Urban Interface Problems: the Bay Area Wildfire Forum[1]

Todd E. Bruce[2]

Abstract: Fire agencies throughout the San Francisco Bay Area formed a grassroots organization to influence a firesafe environment. The Bay Area Wildfire Forum (BAWF) was organized in 1992 to coordinate wildland fire training while promoting and encouraging further activities regarding wildland firefighting and fire prevention.

The Bay Area Wildlife Forum (BAWF) has sponsored, organized, and instructed four live fire training burns in the last 2 years. Hundreds of student firefighters learned to control, suppress, and survive a wildland fire. Also, a newsletter is circulated every other month to provide a valuable means of interagency communication. This has never before occurred within Bay Area fire departments. BAWF attributes its success to regional coordination, cooperation, and participation.

The San Francisco Bay Area has fast developed a fire history like that of southern California. The problems include years of drought, an oppressed vegetative fuel load, and the building of homes in the once undeveloped wildlands. Bay Area fire departments, already stretched thin by staggering budget cuts, have recognized that they can no longer handle these problems alone.

After the Tunnel Road Fire of October 1991, several Bay Area firefighters discussed the problems they were facing with today's wildfires. Most departments were experiencing problems with staffing levels. Different equipment, technology, procedures, terminology, and radio frequencies have created operational nightmares. They recognized the need for fire departments throughout the Bay Area to network on a regular basis.

Thus a grassroots organization, the Bay Area Wildfire Forum (BAWF), was formed. The bi-monthly meetings are hosted by a different fire agency. An educational presentation is given, followed by a roundtable discussion, and then the host fire department presents its agency's wildland firefighting program.

BAWF has made available to all member departments a cadre of highly skilled wildland firefighting instructors. In light of today's budgetary belt tightening, this is an invaluable resource. BAWF will also provide assistance to communities that want to develop a pre-suppression plan by designating the high-risk areas in the community and developing a written report. The plan can outline the local streets, fire hydrants, back-up water supplies, command post locations, staging areas, designated radio frequencies, helicopter landing zones, evacuation areas, etc. BAWF has established an excellent library of educational books, pamphlets, slides, and videos. Additionally, BAWF has a speakers' bureau for public speaking engagements in community organizations and schools.

It is the vision of the Bay Area Wildfire Forum that, one day, all the Bay Area fire departments will have a working knowledge of each other's organization and a sustained commitment by each organization to educate their community and enforce a wildfire hazard reduction program.

Mission Statement

The mission of the Bay Area Wildfire Forum is to provide for a broad base of support for speaking with a unified voice influencing a firesafe environment throughout the Bay Area and surrounding communities; to provide, through cooperation, practical and usable technology on an outreach basis; to assist the general public, planners, and governing bodies in implementing firesafe practices; to coordinate wildland fire training and fire safety activities; and to provide a model for agency cooperation and leadership to other areas of the state and country, which are examples of the progress that can be achieved through local, State, private, and Federal cooperation.

Goals

- To provide a forum for a group of local, state, private, and federal fire agencies who all have a common interest in the advancement and promotion of wildland fire control, training, and prevention.
- To promote and encourage standardization in wildland fire control.
- To promote and sponsor wildland training throughout the Bay Area.
- To promote enhanced interagency communications.
- To be a resource center for wildland public education and wildland fire prevention materials.
- To promote pre-fire suppression planning throughout the Bay Area.
- To remain available to anyone interested in the promotion of wildfire interagency cooperation and training.
- To sponsor the construction of a wildland fire simulator.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Fire Captain, Santa Clara County, Central Fire Protection District, 14700 Winchester Blvd., Los Gatos, CA 95030-1818.

Accomplishments

BAWF has more than 50 member agencies and a handful of individuals. BAWF has the full support and endorsement of the California State Fire Marshall, California State Board of Fire Services, eight of the nine Bay Area County Fire Chief and County Training Officers Associations.

Being a grassroots organization, BAWF has recognized the necessity to bring aboard a group of individuals who, based on their experience, can assist the command staff in avoiding "reinventing the wheel" and other common mistakes that new organizations are prone to make. This advisory board is composed of Dan Coffman, State Board of Fire Services (SBFS); Mike Vonada, SBFS; Chief Mike Bradley, Hayward Fire Department; Battalion Chief Mike Martin, California Department of Forestry and Fire Protection; Battalion Chief Bobby Dixon, Milpitas Fire Department; John Ackerman, Publisher, American Fire Journal; and Chief Douglas Sporleder, Santa Clara County Central Fire District.

Live Fire Training Burns

BAWF is most proud of its success with live fire training burns. It has sponsored, organized and instructed four live fire training burns in the past 2 years. Hundreds of students learned to control, suppress and survive wildland fires while under controlled live fire situations. Student firefighters were placed inside a tent shelter, and the fuel around them was burned. This simulated the heat, smoke, and sounds that one would encounter if forced to deploy their fire shelter.

In June 1993, firefighters from four counties participated in a 110-acre training burn. Representatives from two other counties were on hand to observe the exercise, gather information and report back to their respective agencies. The local media was invited to participate in the activities. The media attended a survival course, developed by BAWF, to give the media the tools needed to survive a wildland fire incident.

Communications

A newsletter is written, published, and circulated by the members and distributed every other month. This provides pertinent interagency information regarding training, prevention, and political and organizational facts. Included are training tidbits, meeting minutes, and other essential information. This has proven to be a valuable means of interagency communications that has never before occurred within the Bay Area fire departments.

Conclusion

The Bay Area Wildfire Forum is committed to raising the level of service, increasing efficiency, and maintaining interagency cooperation. Total support and participation by its member departments will be the only means by which goals will be accomplished. It is our hope that egos can be set aside so agencies will talk and begin to walk side-by-side. Many agencies have taken the first step, to endorse and support our organization. The next step is to get involved, assist with change, take a chance, and stake ownership so the same message can be sent to the public, lawmakers, and our firefighters.

Social and Environmental Issues in Developing Vegetation and Fire Management Plans[1]

Leonard Charles[2]

Abstract: To reduce the risk of wildfire in the California urban interface often requires actions that will be viewed by members of the public as having adverse effects on such resources as wildlife, vegetation, views, air quality, and recreational opportunities. These citizens can substantially delay and even thwart development of fire management plans. In developing such a plan for an area in southern Marin County, California, public agency staff and its consultants encountered significant public opposition. The successful completion and adoption of the plan required an extensive public participation process. The rationale and format for the public participation process are described. As important as the format selected is the mindset of the staff and consultants involved in the process. The attitude of "care" on the part of staff and consultants is investigated and found to be a critical attribute in dealing with the public on controversial plans.

The preparation of a plan for managing vegetation to reduce fire hazard in the urban interface requires not only the involvement of the necessary scientific and professional experts but a willingness by the lead agency staff and any consultants engaged by the lead agency to thoroughly and objectively comply with environmental review requirements (e.g., National Environmental Protection Agency [NEPA] or, in California, possibly California Environmental Quality Act regulations). This environmental review must include an open dialogue with environmental and community groups who may have significant questions and concerns regarding proposed vegetation manipulation. To ignore these questions or concerns can significantly delay approval and implementation, jeopardize eventual implementation of the plan, and/or foster a future atmosphere of distrust between the agency and the local community. Active and wholehearted inclusion of the public, including critics, can result in more environmentally sensitive plans than might otherwise be the case. Ultimately, dialogue with the public improves the chance of plan adoption and implementation, and it can foster an environment wherein the public is more confident of agency sensitivity to environmental and social concerns when making future land use decisions.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Environmental Analyst and Partner, Leonard Charles and Associates, Environmental Analysis and Planning, 7 Roble Court, San Anselmo, CA 94960.

Preparing a Plan for Southern Marin County, California

The Marin Municipal Water District (MMWD) owns 19,000+ acres in southern Marin County, California. This acreage is the primary watershed that MMWD uses to produce and store water provided to 57,000+ residential and business customers (i.e., hookups) in southern Marin County. This property plus an adjacent 1,200 acres owned by the Marin County Open Space District (hereafter referred to as the Study Area) is heavily used for recreational purposes. The numerous Study Area ridges capped by Mount Tamalpais, the tallest mountain in the area, provide the undeveloped visual backdrop for the many urban communities in the area. The 20,000+ acres that comprise the Study Area are considered by the public as one of the region's most important "resources."

The problem with this splendid resource is that the Study Area wildland borders residential neighborhoods of six cities as well as several unincorporated communities. The urban interface is a classic example of California development, with extremely expensive homes built on steep ridges where the trees and chaparral of the wildland interpenetrate the residential areas. No border separates the wildland and the developed areas. And wildland vegetation, or fuels, surround the residences for a considerable distance from the Study Area boundary. Access to the interface areas is limited; water storage and delivery systems are inadequate. The fire hazard is rated very high to extreme throughout the interface. Marin County is one of the wealthiest counties in the United States, and many of the most expensive homes in the County are located in this interface.

The Marin County Fire Department (MCFD) has responsibility for suppression of wildland fires in the Study Area. In the early 1980's, MCFD became concerned about the buildup of fuels on the Study Area and the consequent threat to adjacent residential neighborhoods. From 1982 to 1985, with MMWD approval, MCFD conducted a series of prescribed burns in the remote northern portion of the Study Area. In the autumn of 1985, MCFD conducted a prescribed burn on the south face of Mount Tamalpais that adjoins the community of Mill Valley. The objective of this burn was to burn off most of the chaparral on the south face of the mountain and the adjacent Marin County Open Space District (MCOSD) owned Northridge property. Soon after this prescribed burn was initiated, the weather quickly and drastically changed with the result that only small patches of chaparral rather than the targeted several hundred acres were burned.

These small burned patches on the mountain were perceived by a number of individuals as "scars" on the face of a beloved mountain, scars that had no effect on reducing fire hazard. Concurrent publication of analyses of the botanical effects of the earlier Study Area burns conducted by an independent reviewer described how those burns had produced several adverse effects on chaparral vegetation (Parker 1986, Parker and Kelly 1984). Given the identified adverse effects on vegetation and the visual scarring created by prescribed burns, a number of individuals mobilized opposition to a new (1986) MCFD proposal to conduct prescribed burns on the south face of the Mount Tamalpais. The Districts received letters of opposition from more than 50 individuals including representatives of most of the major environmental organizations active in the area. The Sierra Club Legal Defense Fund, among others, stated that an Environmental Impact Report must be prepared before any consideration of future burning.

MMWD then contacted our firm, Leonard Charles and Associates (LCA), about what work would be required to supplement the State's Program Environmental Impact Report (EIR) on chaparral burning in order to meet the California Environmental Quality Act (CEQA) requirements.[3] After meeting with our staff, MMWD determined that the State's Program EIR was insufficient to meet the stated requests for additional analyses and information. MMWD and MCOSD engaged LCA and Wildland Resource Management to conduct a series of Scoping Meetings with the public to determine what studies were required. Three meetings were held with representatives of environmental organizations and homeowners associations, local fire protection agencies and other pertinent public agencies, and the general public.

The consensus of these meetings was that before developing a plan for managing Study Area vegetation, the resources on the Study Area needed to be identified as well as the fire hazard probability, and the future state of the environment under existing management (existing management was primarily "letting nature take its course" and active fire suppression of all ignitions). LCA and Wildland Resource Management were engaged to prepare the Baseline Studies (Leonard Charles and Associates and Wildland Resource Management 1991). This report included a complete survey and description of vegetation on the Study Area, an analysis of fuels, computer gaming of wildfire behavior, mapping of fire hazards, analysis of future vegetation succession given current management, and installation of a Geographic Information System (GIS). The conclusions of these Baseline Studies were that there was an extreme fire hazard on most of the Study Area and in the surrounding residential areas. In addition, a number of threats to existing plant communities and species given existing management were identified.

The Districts determined that a Vegetation Management Plan (hereafter called the Plan) was required to address these concerns. After a competitive bidding process, LCA was engaged to prepare this Plan and the EIR for that Plan.

[3] Since this paper was originally presented, MMWD has certified the Final EIR for the Plan and has adopted that Plan. The Plan was adopted in October 1994. MMWD is currently implementing the Plan.

The Baseline Studies took nearly 2 years to complete. A Draft Vegetation Management Plan was completed in 1.5 years and accepted by the Districts in autumn 1993. The Draft EIR was scheduled to be published in early March 1994. By the time EIR review is completed and the Districts certify the EIR and act on the Plan, it will have been about 4 years since the planning process began.

Plan Contents

The Draft Plan is a site-specific description of vegetation manipulation to construct a series of fuel reduction zones on about 1,100 acres. A description and mapping of the prescriptions for more than 300 sites (i.e., polygons) are included with a description of the implementation of each technique, and monitoring requirements. The techniques recommended include manual and mechanical cutting of chaparral and woodland understory, thinning of overstocked coniferous stands, and prescribed burning of woodland understory, grasslands, and chaparral.

The Plan also includes programs for controlling and eliminating invasive, non-native plant populations, restoring threatened meadows/grasslands and oak woodlands, protecting and restoring rare plant populations, and upgrading road and water delivery systems. A complete monitoring format is included as well as staffing recommendations. Coordinated Resource Management Plans and Memoranda of Understanding programs are identified for critical areas of the Study Area perimeter that are owned by other agencies or individuals. The costs for treating each polygon are estimated, and a complete fiscal analysis and funding plan are included. Finally, the Plan includes detailed recommendations for work required in the urban interface outside the Study Area. The Draft Plan, including Technical Appendices and the Baseline Studies, includes over 2,000 pages of text. Prescriptions are mapped on large format maps. Baseline data and prescriptions are stored in the GIS.

Plan Preparation

All the time, effort, and costs of preparing these studies and plans may not have been necessary if the vegetation management were proposed in an isolated, rural area of the state or in areas that had recently and/or repeatedly witnessed the residential destruction implicit in urban interface wildfires. However, Marin County is an urbanized area, and a major wildfire has not occurred in the southern half of Marin County since 1945. Thus, a number of individuals and organizations had serious doubts about any plans to make the area "safer" by burning the vegetation on a treasured mountain and watershed.

Some may believe that MMWD and MCOSD should have opted to quickly proceed with preparation of a plan to alter vegetation and invited public participation only to the degree required by pertinent environmental and planning laws. From this perspective, planning should be the job only of those who ensure public safety and manage Study Area resources, such as fire protection and ecological experts. This perspective ignores the influence of the environmental organizations. It ignores that the environmental organizations and other interested parties have already complained about past management activities. It ignores the request for a full EIR made by the Sierra Club Legal Defense Fund and others. It ignores the independent analyses of Study Area burns that indicate adverse effects on vegetation. It ignores numerous articles in the scientific literature that warn against too frequent burning of chaparral and burning "out of season" (J.E. Keeley 1989, S.C. Keeley 1989, Parker 1987). It ignores the fact that MMWD and MCOSD are agencies with elected boards who must maintain a thorough dialogue with the public they serve. And it ignores that an educated public input can provide data and perspectives not available to staff and consultants and potentially improve staff/consultant-prepared plans.

Letters to the Districts opposing any additional burning on the mountain were not submitted only by local citizens. Such renowned scientists and authors as G. Ledyard Stebbins (1986), Peter Raven (Director of the Missouri Botanical Garden) (1986), H. Thomas Harvey (principal of Harvey and Stanley Associates, Inc.) (1987), and many other professors and scientists submitted letters opposing future prescribed burning or, at least, requesting that an EIR be prepared prior to consideration of such burning. The California Department of Fish and Game (1986) recommended no burning on the south and east faces of Mount Tamalpais and the Northridge property.

The Districts were cognizant of the problems that might result if the community was not fully involved in the planning process. They wisely insisted that the Plan be prepared by a group that included all necessary areas of expertise including public participation experts. The 21-member team preparing the Plan included botanists, fire ecologists, foresters, wildlife biologists, archaeologists, geologists, hydrologists, cartographers, land use planners, and public participation consultants. The EIR was being prepared at the same time as the Plan which allowed pertinent experts to review preliminary Plan recommendations to ensure that prescriptions would not harm sensitive or valuable resources nor result in unacceptable impacts; this ensured that the eventual EIR would not expose unforeseen critical impacts or flaws in the Plan.

Public Participation Component

While conducting the earlier scoping meetings and preparing the Baseline Studies, the opposition to any use of prescribed burning and, in many cases, to any manipulation of existing vegetation was evident. From the plan's inception, because of past disagreements, the agencies and any consultants they might hire were considered distrusted. The stated belief was that staff and consultants were simply developing a plan "to have something to do," "to manage for the sake of management," and to justify their jobs. Some believed that the Districts planned to proceed with prescribed burning no matter what any studies showed, that their minds were made up, and that the Districts were unwilling to listen to opposing viewpoints. Many of these same individuals believed that the Study Area did not need management, nature would be better off left alone, and any fire hazard should be addressed by residents making their homes fire safe, rather than treating wildland vegetation.

Given this opposition and the stated distrust of management and consultants, the Districts insisted that the consultant team include experts in public participation. A full public participation program was conducted. This included:

- Five community meetings/presentations—The consultants made presentations of goals, objectives, and preliminary recommendations. Verbal and written input was obtained from the public. The meetings were organized, hosted, and supervised by the public participation consultants.
- An in-depth telephone survey of 400 MMWD ratepayers—The public's opinions were obtained about proposed goals, objectives, techniques, and financing.
- Presentations were made to the MMWD Board and MCOSD Parks and Open Space Commission, and input was received.
- Newsletters.
- Press releases.
- Complete reports prepared as technical appendices for all public participation efforts.

Informal meetings between MMWD staff and the consultants with various environmental and community groups were also important efforts. Robert Badaracco, the MMWD Land Manager, hosted a number of field trips with interested organizations and individuals. He leased small buses and vans and toured the top of Mount Tamalpais to show individuals some of the hazards that were being addressed in the Plan. Consultants generally accompanied him, and together they answered questions and responded to concerns.

MMWD under Mr. Badaracco's initiative and management hosted a 2-day symposium, "Vegetation Management in Natural Areas," on April 3-4, 1992. Symposium speakers addressed a range of issues regarding fire hazard reduction in the urban interface. One of the aims of the symposium was to expose the local community to the points of view of experts throughout California.

The consulting team and MMWD staff voluntarily made contacts with most of the major environmental organizations. They attended informal potlucks, field trips, committee meetings, and ad hoc meetings where they made presentations, answered questions, and received input and criticisms. They made repeated efforts to inform those who expressed the most concern about the Plan about their timetable, approach, and intentions.

LCA maintains that this type of public participation was essential to deal with controversial issues involving vegetation manipulation in such a sensitive area. The actual participation format and the mindset of the consultants or staff were equally important. Many members of the community had become inured to typical "participation" meetings and approaches resulting in the common opinion that such meetings were simply an exercise, a sham, that allowed the lead agency to claim that it had actively sought public input. Individuals responsible for Plan preparation must be aware that he or she does not know everything and that there is value in divergent opinions. This is easy to say and it seems self-evident. However, when one has been working on a project for a long period of time, one begins to feel that one "knows" what needs to be done, what the effects of the recommendations are, what the benefits and costs are, etc. Changing course is difficult to consider once one has invested considerable time and energy developing a set of recommendations. To listen to points of view that are often diametrically opposite is difficult. To be directly or indirectly accused of bias and callousness towards plants, animals, views, etc. is difficult. And, to envision that one might actually be wrong is also difficult.

These critiques of one's work and one's self worth are not simply impassioned outcries. Many of the critics of the planning efforts for the Mount Tamalpais area are very familiar with the literature on the effects of prescribed burning in chaparral. They have reviewed prescribed burns done in other areas. They know where sensitive wildlife species occur in or near treatment areas. They are educated in the literature of ecological succession, restoration, etc. They are familiar with such alternative techniques as the use of foam and residential defensible space strategies. They are able to find the articles in the scientific literature that question or offer an opposite point of view to that held by most members of the scientific community. For example, a customized version of BEHAVE gaming was used to predict wildfire behavior on the Study Area; the exercise was used to gauge the efficacy of the recommended fuel reduction zones. Opponents to prescribed burning criticized the use of BEHAVE gaming as it was not developed for wildfire behavior in chaparral and were able to cite articles that likewise cited the limitations of BEHAVE.

The selective use of scientific articles to prove one's point or corroborate one's position is not a new phenomenon. Yet it remains a very effective means of blocking communication. Opponents using data from selected articles or selected sections of articles make a case that a recommendation or finding in the Plan is not accurate. They make these selections available to other individuals, many of whom are already prone to disbelieve the consultants. The consultants and staff are then accused of bias, of using only data that will support their position, and "if they are biased here, then how can we believe anything in this report." Thus, if BEHAVE gaming in chaparral is inappropriate, as some claim, then the entire exercise is simply a means of frightening people by using inadequate data. One of the main aims of public participation is to be able to discuss, even argue, about these conflicting claims. And the consultant or staff must engage in these conversations willing to learn, willing to admit one is wrong. Equally, one must be able to clearly argue one's position in the case if the opposing view is clearly incorrect.

Although it is incumbent to act in a professional manner when working with the public, an equally important attribute is to care—to care about the environment that has been manipulated and to care about other people's feelings and opinions. The care that consultants and staff brought to the meetings and dialogues with the public was critical in the planning process. Although all individuals still did and do not agree with the Draft Plan recommendations nor the data that were used to develop the recommendations, most people recognized that every effort had been made to be sensitive to environmental attributes but to also address the objectives of reducing the area fire hazard. They could see that staff and consultants cared about the same environment that they cared for and that while we might still be misguided, in their opinion, we were doing our best. This did not stop people from continuing to oppose certain aspects or to call for additional research when preparing the EIR. But for the most part the recriminations and untrusting atmosphere were eliminated from the final hearings of the Draft Plan.

This care and openness is best expressed in the small, informal meetings and conversations. By meeting in people's homes or when on walks on the Study Area, issues may be discussed in a way that rarely occurs in formal meetings or presentations. Opportunities are available for people to see that staff or consultants are real people who are informed and care about the environment and the issues. This personal contact cannot occur in large, formal meetings. Too often, individuals, especially representatives of organizations, have a perceived agenda at these larger meetings, and the ability to actually converse is lost. The time and organizational constraints of these larger meetings also restrict the possibility of open dialogue. Staff and consultants should strive to make themselves available for such informal meetings, conversations, and field trips. The trust developed in these dialogues can then influence the more formal dialogue at larger public meetings and public hearings.

The Draft Plan is based on continual monitoring of actions so that prescriptions and programs can be amended if unforeseen adverse effects are realized. This built-in ability to alter the Plan combined with a trust of staff and consultants' honesty helped assuage fears that the Districts were "running" over the public with a Plan that, once adopted, would eliminate the potential for future review and adjustment.

At the final public hearing where the MMWD Board heard testimony on the Draft Plan prior to approving it so that the EIR could be completed and distributed, representatives of most environmental organizations actually praised the Draft Plan for its sensitivity. Their remaining primary concern was how they were going to have some future voice in plan implementation (they sought some form of Citizens Advisory Committee), which is a political and not a planning issue. Although environmental organizations and other individuals remain concerned about the Plan, the general praise for the consultants, staff, and the Draft Plan is an indication that, so far, our approach to working with the public is an effective planning tool.

Currently, the Draft EIR is being completed for the Draft Plan. The public and reviewing agencies will review the Draft EIR and submit comments asking for clarification or additional information. After responding to all comments, the Final EIR will be submitted to the Districts. Once the MMWD Board (as Lead Agency) determines that the EIR is complete, it will certify that document. At that point, the Board can take action to adopt the Plan, which will probably occur in May or June 1994.

The Concept of Care

Preparation of a Vegetation or Fire Management Plan requires the full use of the expertise of various professionals. This paper has not focused on this expertise, nor the various approaches and techniques available for reducing fire hazard in the urban interface. Such approaches are the subjects for many of the other papers delivered at this symposium. Instead, this paper has focused on the often critical area of involving the public in preparing such a plan, because in addition to the basic professional knowledge, objectivity, and honesty that each participant in the planning effort must maintain, the attribute of care is helpful in resolving controversial planning matters. The American Heritage Dictionary defines the verb “to care” as: “to be concerned or interested; provide needed assistance or watchful supervision; have a liking or attachment; and have a wish, or be inclined.”

These definitions describe the attitude that a staff member or consultant can bring to controversial planning issues. Consultants must be concerned and interested in the planning issues and the target environment. They should also provide needed assistance and watchful supervision to ensure that the Plan is workable and that the effects are predictable. One should “like” the project, the affected environment, and the people involved.

One cannot fake care. One must possess it; at the very least, one must have the wish or inclination to see that the job is done well.

This focus on care is not intended as some “New Age” suggestion of a technique for improving job performance. Obviously, if one does not care about a particular planning effort, then one will proceed on whatever grounds one has found useful or successful in the past. Rather, it is an observation that in this particular planning effort, as well as our firm’s work on several other very contentious projects, the attitude of care can make the difference in successful adoption of a plan as well as the creation of an eased atmosphere for future decision-making.

Neither is this attention to care intended as an invitation to be nice to everyone. Some individuals purposely misuse data and public forums to promote their own narrow view. These individuals may have no desire to listen to opposing viewpoints, to compromise, or to reach a workable decision. These people can be quite vicious in their attacks not only on the data in question but personally. The staff member or consultant has no need to simply absorb such unwarranted behavior. However, such individuals must be handled in a professional manner that addresses the attack without allowing the discussion or the staff member or consultant to become simply reactive. When one becomes reactive, the entire public might be considered as hostile and the possibility of constructive dialogue might be seen as hopeless. It is too easy to react and judge a group by one or two obviously hostile members.

Care provides a long-term view of the situation. One can be angry, defensive, argumentative at times. However, if care is present, then one can focus on the fact that most of the public involved care themselves and are seeking the best for their environment, and that a solution that is effective and generally acceptable is possible.

Most importantly, care means to keep an open mind. A characteristic of many experts is that they become blinded by the very expertise that is their strength. Expertise should not be a shield to deflect opposing data or theories. To care is to recognize that all of us, despite opposing viewpoints, tend to become defensive about our area of expertise, especially if considerable time and energy has been expended to develop a plan or recommendation. To care is to continually be aware of this defensiveness and to try to remain open to a differing perspective even when that perspective includes a personal attack or criticism. It means to be willing to work a little harder.

Although one cannot necessarily order up care in oneself or one’s co-workers or subordinates, this attribute should be recognized when selecting staff members and/or consultants to work on a controversial project. Expertise in one’s field, the ability to effectively write and speak, and other attributes are certainly critical. The propensity to care is an equally valuable characteristic.

The Benefits of Public Participation

Including full public participation in the planning process is not meant simply as a method to deflect criticism of that process. Many real benefits result from involving the public, especially an educated public like the one involved with this vegetation management plan.

This plan addresses a controversial situation. The planning process took about 4 years, and this seems a long time. During the 4 years no work could occur, and one hoped that a wildfire did not ignite. But 4 years is not long for “project” approval in California. Many large development projects take at least this long from the initial planning stage through the environmental and project approval stages. If the Districts had decided not to conduct the Baseline Studies and simply developed a plan and an EIR on that plan, the EIR might have been substantially challenged, including a potential legal challenge. Those familiar with the CEQA process in California know how difficult it is to prepare a legally adequate

EIR that can withstand a vigorous legal challenge even for discrete development projects. The difficulty of assessing impacts on vegetation, wildlife, views, air quality, erosion, etc. for a plan that addresses a wide range of actions in various habitats over hundreds or thousands of acres is immense. If a community is unhappy with the planning process and the plan, they may find many "incomplete" analyses, omissions, and errors. They are likely to mount a legal challenge to such an EIR. This challenge adds months, even years, to the planning process, especially if the challenge is upheld by the courts, and the EIR must be amended and recirculated. Cases like these show that the full public participation approach outlined above is especially warranted.

Some of the other major advantages of public participation in this Plan included:

- The Plan preparers were exposed to many scientific articles and perspectives that they might not otherwise have known existed. Members of the public provided the consultants with full bibliographies of articles on the adverse effects of burning and re-burning chaparral, especially under wet season conditions. The California Native Plant Society and others provided data on the botanical significance of the chaparral community existing on the Study Area. The consulting team reviewed these data and determined that the botanical effects (as well as visual, hydrologic, and fiscal effects) of mass burning and re-burning of large areas of chaparral or other vegetation would have significant environmental impacts. As such, the Plan developed a series of discrete fuel reduction zones on critical ridge lines and other areas where fire access roads currently exist. Input from the public was an essential part of the data base used to develop the Plan. The local community often has many good ideas and particular knowledge about their environment.
- Environmental organizations and other individuals were willing to become participants in Plan implementation. For example, the California Native Plant Society (CNPS) has offered to assist the Districts in locating sensitive plant populations on treatment sites and to assist in expanding the inventory and mapping for sensitive species. The Plan includes a section on the extensive volunteer efforts in removing non-native plant populations and other necessary tasks. Volunteer labor is more likely from an involved community.
- Thorough public involvement ensured that the planners had fully investigated their recommendations and options to those recommendations. This participation ensured a thorough and objective analysis.
- As previously discussed, full participation built an atmosphere of trust between the public and the lead agency. This was beneficial in getting a plan adopted without legal challenges. It may result in an atmosphere wherein future planning and decision making is based on dialogue rather than conflict.

Conclusions

Preparing vegetation and fire management plans may involve changing vegetation in ways that are unpopular or unacceptable to certain members of the local community. In those cases where controversy occurs, the planning effort must include an open dialogue with the affected community. The formats for such dialogues are well known to most public agencies. Particularly controversial projects may require the inclusion of public participation experts. In either case, it is critical that staff and consultants who are in contact with the public remain objective and open in discussions with the public and that they seek every opportunity of meeting with members of the community. An open dialogue assists the planning process, often improves the chance for adoption of a workable plan, and can foster increasing trust between agencies and the public.

References

California Department of Fish and Game; [letter to Marin Municipal Water District]. 1986 August 8. 1 leaf on file with MMWD.

Harvey, H. Thomas. [letter to Marin Municipal Water District]. l987 March 16. 1 leaf on file with MMWD.

Keeley, Jon E. 1989. **Resilience in fire does not imply adaptation to fire: an example from the California chaparral**. In: Sharon M. Hermann and others, ed. Proceedings of the 17th tall timbers ecology conference: high intensity fire in wildlands. May 18-21, 1989; Roslyn, WA: Fire Research Institute; 113-119.

Keeley, Sterling C. ed. 1989. **The California chaparral—paradigms revisited**. Natural History Museum of Los Angeles County; Number 34, Science Series; 171 p.

Leonard Charles and Associates. 1993. **Draft Mount Tamalpais area vegetation management plan**. Report submitted to Marin Municipal Water District and Marin County Open Space District. 1,326 p.

Leonard Charles and Associates; Wildland Resource Management.1991. **Vegetation and fire management baseline studies**. Report submitted to Marin Municipal Water District and Marin County Open Space District; 625 p.

Parker, V. Thomas. 1986. **Evaluation of the effect of off-season prescribed burning on chaparral in the Marin Municipal Water District watershed**. Report submitted to Marin Municipal Water District.

Parker, V. Thomas. 1987. **Effects of wet-season management burns on chaparral vegetation: implications for rare species**. In: Elias, T.S., ed. Conservation and management of rare and endangered plants. Sacramento: California Native Plant Society; 233-237.

Parker, V. Thomas; Kelley, Victoria R. 1984. **The effects of wet season fires on chaparral vegetation in Marin County, California**. Unpublished report on file with Marin Municipal Water District.

Raven, Peter; [letter to Marin Municipal Water District]. 1986 August 8. 1 leaf on file with MMWD.

Stebbens, G. Ledyard; [letter to Marin Municipal Water District]. 1986 July 7. 1 leaf on file with MMWD.

PLENARY SESSION—Solutions

Working to Make the Clean Air Act and Prescribed Burning Compatible[1]

Trent Procter[2]

Abstract: The Federal Clean Air Act of 1963 offers a challenge to the future of prescribed and natural fire programs in the United States. One aspect of maintaining healthy ecosystems for humans and natural resources is clean air. In addition, prescribed and natural fire programs are an important tool in maintaining healthy ecosystems, as well as satisfying the requirements of Federal and State legislation concerning home and structure protection, protecting endangered species, maintaining natural wilderness processes, providing for multiple use, and providing healthy forests and resources for future generations. As legislation to protect the environment grows deeper and more complex, land management agencies find themselves in the position of sorting out conflicts and attempting to manage within legal and publicly acceptable parameters. Presenting a solution to this issue of conflicting legislative mandates will require: the ability of land management and air regulatory agencies to move beyond their normal roles and reach the best position for responsible ecosystem management, including human health concerns; land management agency cooperation in developing a uniform position and resolution; the development of a technically strong and credible resolution that shows sensitivity to the public health issue; strong upper management communication to State and EPA management; and timely regulatory development.

The Federal Clean Air Act of 1963 has been very challenging to the future of prescribed fire programs in California. Rules for prescribed fire need to be developed to meet the requirements of the Clean Air Act of 1990. The practice of allowing fire to play its natural role in wildland ecosystems was endorsed in a 1990 General Accounting Office (GAO) report (GAO/RCED-91-42). The report states that attempts to exclude fire from these lands could lead to major unnatural changes in vegetation and wildlife and contribute to uncontrollable wildfires as the result of an accumulation of fuels. Fortunately, building compatibility between the Clean Air Act and prescribed fire is not a process that needs to begin, but one that needs to continue and be strengthened.

Understanding the legislative history of the Clean Air Act and its apparent conflicts with legislation that guides management of public land is helpful in proposing solutions that create a balance between air quality, ecosystem health, and human health.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Forester, Sequoia National Forest, USDA Forest Service, 900 West Grand Ave., Porterville, CA 92357-2035.

Developing this balance is crucial to ecosystem management and will be the challenge of managing public lands in the future. As issues change, managers of public lands will be presented with the challenge of resolving conflicts between maintaining healthy ecosystems, people, and their economics.

Legislative History

Although the Clean Air Act of 1963 established air quality standards, it did not require State compliance. Amendments in 1967 required States to establish air quality standards but did not provide Federal minimums. In 1970, amendments to the Clean Air Act promulgated Federal standards for some pollutants as well as criteria for motor vehicles and fuels. In addition, one of the more critical components of the 1970 amendments was changing Federal responsibility for the Clean Air Act from the Department of Health, Education, and Welfare to the Environmental Protection Agency (EPA) (Baggett 1993). In 1970 Congress required the EPA to establish deadlines for compliance that, in the following 20 years, became a lesson in understanding the difficulty in achieving the standards. The 1977 amendments recognized the futility of a 1975 deadline and allowed States until 1987 to comply. The 1977 amendments focused on stationary industrial sources and introduced the Prevention of Significant Deterioration (PSD), providing the first opportunity to protect and maintain air quality in areas that were cleaner than the national standards. The amendments provided for Federal Implementation Plans (FIPS) if State Implementation Plans (SIPS) did not achieve compliance.

1990 Clean Air Act and Prescribed Fire

Because the 1987 national air quality goals were not attained, Congress enacted amendments to the Clean Air Act in 1990. The 1990 amendments address four broad categories that may affect the use of prescribed fire in California:

- Federal non-attainment area requirements for PM10 (particulate matter ≤10 microns diameter, 1 micron = 10^{-6} m)
- Conformity
- Air Toxics
- Visibility

Federal Non-Attainment Area Requirements for PM10

The 1990 amendments require dates for compliance of PM10 and other Federal non-attainment pollutants based on severity. Areas that are non-attainment for the Federal PM10 standard and able to demonstrate compliance by August 1994 were classified as moderate, and those areas unable to demonstrate compliance by August 1994 were classified as serious:

Moderate Areas	*Serious Areas*
Imperial Valley	Coachella Valley
Mammoth Lakes	Owens Valley
Mono Basin	San Joaquin Valley
Sacramento County	South Coast
Searles Valley	
San Bernardino County	

Air Pollution Control Districts classified as serious must develop revisions to the SIPS by August 1994 and demonstrate compliance by January 2001. Regulations to achieve compliance must be in place by August 1997.

The 1990 amendments require air pollution control districts not meeting Federal PM10 standards to address fugitive dust, residential wood burning, and prescribed fire. These elements of PM10 must be incorporated into State Implementation Plans revisions and subsequent regulations. Air pollution control districts are required to develop rules that incorporate Reasonable Available Control Measures (RACM) for moderate areas and more stringent Best Available Control Measures (BACM) for serious areas. These measures must be developed for fugitive dust, residential wood burning, and prescribed fire following EPA recommendations. The National Wildfire Coordinating Group participated in the EPA RACM/BACM guidelines.

Conformity

The conformity portion of the 1990 amendments, as well as EPA regulations that became effective in January 1994, require Federal agencies in Federal non-attainment areas to demonstrate that agency activities conform to SIPs. California's plan is a compilation of the States' air pollution control district plans.

In Federal non-attainment areas users of prescribed fire must quantify emissions to determine conformity. Projects may be analyzed in a collective programmatic plan if emissions are predictable or as a part of individual project plans. De Minimus levels, below which conformity determinations are not required, are set at 70 tons annually for serious areas and 100 tons annually for moderate areas.

Air Toxics

Perhaps the most uncertain potential effect of the 1990 amendments on prescribed fire may be the portions of the legislation that deal with toxics. The amendments require the EPA to develop standards for about 200 toxics. Some of these toxics, such as benzene and aldehydes, can be found in wildland smoke. Little progress has been made on toxic regulation development, but this is one element in the near future with potential to impact prescribed fire users.

Visibility

An important visibility-related element in the 1990 amendments is the formation of the Grand Canyon Visibility Transport Commission. This development reflected a Congressional desire to protect some of the nation's most pristine visibility. Recent research indicates that in addition to impact from nearby industrial sources, polluted air masses from California and neighboring western states also impact visibility (Malm and others 1990, Sisler and others 1989). Under certain meteorological conditions these air masses may travel hundreds of miles from large urban areas west of the Colorado Plateau. The Commission is charged with developing management options for all pollutants and sources that contribute to visibility impairment, including forest management activities. The Commission is expected to have draft recommendations prepared by June 1995 and a final report to EPA by November 1995. EPA must act on the final recommendations by May 1997, and California will be required to implement the EPA requirements by May 1998.

Working Toward Solutions

Solutions should be balanced. Prescribed fire users need to recognize air as a resource important to ecosystem function, visibility, and human health. Regulators need to understand that air is but one element of ecosystems that require management to provide for the welfare of the 30 million citizens of California.

Solutions to preserve the use of prescribed fire and reduce the PM10 contribution as a result of prescribed fire include:

- Prescribed fire user coordination.
- Technically strong resolution.
- Communication.
- Timely interaction.
- Upper management awareness.
- Public awareness.

Prescribed Fire User Coordination

Prescribed fire users should coordinate uniformity in proposals to reduce emissions, responses to draft regulations, and communication of the use and benefits of prescribed fire in California. Regulators will be much more receptive to incorporating a well coordinated multiple agency position into planning documents and rules. Well-coordinated input develops credibility and political strength as opposed to putting regulators in a position that requires technical judgments they may not be qualified to make.

A working group is recommended at the State/regional level to develop a framework for regulatory positions that ensures continuity of regulations and programs on broad ecosystem scales. The risk is that prescribed fire management options might vary dramatically between California's numerous air pollution control districts. Although statewide coordination is important, the vast majority of effort is required within individual air basins and air pollution control districts. After all agencies and organizations that may use prescribed fire are carefully identified, working groups need to be established. Interagency coordination groups have been established in the South Coast, San Joaquin, and North Coast air basins.

Communication

As prescribed fire user coordination groups develop, a strong communication link with respective air quality regulators will need to be established. Air regulatory agencies need to account for the interrelationship of fire with all ecosystem elements including air (Bagget 1993). This might be accomplished by establishing contacts or developing periodic meetings with PM10 planning staff. Communication should be frequent and strong enough to create an awareness and appreciation for the needs and objectives associated with improving air quality as well as prescribed fire. Dialogue might lead to a memorandum of understanding that clearly defines expectations in more detail than planning documents and rules. In addition, this would provide the framework for continuity, despite changing staff. At the State level, the recently formed California Air and Smoke Council will provide an opportunity for information exchange. Those participating have included the USDI Bureau of Land Management, USDI National Park Service, USDA Forest Service, California Division of Forestry, Environmental Protection Agency, California Air Resources Board, California Air Pollution Control Offices Association, and representatives from various air pollution control districts. This group will propose recommendations to meet regulatory compliance while maintaining the option for use of prescribed fire.

Technically Strong Resolution

Prescribed fire users need to improve their ability to quantify and manage emissions (Brown 1990). Although research needs should be clearly outlined, prescribed fire users should not hesitate to move forward with professional judgments and assumptions using the best information available. For instance, prescribed fire users can:

- Estimate emission factors, if unknown, based on similar fuel types.
- Estimate total emissions generated.
- Apply techniques to reduce and disperse emissions.
- Monitor concentrations of PM10 at sensitive receptors.
- Develop an emissions inventory.

The existing limitations must also be distinguished. Prescribed fire users cannot:

- Qualify natural or pre-European emissions in California.
- Produce reliable emission factors for all vegetation types.
- Quantify emission reduction techniques.
- Model for 24-hour concentration and predict transport in complex terrain.

Air quality analyses procedures as well as emission reduction techniques need to be institutionalized in agency training programs in order to meet expectations of air quality regulators. Additional research is necessary to resolve regulatory conflicts associated with emission production, combustion efficiency, and smoke management (Brown 1990).

Timely Interaction

In 1994, planning efforts and regulatory development associated with PM10 are moving forward in California at an extremely fast rate. Programs should not be interrupted, however, while the issue of conflicting laws and mandates is debated. Air pollution control districts are thus seeking early involvement to avoid conflicts with rule implementation.

Air districts will likely be conducting California Environmental Quality Act (CEQA) analysis with planning effort and/or rule development, providing an opportunity for evaluation of regulatory impacts on management of public land and public safety. Prescribed fire users need to understand the regulatory process. They need to evaluate the timing of efforts and to whom they should be directed.

Upper Management Awareness

Many Federal, State and county agencies in California are preparing to increase prescribed fire activities for a variety of politically sensitive reasons including recent catastrophic wildfires, spotted owl habitat needs, and a backlog of fire required to create more natural vegetation age classes. The relationship to sensitive issues implies a need to keep management briefed on the status and potential impacts of impending air quality regulations on prescribed fire programs.

Public Awareness

Most public agencies that utilize prescribed fire have developed some level of public education designed to explain the purposes of burning and notify people sensitive to smoke. In light of current regulatory action public awareness efforts should be increased in order to provide the public with enough information to understand the balance between air quality and prescribed fire. Given the importance of prescribed fire programs, agencies should review and revise every public awareness opportunity. In addition to taking advantage of existing public education programs, agencies should be prepared to be very visible and look for opportunities to provide presentations at public meetings associated with air quality regulatory development.

Conclusions

Regulations associated with the requirements of the Clean Air Act amendments of 1990 are developing rapidly to satisfy deadlines developed by EPA. The rationale and process to ensure that the Clean Air Act is compatible with prescribed fire are available. Solutions and success are rooted in communication, the ability to compromise, and the development of a technically credible method for analyzing and reducing emissions.

References

Baggett, Arthur G. 1993. **Only Congress can prevent forest fires: a comment on prescribed and natural fire programs and the Clean Air Act**. San Joaquin Agricultural Law Review: 3(197): 221-246.

Brown, James K. 1990. **The future of prescribed fire: concerns and knowledge needs**. In: Proceedings of the 10th Conference on fire and forest meteorology; 89-96.

Sisler, J.F.; Malm, W.C.; Gebhart, K.A. 1989. **Sources of ions producing acidic rain and visibility impairment at Grand Canyon, Arizona**. In: Proceedings of the 81st annual meeting of the Air Pollution Control Association.

Malm, W.C.; Gebhart, K.A.; Henry, R.C. 1990. **An investigation of the dominant source regions of fine sulfur in the western United States and their areas of influence**. Atmospheric Environment 24A: 3047-3060.

Comprehensive Fire Prevention Legislation Enacted by the California Legislature in 1992 after the East Bay Firestorm[1]

Rachel Richman[2]

Legislation was enacted by the California Legislature in 1992 after the East Bay firestorm on the Oakland/Berkeley border; it included roofing standards, brush clearance, and other safety requirements. Fire safety personnel and local government officials all participated in developing these measures and presenting them to the California Legislature.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solution in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Legislative aide, Office of Assemblyman Tom Bates, 3923 Grand Ave., Oakland, CA 94610.

Florida's Solution to Liability Issues[1]

Dale Wade James Brenner[2]

Abstract: Prescribed fire is used to treat roughly 5 percent (1,500,000 acres) of Florida's wildland each year. Superimposed on this fire-maintained landscape is one of the fastest growing populations in the United States. Much of this population increase is a result of immigration from northern states where ancestral ties with fire have been broken. Many immigrants want to settle along the urban/wildland interface, exacerbating an already detrimental situation. These new arrivals generally view fire as a destructive force rather than as a biological necessity. They have little tolerance for the temporary inconveniences associated with intentional use of fire and view the practice as archaic. Furthermore, many are retirees who have the time and inclination to become politically active. Recognizing that the public will ultimately decide the future of prescribed burning, agency and private resource managers have joined in a cooperative effort to ensure that prescribed fire continues as a viable resource management option. The three regional prescribed fire councils and the Florida Division of Forestry have taken the lead in a multi-faceted approach to accomplish this objective, including: 1) improving the image and competence of prescribed burners through training and burn-boss certification; 2) educating the public through speaking engagements, newspaper and television coverage of prescribed burns, feature stories, videos, and school-teacher guides; 3) enacting state legislation, agency rules, and county ordinances; and 4) opening communication with all parties, including prompt and even-handed response to complaints.

Florida is endowed with a mild climate and abundant sunshine and rainfall, conditions conducive to rank vegetative growth. Florida is also the thunderstorm capital of North America. These factors, coupled with the ubiquitous use of fire by Native-Americans during the past several thousand years, have produced a complex of vegetation communities, some sustained by chronic low-intensity fire and some by periodic stand-replacement fires. Fire exclusion, tried for several decades earlier this century, was found to be a short-sighted alternative characterized by escalating costs, decreasing probability of success, and unwanted ecosystem changes.

Wildfires must be suppressed for numerous reasons, so resource managers have been forced to learn how to harness this ambivalent natural force, not only to enhance our lifestyle, but to serve as an essential prerequisite to the very survival of these ecosystems.Virtually all Federal and State natural resource management agencies and some county agencies use prescription fire, primarily for hazard reduction, wildlife habitat improvement, and ecosystem perpetuation. Fire is used in the private sector by ranchers, forest product companies, game preserves, farmers, the sugarcane industry, and numerous other land owners to accomplish a wide variety of objectives. The 120,000 prescribed burn authorizations granted in 1994 resulted in the intentional treatment of 8 percent (2.3 million acres) of the 29 million acres under fire protection. Subtracting the acres burned for sugarcane production, land clearing, and agricultural stubble removal leaves, about 1,500,000 acres were treated by prescription fire during the unusually wet 1994 year—a figure well below the 10-year average.

Challenges

Superimposed on this fire-maintained landscape is one of the fastest growing populations in the United States. The population of Florida increased from 9.7 million in 1980 to 12.9 million in 1990, and is projected to reach 15.6 million by the year 2000. More than 900 immigrants arrive daily, and a large proportion are retirees from northern population centers where ancestral links with wildland fire have been severed. Of the 141,000 housing starts in 1993, 104,000 were single-family dwellings. Many new residents want to live along the ever-expanding urban/wildland interface where they will be directly impacted by fire management activities. Concomitant increases in the road network and traffic volume further exacerbate the situation. More effort is required to safeguard the public and protect homes from both wild and prescribed fires.

The public has trouble differentiating between these two types of fires. New arrivals are generally not aware of the benefits derived from the judicious use of fire, nor of its biological necessity. They regard a blackened landscape as obviously a damaged one. They have little tolerance for the temporary inconveniences often associated with prescribed fire such as slowed traffic, smokey skies, and fly ash in their swimming pools. Uninformed individuals intentionally setting fires are an enigma to them. Many, who question "wasting" their tax dollars on a practice that seems archaic at best, are retirees who have the time and inclination to become politically active.

Because of the inherent flammability of many of Florida's vegetative types, and the increased potential for catastrophic fire as fuel loads increase in the absence of periodic low-

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Research Forester, Southern Research Station,USDA Forest Service, Route 1, Box 182-A, Dry Branch, GA 31020; and Forestry Program Administrator, Fire Control Bureau, Florida Division of Forestry, 3125 Conner Blvd., Tallahassee, FL 32501.

intensity fires, the Division of Forestry (DOF) has recommended using fire to reduce hazardous fuel accumulations. But all too often, residents do not choose to allow these recommendations to be followed, and soon thereafter, firefighters risk their lives in an attempt to save homes in that subdivision.

Absentee landowners are an even more intractable problem. Vast tracts of land were subdivided and sold worldwide, but relatively few owners ever homesteaded. Again and again, copious plant growth during wet years was followed by the inevitable dry year resulting in disastrous wildfires that stretched available resources beyond capacity. The spread of fire-prone introduced species made the situation even worse. The Florida legislature addressed the problem of hazardous fuel buildup on absentee ownerships by passing the Hawkins Bill in 1977 (Wade and Long 1979). This law (Section 590.025 of the Florida statutes) gives the DOF authority to use prescribed fire, at State expense, to reduce hazardous accumulations of wildland fuels on private property provided the landowner does not object (*appendix A*). Under this law, more than 100,000 acres have been burned. Disastrous wildfires, however, still plague Florida because Florida, like other states, cannot afford enough "on-call" forces to handle worst-case scenarios.

Fires that threaten or destroy large numbers of homes or cause multi-vehicle accidents make the headlines, alerting the public to fire management issues. The occasional ill-timed prescribed fire with a bad outcome also receives full media coverage. Individuals and organizations who disagree with the concept of prescription fire use these incidents to strengthen their arguments. But even without these events, people criticize the practice of prescribed burning; and although criticism may sometimes be justified, many citizens are uninformed or misinformed. An alarming increase in smoke-related litigation is also occurring. Many of the judgments in these cases appear to give generous compensation for unsupported arguments.

In 1987, the Florida Supreme Court ruled that: 1) setting a prescribed fire was an inherently dangerous act; 2) the landowner is liable for damages to others for negligence in setting or maintaining that fire; 3) this liability cannot be delegated to an independent contractor actually conducting the prescribed burn; and 4) a landowner wishing to conduct a prescribed burn must know what "accepted forestry and burn standards" are and be certain they are applied.

In an effort to respond to public concerns, the DOF developed regulations that allowed termination of a prescribed burn if a complaint was lodged. But the DOF found this regulation was increasingly abused by callers with a different agenda. Furthermore, the tourist industry desired clear skies, while some environmental regulators advocated more stringent fire and smoke regulations.

Virtually all county, State, and Federal natural resource agencies in Florida were espousing similar fire messages and were practicing what they preached. Nonetheless, fire managers throughout Florida were witnessing a deteriorating situation. Conducting prescribed fires that met all regulatory restrictions, had no potential smoke impacts on the public, and still achieved the burn objectives in an efficient manner became increasingly difficult. Private individuals who used prescribed fire found it very difficult to obtain affordable insurance. The demise of prescribed fire, and along with it, the management and perpetuation of many of Florida's ecosystems, was a very real possibility.

Solutions

Recognizing that the public would ultimately decide the future of prescribed burning, agency and private resource managers joined together in an effort to ensure prescribed fire would continue to be a viable resource management option in Florida. Fire councils, similar to the one founded in south Florida in 1974, were formed in central and north Florida. These prescribed-fire councils are very pro-active, helping develop posters, publications, and other "handout" materials. They distribute these materials at schools and garden and community service club meetings in which they discuss the advantages and disadvantages of prescribed fire. They hold workshops to enhance the expertise of prescribed burners, host "show-me" field trips, sponsor demonstrations of emerging techniques and equipment, and co-sponsor meetings that address priority issues, such as the national conference on "Environmental Regulations and Prescribed Fire" scheduled for March 14-17, 1995.

The prescribed-fire councils are directing much of their educational effort toward the younger generation. They are helping develop a teachers' manual to introduce the concept of prescribed fire to school children. The role of Smokey the Bear, a fire prevention symbol, was expanded to include the benefits of the judicious use of fire as well. Tall Timbers Research Station produced two excellent videos on prescribed fire in the south, as well as a number of 20-second public service announcements for a Tallahassee television station.

Efforts to educate the public also include writing articles for local newspapers that provide a full discussion of potential deleterious side effects as well as the benefits of prescribed fire. Inviting the news media, especially local television stations, to prescribed burns has proven very successful. To help ensure the safety of the television crew on the burn, a knowledgeable spokesperson is assigned to be with them at all times. Another tactic is to involve local fire departments in prescribed burns. This gives department personnel an appreciation for prescribed fire and provides them with some first-hand experience in wildland fire behavior.

When necessary, peer pressure is applied to encourage prescribed burners to become better trained and to present a professional image. A good professional image is fostered by using personal protective items, maintaining equipment and tools, using "smoke ahead" signs to warn traffic, notifying appropriate law enforcement agencies and adjacent landowners before ignition, and taking the time to explain prescribed fire to anyone who stops to ask about a burn in progress.

The Division of Forestry has made several changes in its administrative rules and regulations. It developed a set of Best Management Practices (BMP'S) for prescribed fire use, tightened the criteria for issuing nighttime burning authorizations (smoke from these fires was a major source of complaints), and developed new training courses and safety requirements for its fire management personnel. One of the changes occurred in 1987 when a voluntary statewide program to certify experienced prescribed burners was implemented. As an incentive, the DOF was more flexible when issuing nighttime burning authorizations to certified burn-managers. When the certification program was begun, a person had to have served in a leadership role on at least three prescribed fires, attend an 8-hour review session, and pass a written test given at one of the 17 district DOF offices. The demand for certification was great, and it soon became obvious that a standardized certification process was needed. To standardize the certification process, a correspondence course has been developed which is administered by Hillsborough Community College in Tampa. Now, appplicants who pass the final exam must prepare a written fire prescription for approval by the DOF, and then have the results of the burn reviewed by the DOF as the final step to becoming a Certified Prescribed Burn Manager.

The DOF also developed an "official agency statement" about prescription fire. A draft of this statement was sent to selected people and agencies for review. The Forestry Forum, a statewide group of natural resource leaders representing public, private, and academic sectors, received a copy. Each year this group selects one critical natural resource issue, then develops and implements a strategy to address it. In 1987 it selected prescribed fire and asked the DOF to rewrite the statement in the form of a bill for submission to the state legislature. When introduced in 1989, this bill was not given much chance of enactment, but a dedicated lobbying effort resulted in its passage without serious opposition (*appendix B*). Legislators strongly supported the bill because they said it was the first time representatives of industry, conservation organizations, and state agencies had been in their offices at the same time promoting the same legislation. Legislators concluded that the bill must be vitally important to the management of Florida's natural resources.

The law, called the Florida Prescribed Burning Act (Florida Statute 590.026), is intentionally general so the DOF can use the administrative rule-making process rather than the legislative process to make changes (Brenner and Wade 1992). It includes a preamble that describes the necessity of prescribed fire and promotes its continued use for ecological, silvicultural, wildlife management, and range management purposes, and charges the DOF with promulgating rules for the use of prescribed fire. It also states that prescribed burns conducted under the auspices of this Act: 1) require a written prescription that must be on site during the burn; 2) be conducted only when at least one certified burner is on site; 3) are a landowner right; 4) are in the public interest and shall not constitute a public or private nuisance; and 5) protect the burner from liability for damage or injury caused by fire or resulting smoke unless negligence is proven.

To become a certified Prescribed Burn Manager in Florida, you have to serve in a leadership role on three prescribed fires, and either pass a comprehensive test designed for experience burners, or successfully complete the 6-day Florida Interagency Basic Prescribed Fire Course. Begun in 1989, this course is held several times a year at various locations throughout Florida. Each class is limited to about 30 students and must be sponsored by an organization. Sponsorship involves securing cadre from a short list of "approved" instructors, providing classroom facilities and areas to burn, and arranging for food. Within a region, a sponsor who can provide student housing is preferred because this facilitates evening trainee-instructor interaction and helps keep costs down. In return the sponsor is given 10 of the 30 student slots; the remainder are allocated on a first-come first-served basis. Hillsborough Community College (HCC) handles registration, distribution of pre-class study materials, and other administrative tasks. The only formal advertising needed to date is a flier HCC mails out each year with class dates and locations for the year and a registration form. The prime reason many graduates list for attending the course and becoming certified is the liability benefits associated with the certification law. Certified burn managers are currently attempting to convince insurance companies to offer them prescribed fire liability coverage at an affordable cost.

Florida continues to set aside numerous relatively small (10- to 100-acre) tracts of land to protect and perpetuate, particularly areas containing diminishing plant communities—virtually all plant communities that can be maintained only through periodic fire. As lands adjacent to these parks are subdivided and sold for home sites, agency resource managers are eventually left with no place to vent the smoke from prescribed fires. One solution involves passage of a county-wide local ordinance creating smoke corridors for the parks within its jurisdiction. Basically, such an ordinance establishes and delineates a smoke transport and dispersion trajectory for prescribed burns within a park. Developers are required to give potential lot buyers a copy of the ordinance, stating that the lot is located in a smoke corridor and will occasionally be impacted by smoke from prescribed fires (*appendix C*). Other solutions with similar results are being achieved through deed restrictions and conservation easements.

The Future

To date, more than 3,000 prescribed burners have become certified. This number is expected to increase rapidly when the prescribed-burn certification correspondence course becomes available. Over 900 burners, many from outside Florida, have graduated from the Interagency Basic Prescribed Fire School. Thirty sessions, including seven scheduled in 1994, have been conducted since its inception in 1989. The Florida Prescribed Burning Act has had a positive impact on prescribed burning but has not been tested in court yet. Georgia, Louisiana, and Mississippi have passed similar legislation, and a similar bill is currently before the Alabama legislature. Planning has begun to teach three of the new prescribed (Rx) fire effects courses approved by the National Wildfire Coordinating Group (NWCG) in Florida in 1994-95.

But we cannot rest on our laurels. Because fire is a two-edged sword that can be easily misapplied, fire management activities will continue to be closely monitored by regulatory agencies and critics. We must demonstrate that we are constantly striving to improve. Maintaining a good image and educating the public are continual challenges. And we must not falter in our effort to convince other lay and professional natural resource organizations to demonstrate their commitment to the need for and use of prescribed fire. For example, the Southeastern Section of The Wildlife Society recently passed a resolution recognizing the importance of prescribed burning in land management. As more organizations publicly support prescribed fire as a viable requirement to sustain certain ecosystems, our defense will strengthen against both those who think all fire management activities not related to suppression are ill-conceived, and those who simply believe we should not interfere with natural forces.

To date, Florida's multi-faceted approach to prescribed burning and smoke management issues has been a success. Whether this success is a result of rear-guard actions or a harbinger of an increased understanding of the need for and use of prescribed fire remains to be seen. As our population continues to swell, increased conflict between people and the environment should be expected. Hard decisions will have to be made. It is incumbent upon fire managers to initiate dialogue on emerging fire issues, respond to questions openly and honestly, show a willingness to correct mistakes, consistently strive to improve fire management activities, and support and conduct research to increase the database showing the necessity of fire to sustain healthy ecosystems. Then, whatever society ultimately decides, fire managers will have done their part to ensure the decision is based on knowledge, and not an emotional reaction to temporarily blackened landscapes or smokey skies.

References

Brenner, Jim; Wade, Dale D. 1992. **Florida's 1990 Prescribed Burning Act**. Journal of Forestry 90(5):27-30.

Wade, Dale D.; Long, Michael C. 1979. **New legislation aids hazard reduction burning in Florida**. Journal of Forestry 77(11):725-726.

Appendix A–Hawkins Bill (Florida Statute 590.025).

590.025 Control burning of wild land; authorization; conditions.

(1) As used in this section, "wild land" means:

(a) Uncultivated land other than fallow. Such land may be neglected altogether or maintained for such purposes as wood or forage production, wildlife, recreation, or protective plant cover.

(b) Land virtually uninfluenced by human activity.

(2) At the request of the governing body of a county, the Division of Forestry of the Department of Agriculture and Consumer Services is authorized and empowered, subject to the provisions and qualifications contained in subsection (3), and provided the owner of the land does not object, to control burn any area of wild land within the county which is reasonably determined to be in danger of conflagration if any open and uncontrolled fire were to occur in the area.

(3) No area of wild land shall be control burned under the provisions of this section unless notice of intent to control burn, describing particularly the area to be burned and the tentative date or dates of the burning, is published in a conspicuous manner in one or more newspapers of general circulation in the area of the burn not less than 10 days prior to the burn.

(4) In addition, the Division of Forestry shall prepare, and the county tax collector shall include with the annual tax statement, a notice to be sent to all landowners in each township designated by the Division of Forestry as a high fire hazard area. Such notice shall describe particularly the area to be burned and the tentative date or dates of the burning and shall list the reasons for, and the benefits expected to result from, control burning.

History § s. 1, ch. 77-17.

Appendix B–Florida Prescribed Burning Act (Florida Statute 590.026).

590.026 Prescribed burning; requirements; liability.

(1) Short Title § This section may be cited as the "Florida Prescribed Burning Act."

(2) Legislative Findings and Purpose.

(a) The application of prescribed burning is a land management tool that benefits the safety of the public, the environment, and the economy of Florida. Pursuant thereto, the Legislature finds that:

1. Prescribed burning reduces naturally occurring vegetative fuels within wild land areas. Reduction of the fuel load reduces the risk and severity of major catastrophic wildfire, thereby reducing the threat of loss of life and property, particularly in urbanizing areas.
2. Most of Florida's natural communities require periodic fire for maintenance of their ecological integrity. Prescribed burning is essential to the perpetuation, restoration, and management of many plant and animal communities. Significant loss of the state's biological diversity will occur if fire is excluded from fire-dependent systems.
3. Forest land and range land constitute significant economic, biological, and aesthetic resources of statewide importance. Prescribed burning on forest land prepares sites for reforestation, removes undesirable competing vegetation, expedites nutrient cycling, and controls or eliminates certain forest pathogens. On range land, prescribed burning improves the quality and quantity of herbaceous vegetation necessary for livestock production.
4. The state purchased hundreds of thousands of acres of land for parks, preserves, wildlife management areas, forests, and other public purposes. The use of prescribed burning for management of public lands is essential to maintain the specific resource values for which these lands were acquired.
5. A public education program is necessary to make citizens and visitors aware of the public safety, resource, and economic benefits of prescribed burning.
6. Proper training in the use of prescribed burning is necessary to ensure maximum benefits and protection for the public.
7. As Florida's population continues to grow, pressures from liability issues and nuisance complaints inhibit the use of prescribed burning.

(b) It is the purpose of this section to authorize and to promote the continued use of prescribed burning for ecological, silvicultural, wildlife management, and range management purposes.

(3) Definitions.§ As used in this section:

(a) "Prescribed burning" means the controlled application of fire to naturally occurring vegetative fuels under specified environmental conditions and following appropriate precautionary measures, which causes the fire to be confined to a predetermined area and accomplish the planned land management objectives.

(b) "Certified prescribed burn manager" means an individual who successfully completes the certification program of the Division of Forestry of the Department of Agriculture and Consumer Services.

(c) "Prescription" means a written plan for starting and controlling a prescribed burn.

(4) Rules.§ The Division of Forestry of the Department of Agriculture and Consumer Services shall promulgate rules for the use of prescribed burning.

(5) Requirements; Liability.

(a) Prescribed burning conducted under the provisions of this section shall:

1. Be accomplished only when at least one certified prescribed burn manager is present on site while the burn is being conducted.
2. Require that a written prescription be prepared prior to receiving authorization to burn from the Division of Forestry.
3. Be considered in the public interest and shall not constitute a public or private nuisance when conducted pursuant to state air pollution statutes and rules applicable to prescribed burning.

4. Be considered a property right of the property owner if naturally occurring vegetativefuels are used and when conducted pursuant to the requirements of this subsection.

(b) No property owner or his agent, conducting a prescribed burn pursuant to the requirements of this subsection, shall be liable for damage or injury caused by fire or resulting smoke, unless negligence is proven.

(6) Duties of Agencies.

(a) The Department of Community Affairs, the Division of Forestry of the Department of Agriculture and Consumer Services, and the Office of the State Fire Marshal shall prepare a report to be submitted to appropriate legislative committees by February 1, 1991, that shall identify actions required to minimize the threat of wildfire in areas where new development is proposed in or adjacent to wild lands.

(b) The Office of Environmental Education of the Department of Education shall incorporate, where feasible and appropriate, the issues of prescribed burning into their educational materials.

History § s. 2, ch. 90-234; s. 1, ch. 90-296.

Appendix C–Sarasota County Smoke Corridor Ordinance.

Sarasota County Planning Staff Report and Recommendation Reanalysis.
U.S. 41/Blackburn Point Road Villade Activity Center Sector Plan No. 89-02-SP

Attachment A

Conditions for Development Approval:

Section A:

V. The respective property owner/developer, their successors or assigns of all parcels east of U.S. 41 contained within the attached Recommended Future Land Use Plan labeled Figure 13, shall cause to be recorded to the Public Records of Sarasota County, Florida, a Notice of Proximity to the existence of the Oscar Scherer State Recreation Area. Said Notice shall be in substantially the same form as attached hereto as Exhibit A. Said Notice shall contain metes and bounds descriptions of the entire Parcels D, E, F, G, and H which will have been prepared by a licensed Florida Land Surveyor. Said Notice shall be recorded at the time of the recording of a final plat or condominium plat survey and which O.R. Book and Page shall be set forth within such plat. Said Notice shall also be required as a part of all Deed Restrictions and Condominium Documents. Said Notice shall indicate the Oscar Scherer State Recreation Area's right to the following: continuing current resource management practices to include but not be limited to ecological burning, exotic plant and animal removal, usage of heavy equipment and machinery and other practices as may be deemed necessary for the proper management of the Oscar Scherer State Recreation Area. Also included shall be a reference that Department of Natural Resources regulations and policies substantially restrict mosquito control in the Oscar Scherer State Recreation Area. Said Notice shall also be referred to in all deed and or property restrictions within Parcels D, E, F, G, & H in the Sector Plan, and said Notice shall be subject to review by Florida Department of Natural Resources legal staff.

Attachment B

NOTICE OF PROXIMITY TO OSCAR SCHERER STATE RECREATION AREA/ CONSERVATION EASEMENT

This Notice date this ______ day of ___________ , 199_, and entered into the public record by and _________________________ , as owners of the property described as:

SEE ATTACHED EXHIBIT I
(Insert description of subject property owned within U.S. 41/Blackburn Point Road Sector Plan No. 89-02-SP)

WHEREAS, it is the intent of this Notice to make known to the public-at-large that the property described in Exhibit "I" attached hereto is located in close proximity to the property known as the Oscar Scherer State Recreation Area/Conservation Easement

WHEREAS, it is further the intent of this notice to advise potential tenants and purchasers of subdivision property located within the boundaries of the property described in Exhibit "I" attached hereto, that said property is in close proximity to the Oscar Scherer State Recreation Area/Conservation Easement.

NOW, THEREFORE, the general public and those parties specifically purchasing or leasing property within the area described in Exhibit "I" attached hereto are hereby notified that:

1. The subject property described in Exhibit "I" attached hereto is located in close proximity to the Oscar Scherer State Recreation Area/Conservation Easement.

2. This Notice is to further advise potential purchasers or tenants of property described in Exhibit "I" attached hereto that the proximity to the Oscar Scherer State Recreation Area/ Conservation Easement may result in said purchasers or tenants being affected by: continuing current resource management practices to include but not be limited to ecological burning, pesticide usage, exotic plant and animal removal, usage of heavy equipment and machinery and other practices as may be deemed necessary for the proper management of the Oscar Scherer State Recreation Area/Conservation Easement.

3. The nature and extent of the effects of the operations of the Oscar Scherer State Recreation Area which shall include: All management practices as contained within the document entitled "Ecological Burn Plan Oscar Scherer State Recreation Area" adopted on April 3, 1990, and which may be amended from time to time.

4. All property owners which take title to property within the boundaries as described in Exhibit "I" attached hereto, or tenants who may occupy the premises within the boundaries described in Exhibit "I" attached hereto, shall be deemed to have constructive knowledge of this Notice due to its recordation in the Public Records of Sarasota County, Florida, and further shall be deemed to have consented to said resource practices, including ecological burning, pesticide usage, exotic plant and animal removal, usage of heavy equipment and machinery and other practices as may be deemed necessary for the proper management of the Oscar Scherer State Recreation Area/Conservation Easement by the recording of a Warranty Deed or other instrument of conveyance, conveying the property within the boundaries in Exhibit "I" attached hereto, or by executing an occupancy agreement and delivering same to the owner of property contained within the boundaries of the property described in Exhibit "I", their successors or assigns.

IN WITNESS WHEREOF, the owners have hereunto set their hands and seals this _____ day of _______, 199 __.

_________________________________ _________________________________

_________________________________ _________________________________

STATE OF FLORIDA
COUNTY OF SARASOTA

I HEREBY CERTIFY that on this day before me, an office duly qualified to take acknowledgements, personally appeared
and ___________________, to me known to be the persons described in and who executed the foregoing instrument and acknowledged before me that they executed same.

WITNESS my hand and official seal in the County and State last aforesaid this ______ day of ________, 199 .

NOTARY PUBLIC

My Commission Expires: (Notary Seal)

The Role of Fire in Ecosystem Management[1]

Jerry T. Williams[2]

Abstract: USDA Forest Service management practices have significantly changed. Past practices were predicated on a strong public expectation for commodity production and protection from the forces of nature that were perceived to threaten that goal. Fire suppression, selective logging, intensive grazing, constrained prescribed burning, and a general emphasis on wood fiber production have, in part or collectively, changed many forests. However well-meaning at the time, in some ecosystems, these changes have adversely affected the health and resiliency of the resource to the point where sustainability may be impeded. Currently the Forest Service has modified its focus and its management practices. These changes have important implications for the agency's wildland fire managers. This paper describes the role of fire in ecosystem management and it answers these three questions: 1) what is ecosystem management? 2) why should fire be considered in ecosystem management? and 3) what role do fire managers have in ecosystem management?

What is Ecosystem Management?

Ecosystem management emphasizes an ecological approach to resource stewardship. It is a holistic approach to natural resource management that attempts to manage the forest, not just the trees. It focuses on long-term landscape management of basins and provinces, not just stands within 10-year planning cycles. The premise is that, in managing for whole, healthy ecosystems, we are better able to sustain resource outputs for the future. Instead of emphasizing short-term resource extraction, ecosystem management attempts to manage for the healthy, long-term functioning of the entire system, with the expectation that, in doing so, commodity and amenity outputs will follow on a sustainable basis.

In some forests, ecosystem management will require that essential ecological processes, such as fire, become more widely included. In these forests, the condition of the resource will ultimately be influenced by the ecosystem's ability to function within natural ecological amplitudes.

Certainly, ecosystem management is more a journey than it is a destination. More than 70 years ago, Aldo Leopold recognized the inextricable webs that define the science of ecology and our understanding of ecosystems: "we [must learn to] realize the indivisibility of the earth—its soil, mountains, rivers, forests, climate, plants, and animals, and respect it collectively" (Meine 1988).

Ecosystem management can also appear to be a contradiction in terms, as Frank Egler remarked, "Ecosystems are not only more complex than we think, they are more complex than we can think" (Egler 1977).

Despite much information about this type of management, we are not yet always able to manage for whole ecosystems. In our attempts to provide for public expectations today—whether clean air or rare owls or big trees—we need to ask ourselves if we might be managing for one thing at the expense of another. In managing for discrete components of the ecosystem, might we be inadvertently jeopardizing the health of a larger whole?

The concern may be most acute in fire-adapted ecosystems. Sustaining these systems in a healthy condition will require the use of prescribed burning. The smoke and risk and cost of those treatments are almost always socially intolerable. However, avoiding treatment promises to result in consequences far worse. In some areas of the United States, we may be glimpsing some of those consequences.

To understand and manage ecosystems we must remember a cornerstone to the concept of ecosystem management: the adaptation of our practices in response to acquired knowledge. In that respect, the development of our thinking and our management practices remain evolutionary.

Why Should Fire be Considered in Ecosystem Management?

The biological effects of fire have a profound influence on composition, structure, and function of forest, brush, and grassland ecosystems on National Forests. The effects of fire are particularly apparent in short interval fire-adapted ecosystems in which fires resulting from lightning or burning by Native Americans, for example, were the most frequent, generally occurring at 5- to 25-year intervals. These ecosystems were the first to manifest adverse biological consequences because of fire exclusion. Fire-related ecological problems are most immediate in short interval fire-adapted ecosystems.

In the prolonged absence of periodic, low-intensity surface fire, stands undergo relatively rapid changes in species composition and structure that often become predisposing factors to epidemic insect and disease outbreak and severe stand replacement wildfire.

Significant forest health problems appear to be most concentrated in short interval fire-adapted types, commonly represented by long-needle pine species (e.g. ponderosa,

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interfaced and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2] Assistant Director—Fire Operations, Fire and Aviation Management Staff, USDA Forest Service, Washington DC 20250.

Jeffrey, eastern and western white, red, loblolly, short-leaf, long-leaf, and slash pine). These pine types, as either dominants or in association with other species, are estimated to occur on nearly 30 percent of the suitable timber base on National Forest lands.

The Blue Mountains in northeastern Oregon and southeastern Washington, the mountains in south-central Idaho, the Colorado Front Range west of Denver, and the central Sierra in California—all conifer-dominated short interval fire-adapted ecosystems—are areas plagued by serious forest health problems. They are also areas where severe wildfires have recently occurred and, inevitably, will recur.

What Is the Role of Fire Managers in Ecosystem Management?

Sustaining short interval fire-adapted ecosystems is expected to be a difficult challenge. In order to better prepare the Forest Service for the issues that are likely to emerge, the USDA Forest Service's Fire and Aviation Management Staff directed development of staffing paper Fire-Related Considerations and Strategies in Support of Ecosystem Management (Williams and others 1993). This paper made five recommendations that were recently adopted as fire and aviation management goals:

• Communicate the ecological roles of fire to our decision-makers and the public. In short interval fire-adapted ecosystems, complex issues are inherent and the risks that surround wildfire threats and prescribed fire applications sharpen the potential for conflict in the social arena. The Forest Service will more completely develop and communicate the scientific rationale behind management of fire-adapted ecosystems.

• Display the long-term effects of prescribed fire and wildfire suppression options. The land management planning process affords the means to display trade-offs, assess benefits and consequences, and determine costs among a full range of alternatives. In order for the public and our decision-makers to benefit from the information required to make informed judgments, fire and aviation management will better display the long-term effects of prescribed fire and wildfire suppression options.

• Maintain strong wildfire suppression capability and continue to strengthen prescribed fire expertise. Fire suppression capability will remain a vital cornerstone of the Forest Service mission as fire-adapted ecosystems continue to approach high-risk conditions and as private development continues to expand at the wildland/urban interface. Prescribed fire, despite the concerns that surround its use, remains an important, ecologically appropriate management tool. Fire and aviation management will develop practitioners that have the skills to use fire safely and effectively.

• Manage prescribed fire risk: assess it, mitigate it, and seek partners to share it. Risk management will become a fundamentally important component of the prescribed fire program. A risk assessment process will become the basis for ignition decisions. Managers will be better apprised of high-risk prescribed burning treatments and avoid them, unless they can be adequately mitigated or risks can be shared among partners. Fair, timely reimbursement will be provided the public in the event of loss resulting from prescribed burning escapes.

• Align fire management programs to better complement one another. Although fire policies are sound, program areas (prevention, pre-suppression, suppression, fuel management, and prescribed fire use) will be fully integrated, better reflect a common purpose, and complement one another toward an ecosystem management objective.

These goals and actions signal important changes for Forest Service fire and aviation management. They require that managers take a proactive role in explaining the consequences of both the presence and absence of prescribed burning and wildfire suppression and fully integrate these considerations into the decision-making process. They also require an improved, more balanced fire management approach to land and resource management.

References

Egler, Frank E. 1977. **The nature of vegetation: its management and mismanagement: an introduction to vegetation science**. Norfolk, CT.

Meine, Curt. 1988. **Aldo Leopold: his life and work**. Madison, WI: University of Wisconsin Press.

Williams, Jerry T; Schmidt, R. Gordon; Norum, Rodney A.; Omi, Phillip N.; Robert G. 1993. **Fire-related considerations and strategies in support of ecosystem management**, USDA Forest Service, Washington Office Service Staffing Paper.

Structural Wildland Intermix[1]

Ronny J. Coleman[2]

Abstract: Because many major population centers are located in wildland areas, many structures have been destroyed by increasingly more costly wildland fires. The structure and jurisdiction of the fire service in California are complex, and a uniform approach to fire prevention is lacking. A description of many of the fire issues in the wildland-urban intermix is provided. The relationship between State and local governments is at the heart of many of the issues. Cooperation between State and local governments coupled with public education and enforcement of current standards and regulations should reduce the occurrence of catastrophic wildland-urban intermix fires.

Wildland fire has been a recurring component of California history. Native-Americans intentionally set fires to the same areas that have currently suffered from major fires. Researchers have determined that about 12 percent of the State of California was burned every year by various Native-American tribes.

In the early 1920's, at about the same time development began in the foothills, firefighting agencies became active in trying to prevent fires from occurring in these areas. Fuel loads became extraordinary after about 20 years with no fire. A major catastrophe (the Berkeley fire) occurred in Berkeley as early as 1923.

Major population centers are now located on formerly uninhabited wildland areas. Fuel loads are of such a magnitude that the fires have increased in frequency and severity, are destroying large numbers of structures, and are becoming extremely costly to combat. They are a major factor in what is now classified as the urban wildland interface or "intermix."

Frequency of Loss

In the past, Californians suffered a major fire loss about every 7 to 10 years. Catastrophic fires have now occurred each year from 1990 to 1993. In each of the last three after-action reports, one benchmark statement reflects the increasing severity of these fires: "this is the largest single mobilization in the history of California." The costs to suppress these fires are substantial and the trend is likely to continue. We can reasonably expect another fire of significant loss in the next 12 to 18 months.

According to the California Fire Census, more than 390 of about 1,000 separate fire departments currently claim to have an urban wildland interface problem. These communities range in size from small fire districts to metropolitan fire departments. The census contains numerous data elements that reflect both the prevention and suppression capacity of the California Fire Service. This document clearly illustrates that the jurisdiction and structure of the fire service in California is quite complex, thus contributing to the lack of a uniform approach to prevention efforts.

The spiraling losses are partially the result of the denial of the fire problem by both individual property owners and, to some degree, local government officials. The mistaken assumption that larger and larger mobilization efforts are needed to limit losses is also a factor. Although the media responds with major coverage to the scenes of these events when in progress, the follow-up coverage and resolution of specific mitigation efforts is of relatively insignificant media interest. The California urban/wildland fire problem is not perceived as a major policy consideration by local or State government when compared to other issues. When the fires are in progress, everyone is interested. As soon as the fires are over, the issue becomes secondary to daily concerns.

Written documentation from the last 10 years of these fires suggests that the specific findings from each successive fire is consistent with the findings of the previous ones. The more common factors that lead to catastrophic losses are well-defined and repeated in report after report. The mitigation efforts that are fairly effective are also well-defined. However, cohesive action that would result in comprehensive changes is lacking. For example, some mitigation efforts apply only to the burned area. In actuality, the mitigation efforts must be applied in areas that have not burned or the effort is wasted.

Fires in the recent past have resulted in a significant economic impact on the State. Fire losses are only one factor. The impact on the tax base and the costs of suppression are equally important. For example, the Oakland fire of 1989 removed over $100 million of assessed valuation from the tax rolls of that city alone (in accordance with Revenue and Taxation Code, Article 70 and Article 74). These last fires will probably result in significant reduction in the assessor's tax rolls in Orange, Los Angeles, and Ventura Counties. During the period of rebuilding, property taxes are not paid by the affected property owners. In addition, after rebuilding, the property owners are protected from incremental tax increases based on Proposition 13 provisions.

Fire suppression costs are severely impacted by the need for overtime to provide adequate personnel resources. Initially, responding engines are taken from on-duty

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17,1994, Walnut Creek, California.

[2]State Fire Marshall, California Fire Marshall Office, 7171 Bowling Drive, Sacramento, CA 95823.

companies. But, when the engine company leaves the community, it must be backfilled to maintain coverage in the community. This means bringing in personnel on an overtime basis. Because of Federal Fair Labor Standard Act requirements, overtime compensation is almost always at a time-and-one-half rate. (Responding agencies usually leave fire engines on the scene of major fires past their original 24-hour shift.) A single engine company on a fire is actually two companies at a rate of about $2,000 per day. A significant amount of the staffing costs are involved in the time it takes to demobilize an incident. Some documented cases show that strike teams can take more than 12 hours to get out of demobilization areas. We are paying the costs portal to portal.

Personnel costs also include workers' compensation costs that are inordinately high compared to other types of fires. According to 10 years of firefighter fatality data, 30 percent of all firefighter deaths are attributed to only two types of fire: grass and wildland. The death of a firefighter has a price tag to the taxpayer of about a million dollars per death in workers' compensation costs.

The Causes of Property Losses

We are losing more structures in these types of fires because of (1) the speed of the initial fire; (2) stressed environmental conditions; and (3) fire intrusion into a structure because of lack of an integrated system for fire resistance.

Speed of the initial fire merely means that many of these fires are entering into intermix zones and destroying structures before enough resources can be mobilized to make a significant difference. Although we ultimately deploy hundreds of apparatuses and thousands of firefighters, resources in these numbers are usually not available until after major damage has already occurred. The rate of heat release in areas with limited fuel modification is vastly greater than the suppression capability available to most fire scenes within the first 4 hours of the fire. The Oakland fire scenario, for example, demonstrated that the majority of losses occurred in the first 2 hours of the fire. The first 4 to 8 hours of these fires are more critical now than the next 48 hours. This phenomenon places much more priority upon initial attack capability.

Extraordinary losses can also be explained by the phenomena that many structures are lost after the first wave of fire hits. This is because resources are often removed from one neighborhood and sent to another area of the active fire front. When the fire front is moving at a faster rate than the rate at which resources are arriving, secondary fires are often left unfought in evacuated neighborhoods. The fires rekindle and destroy structures that could have been saved if fire apparatus had not been redeployed. Although we are proud of our mobilization efforts, the driving of a strike team from northern California to a fire in Laguna Beach looks good, but does not reduce actual losses.

Stressed environmental conditions mean that in high wind, high temperature, low humidity weather conditions coupled with steep topography and dense fuel conditions, no amount of conventional fire suppression can adequately protect structures that lack defensible space or structural integrity.

Structural intrusion means that structures are not inherently safe because of the presence of one feature. For example, in the recent fire experience, structures with Class A and Class B roofs were lost because of the lack of design features that prevent the fire's intrusion into windows, doors, attics and eaves. Glazing failure, exposed siding, and underpinning of wooden structures are also a problem. Yet, existing state building standards do not require universal structural integrity features for structures located on hillside sites. A situational formula demonstrates the potential for losses:

$$\frac{\text{Risk}}{\text{Mitigation}} + \frac{\text{Demand}}{\text{Response}} = \text{Potential Loss}$$

Mitigation Response

By assessing risk levels, taking appropriate mitigation efforts (prevention), and adding to them actual demands upon the system and the response of firefighter (suppression) forces, the net result is a loss ratio. High risk plus high demand equals maximum loss. Maximum mitigation plus strong response reduces potential loss. All mitigation with no response results in significant loss. No mitigation and maximum responses result in significant loss, also. As risk and demand levels go up, so should mitigation and response. Lastly, risk is not an issue unless it is calculated economically. Maximum response is not a factor unless it is timely.

The economics of the formula are that risk is primarily personal and private. Mitigation and response have always been considered a responsibility of government. The lack of accountability for mitigation by individual property owners literally means that the more they are willing to risk, the more it is going to cost the public sector to protect the risk.

The formula is dynamic. It represents the current situation throughout California. The formula also reveals that if a community does not have a mitigation plan, then deploying enough fire apparatus quickly enough to control losses is physically impossible.

The political vulnerability in this formula is that frequently incumbent leadership is criticized for conditions they did not create. At the technical level, fire officials understand the relationship of these elements but, at a political level, the issues are often obscured by other considerations. At the time of a specific emergency, the formula is totally disregarded except to evaluate the adequacy of the response and to try to blame the lack of resources.

Jurisdictional Conflict

The body of knowledge regarding mitigation requirements that have been proven to work, and fire suppression deployment methods are fairly well-defined. The response component is well-structured through the California Office of Emergency Services (OES) Master Mutual Aid System, but it lacks a uniform comprehensive approach to the application of site mitigation methods. This would involve the use of adequate standards, an active code enforcement program, inspection, and penalties for violations. There is no equivalent to OES-type coordination system in the regulatory process, especially as it relates to defensible space and structural integrity.

Consistency is absent because the laws, regulations, and standards to remedy the exposure problems are scattered among Federal, State and local jurisdictions. After-action fire records identify the same lack of regulatory controls on specific fires, i.e., roof coverings, defensible space, vegetation management, access and infrastructure problems, and water supply.

The Building Codes and Fire Codes

The California Building Code (CBC) Title 24 was adopted from a model code, with amendments made by the State. The CBC must be enforced by all local governments after the State adopts the most recent edition of the Building Code; local government has 6 months to prepare findings of fact that allow them to make Title 24's minimum requirements more strict based on local conditions. A major portion of municipalities have adopted local amendments to the Building Code. Yet, very few of these amendments deal with the urban-wildland interface. The Building Code itself does not distinguish the requirements for structural features based on location in the interface. The basic requirements are keyed to the type occupancy, not to the exposure to a specific hazard.

Have We Learned the Lessons?

The lesson that we should have learned from a past fire is that fire behavior is not exclusive to that fire. The common thread among past fires is that local action to remedy the situation did not occur before the fire, and, moreover, many local communities have failed to exercise reasonable mitigation strategies in the aftermath of the fire. This has already occurred in Oakland. In effect, they are rebuilding the same fire condition for the future. Further, the fact that the average period of ownership of a California dwelling is only 5 years results in a turnover that creates an information gap between generations of homeowners in impacted areas.

Two mutually contradictory examples can be highlighted: positive and negative. The first is the success of the California Department of Forestry and Fire Protection (CDF) in creating reasonable site safety conditions by enforcing the Public Resource Code (PRC) Sections 4290 and 4291. PRC 4290 is the basis for the Fire Safe California program. PRC 4291 is an excellent approach to the business of mitigation. PRC 4290 cannot be enforced by local governments unless they are contracted with or under State Responsibility Area (SRA). PRC 4291 can be enforced by local governments, but routinely is not.

Second, State and Federal agencies constantly debate the issue of fire clearances and vegetation management. Even in CDF's primary jurisdictions, vegetation management and prescribed burning are difficult to enforce because of local resistance and disputes with environmental agencies. The "kangaroo rat" discussion in Riverside County is one example of this debate. The problem is that frequently State and Federal environmental agencies will not say "no" to vegetation management activities. They just say "maybe" for so long that eventually no action is taken.

In addition, land-use patterns in portions of the state have resulted in allowing development in high fuel loads areas and enforcement efforts have become limited or non-existent. Classic examples of this can be found in Marin County, the Tahoe Basin, and all across the Sierra Nevada.

The issue of fuels and fuel modification is probably the most critical question to be resolved in creating defensible space. The conflict between the need to retain ground cover for wildlife habitat contradicts the need to control fuel levels to protect human habitat. This affects our risk management efforts to a large degree.

Why Have We Not Solved the Problem?

The current situation creates a complex problem without a simple solution: a significant portion of our state has a "growing" fire problem that is under the jurisdiction of both State and local government. Local governments are often reluctant to deal with the issues and State government is often restricted in its efforts because of conflicting special interest from environmental groups.

The problems of adopting specific solutions are further complicated by the political volatility and economic considerations inherent in mitigation efforts. All fire protection mitigation efforts cost money. An increase in roof classification increases a homeowner's costs. Interestingly, adding new fire protection levels actually penalizes a property owner by raising the assessed valuation of the property by the value of the improvements. The Revenue and Taxation Code exempts certain enhancements in fire protection improvements (Revenue and Taxation Code, Section 74):

> § 74. Exclusions from definitions of "newly constructed" or "new construction" of certain fire protection devices and improvements
>
> > (a) For purposes of subdivision (a) of Section 2 of Article XIII A of the Constitution, "newly constructed" does not include the construction or installation of any fire sprinkler system, other fire extinguishing system, fire detection system, or fire-related egress improvement which is constructed or installed on or after November 7, 1984.

This concept could be considered for expansion to other fire protection features because they help control costs of State and local government.

Access and infrastructure are both expensive to create and to maintain. As a result, local government often lacks the will to impose more stringent infrastructure requirements upon specific developers. The public perception of this problem is not helpful either. The general public considers most mitigation efforts unnecessary and an abuse of their quest for privacy. For those individual property owners who reject recommendations for improving fire defensibility, there are few penalties.

The perception that insurance exists to repay people for lost property is based on the notion that compensation is available for all property losses. The California Fair Plan, which was created to serve homeowners in high-risk situations, is intended to ensure coverage is available. For the first time in the recent past, even the Fair Plan has asked for supplemental funds from the contributing companies because of the severe losses.

Unfortunately, insurance does not address the problem that these catastrophic fires result in hundreds of millions of dollars of public expenditures that are a direct burden to the taxpayer at both the State or Federal level.

The financial liability to both State and Federal government has grown because of the increased frequency of catastrophic fires. Local government does not see this as a liability because, after a state of emergency is declared, everyone gets reimbursed for their extraordinary costs. Some communities have even indicated these fires are financial windfalls. The reimbursement is sometimes in excess of actual expenditures, so there is no reason to complain or remedy the situation. The deep pockets that continue to accrue liability are the State and the Federal governments. If the trend towards more frequent and wider spread losses continues, the costs to government will continue to escalate. Therefore, fire is of statewide concern.

Risk Management

Risk can be categorized at three separate levels: site risks, neighborhood risks, and community risks. Site risk is a factor of evaluating building sites and structural integrity, specifically slope and aspect orientation and fuel loading relationships. The tool available to accomplish this evaluation is a "Wildland Risk Calculation." Neighborhood risk is a factor of density, structural conditions, topographical layout, and vegetation management, evaluated by using a "Field Evaluation Form." And finally, the community risk level is a factor of infrastructure, community emergency planning, and the level of policy commitment to mitigation gauged by using the form of OES Disaster Plans.

Mitigation Efforts

The most effective stage for mitigation against urban wildland fires for all these levels is during the development stage. Yet, the issue of urban wildland fire is conspicuously absent from planning concerns in most communities. A review of the Office of Public Resources (OPR) report on strategic growth indicates that discussions of the California Environmental Quality Act (CEQA) requirements do not address the issue of the urban wildland interface at all.

The second point of mitigation is at the site construction phase. However, unless the community has adopted a code or ordinance similar to PRC 4291, there are no requirements for site analysis. One of the biggest problems is the lack of training of fire and building department inspectors. This results in a wide variety of interpretations of even the simplest of requirements such as clearance distances, glazing requirements, and attic or eave protection.

Another influence in the mitigation effort is at the property owner and community-based action group level. The deficiency here is the lack of effective educational efforts to obtain and maintain public support. The CDF and Los Angeles City Fire Department have two of the most successful efforts, but they are not typical. In some cases, these activities have actually been rejected by community-based groups who use Codes, Covenants and Restrictions (CCR's) to promote "ambience" at the expense of safety.

Existing Regulations

We already have a great deal of statutes and regulations. Roofing requirements can be divided into two distinctly different levels: Assembly Bill 337 (Bates 1992), requiring Class B roofing and defensible space in Very High Fire Risk Severity Zones (VHFRSZ); and Assembly Bill 2131 (O'Connell 1992) requiring Class C roofing in all other parts of the state. Both of these bills were signed into law last year. Because of post-enactment implementation dates, neither has been implemented and thus has not produced tangible results. The key point is that the exposure to urban/wildland fire situations is a statewide problem. But it is not a uniform problem. Attempts at statewide mandates to deal with the problem almost always face strong resistance from those agencies and property owners who will not benefit from the new requirements.

However, significant gaps in the Bates bill involve the areas mapped by CDF as VHFRSZ—these can be rejected by a non-rebuttal response from the local governing body. This does not result in any consequence if they suffer a subsequent fire in that area. If CDF applies the Class B requirement in an area with a common boundary to a city identified as VHFRSZ, and the city does not adopt it for themselves, we have an exposure problem. If CDF has the authority to require Class B in their area, and a local community rejects it for other reasons, what has been accomplished?

The Public Resource Code provisions used by the CDF are probably the best overall mitigation approaches in the code system. However, to be used by local government, PRC 4291 requires it to be adopted by each one independently. Model ordinances achieve this, such as the City of La Verne and Napa's "Hillside Overlay Zone," but historically very few have such ordinances. Three other documents in existence could be used as a basis for adopting local ordinances. They are the National Fire Protection Association (NFPA) 299, the Western Fire Chiefs' Urban Wildland Interface text, and the CDF's Fire Safe Guides for Residential Development.

What Needs to be Regulated?

Roof covering is frequently considered as the ultimate villain in these types of fires, but this is entirely too simplistic and is one of the reasons we are not making progress on resolving the problem. Roofs are an issue, but there are many other factors that must be considered in the regulatory scheme, such as:

- Structural integrity—the ability of the structure to withstand intrusion by fire.
- Defensible space—the use of fuel and vegetative management techniques to reduce fire exposure to a vulnerable structure.
- Infrastructure reliability—the ability for fire suppression forces to have access to structures and for the water supply to remain in service for the duration of the fire attack.

None of these issues is independently addressed in the current model code, and they are absent from planning requirements in CEQA. (The Uniform Fire Code currently has a proposed amendment to create a set of requirements for model code, which will probably be adopted in about a year.)

Current Action

The political environment regarding imposing new regulations is not favorable in spite of the fact that almost everyone agrees that we have a serious problem. Although most local governments readily agree on the consequences of these fires, many disagree about the preferred solution. To propose more mandated duties on local government is volatile; yet, at the same time, these same officials are looking for leadership in the area. They are under a great deal of pressure to define activities that get results, and they also recognize the need to reevaluate priorities.

The CDF has followed through in its commitment to map the VHFRSZs. The California State Fire Marshall (CSFM) is in the process of preparing a model ordinance for adoption of the VHFRSZ by local government. Both efforts are on schedule, but are unlikely to make any significant difference in this problem for a period of 7 to 10 years. The reason is fairly simple; they apply only to a limited area of growth. They are not retroactive, and they are dependent upon political action by local government.

The major obstacles to significantly reduce the current potential for large-loss fires include: (1) lack of knowledge by local officials as to how to take action; (2) confusion and ambiguity about the imposition of structure requirements in building codes based on local conditions; and (3) funding reduction in the fire prevention capacity of many agencies.

Distribution of Existing Information

Knowledge of the appropriate mitigation efforts is not evenly distributed. In fact, the methods and techniques for controlling the problem are not taught in any of the recognized fire science curricula at community colleges or universities. We do have a fire suppression course on wildland operations, but no fire prevention course is focused on this area. A tremendous amount of information is available, but it has not been widely used by local government. The distribution matrix of proposed state regulations, and the mailing lists to provide updates on this topic do not currently serve to keep communities well informed of appropriate authority, or how to implement more comprehensive regulations.

Summary

The problems will not be significantly reduced unless we motivate local government into action, supported by a coordinated state response to the issue of vegetation management and a comprehensive training and education program. Because these types of fires will be difficult to eliminate, all forms of government must be proactive to limit losses. The issues will focus on costs for solutions and the ability to avoid conflict with local government.

And finally, the public needs to understand that this is a serious social issue that can be addressed only by cooperation between State and local government and that a combination of education, partnering processes, technology transfer and improved enforcement of current standards and regulations will ultimately impact the potential to reverse the trend towards more catastrophic fires.

References

Bates, Tom. 1992. Assembly Bill 337. California Health and Safety Code, Chapter 6.8.

O'Connell, Jack. 1992. Assembly Bill 2131. California Health and Safety Code, Section 13132.7. California Revenue and Taxation Code; State of California.

Rice, Curt; Dave, James. 1989. A discussion of the County General Plan and the role of Strategic Fire Protection Planning; prepared for the California Department of Forestry and Fire Protection by Robert L. Irwin, Tuolomne County Planning Commissioner; 1989 September 30; 35 p.

Appendix

California Department of Forestry and Fire Protection (CDF).
California Environmental Quality Act (CEQA).
California Office of Emergency Services (OES).
California State Fire Marshall (CSFM).
National Fire Protection Association (NFPA).
Office of Public Resources (OPR).
Public Resource Code (PRC).
State Responsibility Area (SRA).
Very High Fire Risk Severity Zone (VHFRSZ).

A Balanced Approach: Dr. Biswell's Solution to Fire Issues in Urban Interface and Wildland Ecosystems[1]

Carol Rice[2]

Abstract: Dr. Biswell's approach to fire management balanced fire prevention, suppression, and fuel management. Dr. Biswell maintained that with increased support for fire prevention and fuel management, several profound changes would be anticipated, including a decrease in the number of wildfires, as well as a decrease in requirements for suppression. Interested persons can help shift the current emphasis in fire management to increased support for fuel management (and particularly prescribed burning) by repeatedly informing the public of the benefits of prescribed burning in terms the lay public understands and demonstrating the advantages with successful local projects.

On February 15-17, 1994, the Biswell Symposium, Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, was intended, in part, to memorialize Dr. Harold Biswell (or "Doc" as he was affectionately known), a fervent proponent of prescribed fire to manage fuels in both the wildlands and in the wildland/urban interface.

Many have heard his message about resource management in wildland ecosystems, and fire hazard reduction in the urban interface. But Dr. Biswell also considered fire a tool for resource management in the urban interface and for hazard reduction in wildland ecosystems. The mixing of the two areas of interest therefore seemed appropriate for a meeting commemorating Dr. Harold Biswell.

A Balanced Approach

Many types of actions and mixes of approaches can be engaged to solve the "fire problem." Throughout this Symposium, solutions have been offered for both specific circumstances and national situations. The solutions have encompassed new legislation, revised policies, technological improvements, increased participation in land use planning, and public education. Speakers in the introductory session addressed a city solution and a state solution. Dr. Biswell advocated a balanced approach as a solution to fire management issues where, ideally, fire prevention, fire suppression, and fuel management received an equal level of support. Of course, to Dr. Biswell, fuel management was nearly synonymous with prescribed burning.

Currently the world of fire management is not ideal if judged by this criteria. Many in fire management recognize that the mix of prevention, fuel management, and suppression is not optimum. In a national survey by the Wildland Fire Management Section of the National Fire Protection Association in 1989, both prevention and prescribed burning programs were identified as top issues facing fire management nationwide. In this same survey, an increase in prescribed burning programs was by far the most frequent suggestion for desired change in fire management policy, and prevention was listed almost twice as many times as an activity most in need of funds.

Dr. Biswell maintained that by using the balanced approach, the number of unwanted fires would decrease as a consequence of the heightened prevention efforts. Suppression requirements would likewise decrease because more of the fuels would be transitioned into a managed condition. Opportunities for successful suppression would become more plentiful because fuels would become less continuous. In addition, a greater percentage of the land would become less resistant to control as the amount of available fuel (especially heavier fuels) decreased on any one piece of land.

A Fuels Management Shift

There are several ways to shift the current mix of fire management programs to one with a greater proportion of effort allocated to fuels management and fire prevention.

The first way is to explain to the public, the media, and opinion leaders the benefits of fuel management, and specifically, the benefits of prescribed fire. References abound about the benefits of and even the necessity for fuel management, especially prescribed burning. Because the public appears to be more convinced by specifics than general observations, these references are a useful resource for describing the advantages of fuel management. The public has been especially receptive to explanations of the fire ecology of specific sites. A fire manager might use written fire histories and fire-scarred trees to explain the natural role of fire and its inevitability. Local vegetation usually provides numerous examples of adaptations to fire; "reading the landscape" makes a great story.

Recently, the public has been responsive to proposals for fire hazard reduction with prescribed fire. Resource managers or other interested persons might explain how prescribed burning reduces the biomass left to burn, changes the structure of the fuel so that it is less likely to burn intensely, and how it can even change the vegetation type to one less resistant to control. Cost comparisons of techniques, or of damage scenarios without action can be persuasive points for highlighting the value of prescribed burning. The

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Proprietor, Wildland Resource Management, 134 Journey's End, Walnut Creek, CA 94595.

benefits to fire personnel provided by the training and communication opportunities afforded during prescribed burning may likewise be important to a public who depends on a well-trained fire suppression organization. A prescribed burn is often a media event that should be capitalized upon as an opportunity to contact thousands with a message about the value of such actions and programs.

Research has shown that a message needs to be heard 400 times before a person's opinion will be changed or altered. The message about the benefits of prescribed burning needs to be told many times and in many ways simply to reach many people. By the end of any outing, field trip or workshop, Dr. Biswell had told the story of prescribed burning's benefits repeatedly, but not redundantly.

Telling the story about prescribed burning clearly, stated for an intelligent but currently uninformed audience, is very important. Dr. Biswell often quoted Albert Einstein, who suggested that a person did not really understand a concept if he could not explain it to his gardener. Fire managers need to be able to explain the process of fire, its application, and the value of fire's controlled use in terms that mean something to the audience.

A successful local project can illustrate the benefits of fuel management. Fire managers are able to show the applicability of fuel management and prescribed burning in a wide range of circumstances when many successful projects are nearby. Some audiences would prefer to believe fires did and should occur someplace else; thus, the applicability of fire's use in their particular circumstance is best argued by examples of successful local burns in a variety of conditions.

Conclusion

Those responsible for planning and conducting prescribed burns must persevere to achieve successful projects. Conducting a prescribed burn is not an easy task. Each burn entails challenges regarding scheduling, logistics, communications (to the public and between agencies), air quality management, finances, and many more. However, these projects are nearly always well worth the effort. For example, according to John McMillan (personal communication with author, September 9, 1993), the site of a prescribed burn conducted by staff on the USDA Forest Service's Pacific Ranger District in California was the only green area visible within miles after the Cleveland Fire of 1992. Although its advantages to this site are obvious, the illustration of prescribed burning's benefits are also very powerful for potential application elsewhere.

Dr. Biswell believed in a balanced approach to fire issues in urban interface and wildland ecosystems, and he worked with a passion to make it so. He did this by repeatedly explaining the benefits of prescribed burning to all those who would listen and many who would not. He told the message about fire's use in terms all could understand. He always encouraged the wise use of fire and illustrated this with demonstrations. By mimicking Doc's actions and approach, we will be able to move closer to garnering the support necessary to create that balance Doc was so eager to attain.

Reference

Rice, Carol L. 1989. **Personnel, equipment, budget, costs and issues of Federal fire management programs**. Unpublished paper presented to the Wildland Fire Management section of the National Fire Protection Association; 1989 May 19; Boston, Massachussetts.

POSTER SESSION

Use of Aerial Photography for Fire Planning and Suppression[1]

Alan H. Ambacher[2]

Abstract: Aerial photography has long been considered a valuable tool for wildland fire suppression activities. The Fire Resources of Southern California Organized for Potential Emergencies (FIRESCOPE) mapping program introduced the use of aerial photography as a critical component of an integrated mapping program for daily emergency response for the community of southern California map users. The Oakland fire storm and the recent southern California fires are examples of multi-agency involvement that demonstrate the importance for current information of existing ground conditions. Aerial photography is one source for obtaining current information.

Western Federal agencies involved in fire protection, such as the USDA Forest Service, USDI Bureau of Land Management, and the National Park Service, use aerial photography as an information base to support fire planning and suppression in wildland areas. As Federal agencies became involved in the multi-agency effort through Fire Resources of Southern California Organized for Potential Emergencies (FIRESCOPE) to improve coordination and communication, the use of aerial photography as an information base was expanded into interface and urban fire response areas.

The FIRESCOPE mapping program was designed to provide fire service agencies with a consistent, standardized set of cartographic products derived primarily from National, State, and local government mapping programs. The value of the FIRESCOPE mapping program to partner agencies depended upon timely maintenance of operational data layers. Current aerial photography to create orthophoto bases for ensuring positional accuracy of data collected by the fire services, or used directly as an information layer, was deemed critical to the success of the mapping program. The FIRESCOPE program concluded that Federal or State aerial photo sources were not adequate to meet this critical demand for updated aerial photography. Other sources for aerial photography had to be developed, including the private sector companies. Fire service agencies now use geographic information systems, electronic vehicle maps, and other technology to supplement their mapping programs. Yet, the need for consistent current map information to support on-site multi-agency emergency management continues, evidenced during the Oakland fire storm as fire crews from areas throughout the West arrived to support the City of Oakland Fire Department. Aerial photography from a private photo company, such as Pacific Aerial Surveys, can be used to create a range of photo products to quickly update existing operational data; as record keeping documents; for strategic planning, fuel assessment, structure locations, and evaluation hazard potential; and to familiarize emergency personnel on existing ground conditions before entering an area.

Current and historical high resolution aerial photography is available at various scales and film emulsions from private companies. The photography is remarkably detailed, allowing for easy interpretation of ground features such as street patterns, access roads, drainage patterns, tank locations, water sources, buildings, parking lots, light and telephone poles, and vegetation characteristics and types. Historical aerial photography is an excellent source to evaluate land use change that has occurred over large areas or individual sites.

Photo Laboratories

Aerial photo negatives for Federal agencies are stored at the Agricultural Stabilization and Conservation Service (ASCS) Aerial Photography Field Office in Salt Lake City, Utah, and the Earth Remote Observing Satellite (EROS) Data Center in Sioux Falls, South Dakota. Although these laboratories have emergency response plans to create aerial photo products, the currency and scale of the photography is not acceptable for information needs by fire personnel during or after a major interface incident. Also, it is impractical to expect these laboratories to respond within the first few hours of an incident to deliver aerial products to fire personnel.

Private laboratories, such as Pacific Aerial Surveys, located within or near the immediate area of concern can provide digital or hard copy aerial products from their library stock of aerial photography. By using the information network with other aerial photo firms and the government photo labs, Pacific Aerial Surveys can coordinate deliveries of aerial photo products within hours after receiving the initial request.

Photo Libraries

Pacific Aerial Surveys maintains in its photo libraries current aerial photos of the greater Bay Area, Monterey, Sacramento, Redding, and selected Los Angeles area counties.

[1] An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Vice President, Pacific Aerial Surveys, Hammon-Jensen-Wallen & Associates, 8407 Edgewater Drive, Oakland, CA 94621.

Pacific Aerial Surveys' corporate office is located in Oakland, California, where all Company film is stored. Sales offices are located in Van Nuys, Redding, and Monterey, California.

Private aerial photo companies have photo-equipped planes and calibrated aerial camera systems with 3.5-inch, 6-inch, 8.25-inch, or 12-inch lens ready for immediate mission mobilization. Other sensors can also be flown in these airplanes. Most companies now use Global Positioning Systems (GPS) technology to control photo exposure stations so coordinate information and not maps need only be transmitted to a company from a fire command center for a flight to occur.

Characteristics of Coastal Sage Scrub in Relation to Fire History and Use by California Gnatcatchers[1]

Jan L. Beyers **Ginger C. Peña**[2]

Abstract: Plant cover and vegetation structure were examined at two inland coastal sage scrub sites differing in fire history and use by California gnatcatchers. *Salvia mellifera* and *Eriogonum fasciculatum* dominated one site; shrub cover on gnatcatcher–occupied plots averaged 50 percent greater than on unoccupied plots. At the other site, gnatcatcher-occupied plots had high cover of *Artemisia californica* and *Encelia farinosa* while unoccupied plots were dominated by *E. farinosa* alone and had half as much total shrub cover. Gnatcatcher territories at both sites had taller shrubs than unoccupied plots. Recently burned areas and areas with little regrowth were not used by gnatcatchers.

Coastal sage scrub is a fire-dominated vegetation type that has been largely converted to agricultural and urban uses in southern California. Less than 20 percent of the original area of this vegetation type probably remains (Westman 1981). The California gnatcatcher *(Polioptila californica)* lives only in coastal sage scrub in California and Baja California (Atwood 1993); because habitat loss jeopardizes its survival, it has been federally listed as "threatened."

Inland Riverside County contains numerous remnant areas of sage scrub. Studies of gnatcatcher habitat have been conducted in coastal Orange and San Diego counties, often by biological consultants working for developers (e.g., Bontrager 1991, Ogden Environmental and Energy Services Co., Inc. 1992), but relatively little is known about gnatcatcher requirements in inland areas (Atwood 1993). In conjunction with two ornithologists studying gnatcatcher nesting success, we undertook this study to help clarify the relationship between California gnatcatchers, coastal sage scrub, and fire history.

Methods

Two study sites were chosen in western Riverside County: the University of California, Riverside's Motte Rimrock Reserve, located in the hills near Perris, California, and Lake Mathews, a Metropolitan Water District storage reservoir near Riverside, California. Almost half of the Motte Reserve was burned in a fire in September 1979; much of the rest burned in June 1981. California gnatcatcher territories are found only in the 1979 burn area. We sampled four plots each in known gnatcatcher territories, in 1979 burn areas without gnatcatchers, and in 1981 burn areas. Plots without gnatcatchers were randomly selected; plots in territories were chosen so as not to interfere with gnatcatcher breeding activity. On each plot, four line-point transects were randomly chosen perpendicular to a baseline. Vegetation cover was measured every 0.5 m along each 25-m transect by dropping a vertical pointer and recording the identity and height of each species touched by the pointer. Sampling was done in late spring. At Lake Mathews, plots were located in unburned vegetation occupied by gnatcatchers, unburned vegetation without gnatcatchers, and in an area burned in 1990. Sampling procedures were the same as at Motte.

Results

At Motte, plots in the 1979 burn area used by gnatcatchers averaged 50 percent greater shrub cover than 1979 burn plots not in active use. Plots in the area burned in 1981 had little live shrub cover and were not used by gnatcatchers (*table 1*). At Lake Mathews, unburned plots used by gnatcatchers had almost twice as much cover as those not used, and *Artemisia californica* was an important component of the cover. Shrub cover was very low in the 1990 burn plots (*table 1*). Plots in bird territories had taller shrubs than unoccupied plots at both sites as well (data not shown).

Discussion

California gnatcatchers do not rely exclusively on California sagebrush (A*rtemisia californica*) in inland sage scrub, as they appear to do near the coast (Bontrager 1991). Gnatcatcher plots at Motte were dominated by black sage (*Salvia mellifera*) and California buckwheat (*Eriogonum fasciculatum*); those at Lake Mathews had about equal cover of California sagebrush and brittlebush (*Encelia farinosa*). Sites used by gnatcatchers averaged more than 50 percent shrub cover, similar to results tabulated by Atwood (1993). Recently burned sites were not used by gnatcatchers. Conditions that inhibit shrub recovery after fire, as apparently occurred with the 1981 fire at Motte, could reduce the amount of usable habitat available for California gnatcatchers.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Research Plant Ecologist and Biological Technician, respectively, Pacific Southwest Research Station, USDA Forest Service, 4955 Canyon Crest Dr., Riverside, CA 92507.

Table 1—*Average percent shrub cover (standard deviation) of plots at Motte Rimrock Reserve and Lake Mathews. "Total" may not equal the sum of each column because shrubs often overlapped.*

Species	Motte Site: Bird Plots[1] 1979 Burn		Non-bird Plots 1979 Burn		Non-bird Plots 1981 Burn	
Artemisia californica	4.3	(4.0)	6.1	(10.)	0	
Encelia farinosa	7.9	(10.2)	0.5	(0.9)	0	
Eriogonum fasciculatum	19.3	(16.3)	9.5	(8.2)	4.8	(2.0)
Salvia mellifera	31.5	(18.1)	24.3	(10.8)	0	
Total	62.9	(24.3)	40.4	(12.3)	4.8	(2.0)
	Mathews Site: Unburned		Unburned		1990 Burn	
Artemisia californica	33.6	(19.0)	1.3	(1.6)	0	
Encelia farinosa	28.2	(10.6)	31.1	(12.7)	2.5	(2.9)
Eriogonum fasciculatum	0.4	(0.4)	1.4	(1.4)	0.3	(0.5)
Bebbia juncea	0.7	(1.2)	0.1	(0.2)	2.5	(3.5)
Lotus scoparius	0		0		5.2	(7.3)
Total	62.9	(11.3)	33.9	(13.5)	10.5	(9.8)

[1] Bird plot denotes use by California gnatcatchers; non-bird plot denotes no use by California gnatcatchers in spring 1993. N=4 plots per category at Motte site; n=3 for burned plots at Mathews, n=4 for unburned plots at Mathews.

Acknowledgments

Permission to work at the Motte Rimrock Reserve was granted by Reserve Director Barbara Carlson, University of California, Riverside; she also provided information on gnatcatcher territories and safe sampling times. Metropolitan Water District allowed us to work at Lake Mathews. Dr. William O. Wirtz II and Audrey Mayer of Pomona College identified gnatcatcher territories at Lake Mathews. Carla Wakeman, Michael Oxford, and Peter Coy assisted with the vegetation sampling.

References

Atwood, Jonathan L. 1993. **California gnatcatchers and coastal sage scrub: the biological basis for endangered species listing**. In: Keeley, J. E., ed. Interface between ecology and land development in California. Los Angeles: Southern California Academy of Sciences; 149-169.

Bontrager, David R. 1991. **Habitat requirements, home range and breeding biology of the California gnatcatcher (*Polioptila californica*) in south Orange County, California**. Unpublished report prepared for Santa Margarita Company, Rancho Santa Margarita, California.

Ogden Environmental and Energy Services Co., Inc. 1992. **Ecology of the California gnatcatcher at Rancho San Diego**. Unpublished report prepared for Home Capital Development Corp., San Diego, California.

Westman, Walter E. 1981. **Diversity relations and succession in Californian coastal sage scrub**. Ecology 62: 170-184.

The Quest for All-Purpose Plants[1]

Susan L. Frommer David R. Weise[2]

The Problem

The fire safety of a home in the wildland/urban interface is influenced by several factors—one of which is the presence and proximity of vegetation to the home. Landscaping may either provide a significant barrier to fire spread and thus potentially increase a home's fire safety or favor fire spread and reduce a home's fire safety. However, fire safety of vegetation is not the only criterion a homeowner or landscape designer uses when selecting plants for use in a yard. Other criteria include drought resistance, erosion prevention, and esthetics.

Many lists of "fire retardant" plants are available in trade magazines, newspapers, and from various public agencies like water districts and resource conservation districts. The bases of these lists are often unknown; fire safety ratings for a particular plant may vary appreciably from list to list, only the genus of the plant may be given with no species name, or the same species names keep appearing from list to list including even misidentifications and misspellings. For example, *Cupressus sp* is listed in one publication as being highly flammable (Baptiste 1992); however, *Cupressus arizonica* was rated as weakly flammable in France for the months of May, June, and October; not very flammable for July, August, and September; and moderately flammable in November (Valette n.d.).

Plant lists often fail to consider the fact that plants may be reasonably fire retardant (however it is defined) when watered but become more flammable when dry. Some plants have a natural ability to retain a higher fuel moisture content longer than others after the onset of the dry months, which prolongs their fire-retardant characteristics later into the dry season on unirrigated sites.

Furthermore, relying on only one attribute, flammability, as a guide to plant selection ignores the many other functions we expect from our landscape plants such as the abilities to control erosion on slopes, to shade our homes during the hot summers, to provide food for us and for wildlife, to conserve water, and to be esthetically pleasing. Some lists of "fire-retardant" plants have information about other desirable attributes, but there are enormous gaps in this information as well.

A Possible Solution

We propose to develop a preliminary set of techniques based on flammability tests for building materials to determine flammability and total heat release rates of intact vegetation, both green and dried. This information can then be used to devise a rating scale for relative "fire retardance" which then can be coupled with another series of ratings for water consumption, frost tolerance, climate modification, erosion control, wildlife habitat, etc. *Table 1* lists possible candidate species that meet criteria other than flammability. Information on fire retardance is often missing. This information will help homeowners, planners, plan checkers, and others to make intelligent and economical landscaping decisions based on the particular hierarchy of needs of each site. Once such a system exists, fire-safe landscaping decisions will have a stronger scientific basis.

[1] An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2] Partner, Plants 4 Dry Places, Menifee Valley, CA; Supervisory Research Forester, Pacific Southwest Research Station, USDA Forest Service, 4955 Canyon Crest Drive, Riverside, CA 92507.

Table 1– ***Candidates for fire retardance tests with ratings for other desirable characteristics for landscape plants.***

Plant	Fr [1]	Wtr	Aes	Er	Oth
Oenothera berlandieri	?[2]	x	x	x	x
Cistus crispus	?	x	x	x	?
Olea europa	?	x	x	?	x
Rhus ovata	?	x	x	x	x
Correa 'Carmine Bells'	?	x	x	x	?
Muhlenbergia rigens	?	x	x	x	?
Rhagodia spinescens	?	x	x	x	?
Rosmarinus officinalis	?	x	x	x	x
Melia azedarach	?	x	x	?	x
Cistus salviifolius	x	x	x	x	?
Baccharis pilularis	?	x	?	x	?
Salvia microphylla	?	x	x	x	x
Myoporum 'Putah Creek'	?	x	x	x	?
Heteromeles arbutifolia	?	x	x	x	x
Verbena tenuisecta	?	x	x	x	?
Westringia rosmariniformis	?	x	x	?	?
Salvia greggii	?	x	x	?	x
Acacia redolens	?	x	x	x	?
Calystegia macrostegia	?	x	x	x	x
Cistus purpureus	?	x	x	x	?
Prunus ilicifolia	?	x	x	x	x
Sophora japonica	?	x	x	?	x

[1] Fr = fire resistant, Wtr = drought resistant, Er = erosion resistant, Aes = esthetically pleasing, Oth = other (wildlife habitat, food production, climate modification)

[2] x = suitable application, ? = information not available

References

Baptiste, L. 1992. **FIRESCAPE—Landscaping to reduce fire hazard**. Oakland, CA: East Bay Municipal Utility District; 16 p.

Valette, Jean-Charles. n.d. **Flammabilities of Mediterranean species—I.N.R.A.'s methodology**. Document PIF 9328. Avignon, France: Laboratoire de Recherches Forestieres Mediterraneennes; 15 p.

A High-Resolution Weather Model for Fire Behavior Simulations[1]

Francis M. Fujioka[2] John O. Roads Kyozo Ueyoshi Shyh-Chin Chen [3]

Abstract: The typical computer fire model requires much greater spatial detail than current weather forecast models provide. One way to obtain more spatially descriptive weather simulations is to nest a fine model grid within a coarse one. This paper briefly describes a nested grid model with a fine grid interval of 2 km to simulate weather over Maui, Hawaii.

Wildland fire scientists today strive for greater detail, with the aid of computers. The computer is a virtual laboratory in which simulated fires burn through spatially complex fuel matrices, in response to weather and terrain conditions. The fire model sees the world as points on a regular grid. In one study of 2,000 ha on the Los Padres National Forest, California, grid points were spaced 50 m apart (Kalabokidis and others 1991). It is practically impossible to obtain vegetation, terrain and weather conditions for a grid this size by direct sampling. The vegetation grid was digitized from cover type maps and the terrain grid was obtained from a digital elevation model. But the study lacked the means to describe weather methodically on a fine grid. In fact, a fire weather model for the Los Padres study grid is theoretically possible, but computationally impractical.

Computer models are used to describe weather worldwide every day. The National Weather Service Medium-Range Forecast model (MRF) runs on a 160 km grid (approximately). At this resolution, the model hardly sees the Sierra Nevada Range. The spatial resolution is much better in the Nested Spectral Model (NSM), an as yet experimental model with a grid interval of 25 km (Juang and Kanamitsu 1994). The NSM is much more descriptive than the MRF (*fig. 1*), but it still lacks the detail needed for a fire simulation. We are developing a fire weather model for Maui, Hawaii that employs a 2 km grid interval. To our knowledge, it is one of the most spatially descriptive fire weather models of its kind.

An application of the Colorado State University RAMS code (Walko and Tremback 1991), the Maui weather model simulates dynamical changes in temperature, humidity, wind and precipitation fields, among others. Snapshots of the model fields every few minutes can provide weather information for fire simulations. The model grid is hierarchical. A National Meteorological Center coarse grid analysis describes the large-scale weather pattern over the state of Hawaii. Nested within this grid is a finer grid over the main islands of Hawaii. The densest grid is a 2 km grid centered on Maui (*fig. 2*).

We are just beginning the Maui modeling study. Preliminary results show tantalizing detail of the wind circulation over Maui. In one case, the model described locally stagnant winds where smoke dispersion tends to be a problem. We plan to verify the model to the extent possible, with a mesoscale network of automatic weather stations in Maui's central valley. We produced computer visualizations of the model output that show the motions of simulated air particles released at the 2 km grid points. Each particle is color-coded according to the wind speed at its location. The particles also leave streaks, similarly color-coded, that accentuate the flow field.

The model calculations are not trivial. It takes about 12 hours of computer time to produce a 12 hour simulation on a 100 Mhz workstation. The model physics and the number of grid points require a powerful number cruncher. But computers no doubt will run faster, and spatially detailed fire weather information is needed.

---

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosyystems, February 15-17, 1994, Walnut Creek, California.

[2]Research Meteorologist, Pacific Southwest Research Station, USDA Forest Service, Riverside, CA 92507.

[3]Research Meteorologists, Climate Research Division, University of California Scripps Institution of Oceanography, La Jolla, CA 92093.

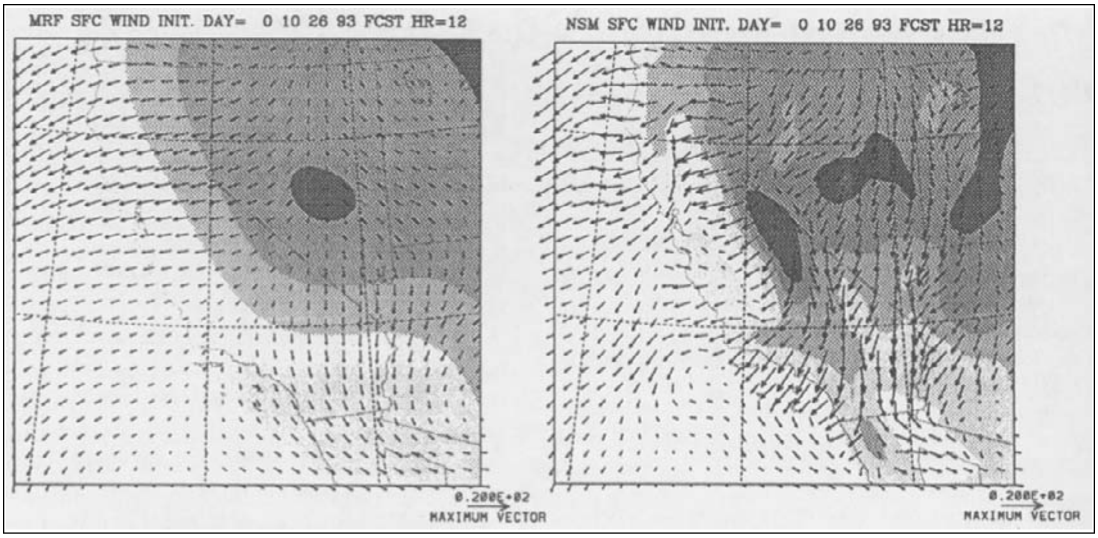


Figure 1–A comparison of the Medium-Range Forecast (MRF; left) and Nested Spectral Model (NSM; right) forecasts. The gray scale depicts topographic elevation bands, and the vectors represent the wind field.

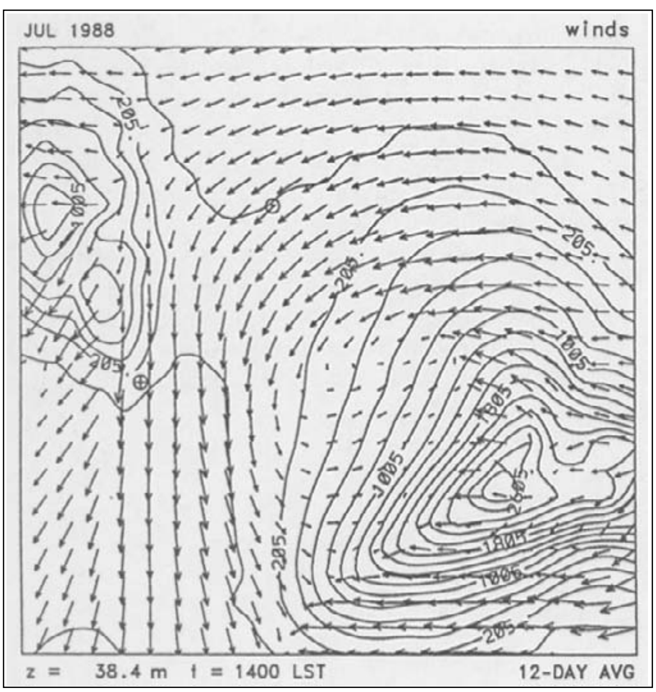


Figure 2–An average of the flow patterns at lower levels in July 1988 clearly shows an eddy on the lower northwestern flanks of Haleakala, Maui.

References

Juang, H.-M. H.; Kanamitsu, Masao. 1994. **The NMC nested regional spectral model**. Monthly Weather Review 122: 3-26.

Kalabokidis, Kostas D.; Hay, Claire M.; Hussin, Yousif A. 1991. **Spatially resolved fire growth simulation**. In: Andrews, Patricia L.; Potts, Donald F., editors. Proceedings, 11th conference on fire and forest meteorology; 1991 April 16-19; Missoula, Montana. Bethesda, Maryland: Society of American Foresters; 188-195.

Walko, Robert L.; Tremback, Craig J. 1991. **RAMS, the Regional Atmospheric Modeling System, Version 2c, user's guide**. ASTeR, Inc. Ft. Collins, Colorado; 89 p.

Using a Geographic Information System (GIS) to Assess Fire Hazard and Monitor Natural Resources Protection on the Mount Tamalpais Watershed[1]

Thomas H. Gaman **Philip Langley**[2]

A natural resource management geographic information system (GIS) was developed that has proven useful in urban interface fire hazard mitigation planning and natural resource protection. A consultant team, selected to prepare the Vegetation Baseline Studies and Management Plan for the Mount Tamalpais Watershed in Marin County, California, obtained data from a variety of sources to create 25 data layers using BASEMAP 2000 GIS. The system provided a practical means for spatial data analysis and storage. It was also used extensively for graphic map production for the 20,000-acre watershed of the Marin Municipal Water District and the Marin County Open Space District.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.
[2]Foresters, Forest Data, PO Box 276, Inverness, CA 94937.

Homeowner Intervention in Malibu[1]

Tom Gardner[2]

The Old Topanga Fire arrived in the Malibu neighborhood of upper Las Flores Canyon after 3 p.m. on Tuesday, November 2, 1993. Virtually every home survived the initial 10-minute passage of the flame front, but nearly all experienced a rain of hot embers that continued past dawn on Wednesday. One surviving home was protected by pool water, Class A foam concentrate, and a fire pump designed for home-owners living in the wildland/urban interface (*fig. 1*). This Malibu resident is the first known civilian to save a structure from wildfire using Class A foam technology. The fire pump, a Defender Foam System model #501 manufactured by Brushfire Hydrant Co. in Walnut Creek, California, was delivered in March 1991 (*fig. 2*). The system sustained extensive damage by the fire, but never failed during 6 hours of operation. The original design was awarded United States patent 4,671,315 in 1987 as the portable brushfire hydrant. When the patent expires in 2004, the surviving system will be offered to the Smithsonian Institution.

Figure 1–A home located in upper Las Flores Canyon, Malibu, California, that survived the Old Topanga Fire because of homeowner preparations.

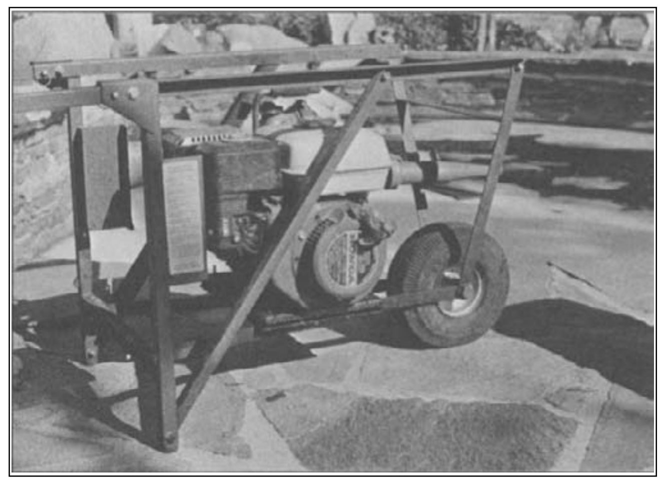


Figure 2–Portable fire pump used by a homeowner to protect his residence with pool water and Class A foam concentrate.

---

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Project Engineer, Brushfire Hydrant Company, Walnut Creek, CA 94596.

The Legacy of Harold Biswell in Southern California: His Teaching Influence on the Use of Prescribed Fire[1]

Walter L. Graves[2] **Gary Reece [3]**

Historical accounts from early Spanish explorers who came to California looking for gold indicate that often they saw many columns of smoke rising from distant mountains. Little did these explorers know that what they were witnessing was a time-tested demonstration of natural lightning fires and/or "controlled burning," a technique practiced by Native Americans to prevent wildfires in the area's wildlands. Today we know this early fire ecology philosophy helped shape California's ecological history.

But in the years that followed the Spanish explorers, controlled burning by new migrations of settlers colonizing the West was thought to be destructive to our wildlands until a modern-day pioneer in fire ecology training came along. That man was Harold Biswell. His teaching and training activities in fire ecology, especially in southern California's San Diego County, during the 1970's and 80's continue to influence today's ecologist working to restore fire to the forests, chaparral, and grasslands in this region. Biswell was able to "transcend" the barrier between scientist and classroom. His "hands-on" concept of training and applying prescribed fire techniques is considered by many observers to be a unique approach to California's wildlands management.

Harold brought his wisdom and experience to southern California during the middle 1970's, when fire suppression philosophy and policy had become entrenched in government and public agencies responsible for wildlands fire control. Agency leaders were convinced that prescribed fire was of no value in chaparral and forest vegetation management. They believed it would adversely affect too many people and increase the threat of liability. In fact, during this period, the idea of prescribed fire technology and training was practically non-existent. But Harold Biswell, on the other hand, firmly believed in the importance of fire and its role in nature's plan. He based his beliefs on extensive research that examined not only the thousands of years of "natural fires" that had occurred in California, but also how Native Americans used fire in shaping the state's landscape. The message was long overdue when "Doc" Biswell began his educational and training programs in San Diego County nearly 20 years ago. His persistent and tireless efforts at promoting the restoration of fire to its evolutionary role in this region eventually influenced and encouraged state government leaders and others to lay aside the "myths" of fire exclusion in southern California.

Summary

We believe our videotape showing the following field day and workshop at the William Heise County Park in San Diego County in May 1983 illustrates Harold Biswell's teaching and training methodology in fire ecology and the importance of restoring (controlled) fire to our wildlands. Truly, California's history was born of fire, and this video captures Professor Harold Biswell's teaching emphasis on fire as a natural component of wildland ecosystems, Native Americans' use of fire in wildland ecosystems, smoke management, the importance of prescribed fire in fire management, the importance of training in fire management, and the education of the public about fire's role in ecosystem management.

Acknowledgments

We thank the Cooperative Extension Visual Media staff at the University of California, Davis–Harry Stoble, Steven Lock, and Robert Singleton–for helping us, with extreme patience, to produce this video. We especially appreciate the willingness of Visual Media's Coordinator, Rosalind Rickard, to allow these video production specialists to participate in this venture. We also want to applaud San Diego County's Department of Parks and Recreation for their courage in implementing a prescribed fire program at a time in our history when this concept was not considered popular.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Area Farm Advisor Emeritus for Natural Resources Management, University of California Cooperative Extension, San Bernardino County, 777 E. Rialto Ave., San Bernardino, CA 92415

[3]Prescribed Fire Specialist and Chief of Agricultural Services, San Diego County Department of Agriculture, Building 3, 5555 Overland Ave., San Diego, CA.

Helping Wildland-Urban Interface Residents Reduce Wildfire Hazards[1]

Warren E. Heilman[2] Jeremy S. Fried[3] William A. Main[2] Donna M. Paananen[2]

Abstract: Researchers in Michigan are designing and supporting studies to facilitate the identification of fire hazards on homesites in the wildland-urban interface, to elicit homeowners' perceptions of the wildfire risk where they live, and to assess the values that residents in fire-prone ecosystems place on reducing wildfire risk. A better understanding of the attitudes and values of interface residents will aid prevention specialists in targeting programs to help these residents mitigate wildfire hazards and reduce potential losses on their properties.

To help homeowners in the wildland-urban interface improve the chance that their homes will survive a wildfire, prevention specialists need to understand the many and varied reasons why homeowners choose to live where they do. They need to know which wildfire hazards are present on the homeowners' property that would increase losses to wildland fire. They also need to assess the homeowners' perception of wildfire risk (the probability that a wildfire will threaten their property).

Typically, prevention programs have been focused on the segment of the wildland-urban interface population that is most aware of wildfire risk and is most willing to remove or mitigate hazards on their property to reduce risk of property damage. A better understanding of risk perception and attitudes toward hazard reduction could help prevention specialists assess the understanding, values, and needs of all homeowners residing in the wildland-urban interface.

Morgan (1993) asserts that "the public can be very sensible about risk when companies, regulators, and other institutions give it the opportunity." He further states that risk communication is simple: "Learn what people already believe, tailor the communication to this knowledge and to the decisions people face and then subject the resulting message to careful empirical evaluation."

The USDA Forest Service's Atmospheric and Socioeconomic Relationships with Wildland Fire Work Unit, North Central Forest Experiment Station, is supporting cooperative research at Michigan State University (Fried 1993) that will increase the knowledge of homeowners' perceptions of wildfire risk and will assess the values of residents in fire-prone ecosystems about reducing risk. The unit is also developing studies to address the relationship between awareness of fire risk and hazard reduction activities among wildland-urban interface homeowners. As part of this research, four categories of these homeowners will be identified, on the basis of their hazard assessment rating and wildfire risk awareness:

- Low hazard rating and Aware of fire risk (L/A)
- Low hazard rating and Unaware of fire risk (L/U)
- High hazard rating and Aware of fire risk (H/A)
- High hazard rating and Unaware of fire risk (H/U)

Conceptual Approaches

The success of these studies will depend on conducting personal interviews. In addition to demographic questions (Bureau of the Census-type questions), open-ended questions will be designed to ascertain the homeowners' perception of wildfire risk around their homes, such as:

- How long have you lived at your current residence?
- If a fire occurred, how would firefighters locate your property?
- Have you experienced a wildfire at or near your home?
- Before that fire, were you concerned that a wildfire might occur?
- How often do wildfires occur in your neighborhood?
- If your home burned down tomorrow, what would you miss most?

Using a "wildfire hazard rating form" (Great Lakes Forest Fire Compact 1992), the interviewer and homeowner could rate site hazards (e.g., surrounding trees, type of ground cover, fuel storage), structural hazards (roofing materials, decks, and overhangs), and existing hazard reduction (trees pruned, leaves raked, roof cleaned outbuildings hazard-free). A "property hazard value" could be calculated by adding the total site hazard to the total structural hazard and subtracting the total hazard reduction.

In conjunction with these studies, geographic information system (GIS) databases could be built and maintained to store: (1) the information obtained during the interviews, (2) the owner's perception of risk, and (3) the "property hazard value." This information would facilitate queries like "how many" and "location of" the homesites with a given property hazard, owner risk-perception strata, or a combination of attributes. A GIS would also support tests for differences in demographic and site characteristics between homesites with low/high hazard ratings and homeowners with low/high risk awareness.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Project Leader—Wildland Fire Research, retired Computer Specialist, and Technical Publications Writer, respectively, North Central Forest Experiment Station, USDA Forest Service, 1407 S. Harrison Road, Rm. 220, East Lansing, MI 48823-5290.

[3]Assistant Professor, Department of Forestry, Michigan State University, 110 Natural Resources Bldg., East Lansing, MI 48824-1222

Anticipated Benefits

Depending on how the database is sorted and analyzed, researchers can obtain a variety of information ranging from whether fire hazards are associated with income to the number of homeowners in each of the identified categories. Results can aid the wildfire prevention community's understanding of the knowledge, attitudes, and needs of homeowners who reside in the wildland-urban interface. Prevention specialists can use this information to select specific prevention programs for specific groups of homeowners and provide policymakers with information that can help them in developing cost-efficient programs to reduce the risks associated with fire in wildland-urban interfaces.

Acknowledgments

We thank Donald Johnson, fire prevention specialist at the Michigan Department of Natural Resources, Forest Management Division, Lansing, Michigan, for providing background information about wildfire hazard rating.

References

Fried, J.S. 1993. **Valuing social and economic impacts of fire at the urban-wildland interface: a proposal**. Unpublished study, USDA Forest Service Cooperative Agreement #23-93-32.

Great Lakes Forest Fire Compact. 1992. **Wildfire: are you and your home prepared?** Ontario: Great Lakes Forest Fire Compact; 30 p.

Morgan, M. Granger. 1993. **Risk analysis and management**. Scientific American 269 (1): 32-41.

Mt. Diablo Park: The Role of Fire in a Controversy about Cattle Grazing at the Urban Fringe[1]

Lynn Huntsinger Jeremy Fried Lita Buttolph[2]

Mt. Diablo State Park is in rapidly urbanizing Central Contra Costa County, a few miles inland from the eastern San Francisco Bay. The Park encompasses 18,000 acres of mountainous and rolling oak woodlands, chaparral, and grasslands, increasingly surrounded by San Francisco Bay Area suburbs. Easily accessible to millions of nearby urban dwellers, Mt. Diablo is among the most frequented of the California State Park System's 300 units, with more than 500,000 visits annually. The 1989 Park General Plan set goals for the park that included managing to restore natural processes. The Plan called for removal of livestock grazing from most of the park. Controversy over the elimination of grazing was of surprising vehemence and has lasted years. As a result, the General Plan process consumed more State Park time and resources than any previous Plan—even though this was not the first time grazing was phased out of a State Park.

Livestock grazing has been a component of the Mt. Diablo landscape since about 1834, when the mountain's slopes were part of a Mexican land grant. Founded in 1921, the Park has expanded from its original few hundred acres. In 1979, 2,000 acres of Mt. Diablo Ranch were sold and 281 acres donated to the State Park System by the owner, Angel Kerley. In exchange, a 10-year grazing lease was signed, but participants in the controversy disagreed about the nature of the lease. Some argued that the intention was for grazing to continue in perpetuity as an exhibit of ranching for local residents, while grazing opponents contended that there is no written evidence supporting this claim. During the last decade, Mt. Diablo Ranch, now a small in-holding, leased about 7,500 of the Park's acres for grazing. The 1989 Park General Plan decision was to not renew the lease, but to instead graze a few hundred acres for interpretive purposes.

Ecologically and socially, the grazing controversy echoed those on Federal lands. Plan proponents pointed to the "scientific evidence" that grazing benefits the environment. For example, grazing proponents argued that cattle refill the ecological niche left vacant by the absence of native tule elk and pronghorn antelope. Opponents argued that livestock grazing is significantly different in distribution and diet, injuring native plants and encouraging the spread of non-native weeds. But the Park's location on the urban fringe introduced a third, less typical viewpoint into the argument: local residents who believed that cattle grazing reduced the threat of wildfire.

The Cow as Symbol

This public lands grazing controversy had all the usual players: a remnant rural community for whom the cow symbolized "wise use" of natural resources to improve human life, and grazing opponents, for whom the cow symbolized human exploitation and abuse of natural resources. A new element was added because of the Park's suburban-fringe locale: a suburban public concerned about the hazard of wildland fires spreading to nearby residences. As a result, active participants in the Mt. Diablo debate included owners of high-priced homes near the Park. This wealthy, well-educated group strongly supported continued grazing in the Park and had the support of many local business interests.

Left ungrazed, the annual grasses of Mt. Diablo's slopes often reach 5 feet tall. Tinder-dry in summer and fall, they pose a considerable fire hazard. In Mediterranean climate zones worldwide, wildfire is a normal part of ecosystem function, as it is at Mt. Diablo. Grazing advocates, including some local Fire Chiefs, believe that grazing reduces fire hazard by removing biomass, and perhaps more importantly, preventing brush encroachment into grasslands. Opponents of grazing believe that only overgrazing reduces fire hazard, and believe that prescribed burning, mowing, and other techniques should be used instead of grazing. Unfortunately, in rapidly growing Contra Costa County, increasing development of wildlands and air quality restrictions can make extensive vegetation management practices, such as prescribed burning, costly and sometimes controversial. Letters from a local homeowner's association, for example, complained of unsightly blackened earth after a burn.

An Urban Fringe Controversy

The wildfire threat lent unusual power and financing to the pro-grazing side of the issue, contrary to the usual pattern of an "anti-grazing" block composed of people without rural roots. With homes near the Park commonly priced at more than $300,000, residents pay a premium for living near

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Assistant Professor of Environmental Science, University of California, Berkeley, CA 94720; Assistant Professor of Forestry, Michigan State University, 110 Natural Resources Bldg., East Lansing, MI 48824-1222; Graduate Student Researcher, Utah State University, Logan, UT 84322.

nature. They expect nature to be a "good neighbor." This expectation affects their view of land management policy and practice. In some places, urban residents dislike living near grazing operations. Livestock owners complain about trespass problems and depredation by pet dogs. At Mt. Diablo, a vocal portion of the local residents believed that the benefits of fire hazard reduction outweighed any inconvenience caused by the proximity of cattle. The livestock owner allied himself with these interests, and the controversy became a divisive and drawn-out one.

Suburbanites often move to the suburbs to escape urban dangers, and to make a long-term, secure investment in a home. For many in this controversy, the cow symbolizes a safe relationship with nature. By consuming flammable biomass, the cow seems to make the mountain a less capricious neighbor. This vision of the Park as a good neighbor makes restoration of natural processes difficult, particularly when one of the most important natural processes at Mt. Diablo is fire. Allowing development to border parks in which the goal is to restore natural processes makes achieving that goal nearly impossible. Ranch lands might be a valuable buffer between urban/suburban areas and protected or preserved natural systems. Ranches can provide an income to private landowners, yet connect preserved areas for wildlife and buffer developed areas from wildfire, prescribed burning, and other management activities. At the same time, they may buffer preserved areas from pets, vandals, and other intensive human impacts. Unfortunately, although those concerned with the protection of wildland systems and restoration of natural processes are distracted by their extremely polarized view of that ubiquitous rural resident, the cow, the prospects of achieving effective conservation of natural systems have become ever more remote because of urban sprawl.

Fire in a Tropical Savanna—a Double-Edged Sword[1]

Andrea L. Koonce, Timothy E. Paysen, and Bonni M. Corcoran[2]

Since the early 1960's, Caribbean pine (*Pinus caribaea var. hondurensis*) has been used for reforestation in northeastern Nicaragua. Caribbean pine is a species that grows naturally in the area, but its occurrence has increased because of its use, almost exclusively, as a reforestation species. It is thought to rely on the introduction of fire to successfully regenerate in tropical broadleaf zones (Perry 1991). Stands in northeastern Nicaragua, however, have been subject to an intolerably high fire frequency in recent years. In the area under study, 90 percent of the pine stands burn every year (*fig. 1*). Whether resource managers can turn around a self-perpetuating, downward spiral in resource production is an issue of critical importance for future rural economic development in the Miskito region. The current pathological fire frequency in the Caribbean pine savannas results from a combination of high levels of fire risk from human sources, and extremely flammable savanna fuels that thrive on fire. These pines are highly resistant to fire and are rarely killed, although they suffer severe setbacks in wood production and vigor for a number of years after a fire (*fig. 2*). The severe fire regime of the last 10 years has reduced the volume increment for the pines to 60 percent of its potential (Koonce and others 1993). Even if the introduction of fire into Caribbean pine stands is necessary, the stands of the Miskito Coast region of Nicaragua are examples of "too much, too often." Current and planned research in the region has the general goal of determining fire regimes that will optimize the vitality of northeastern Nicaragua's natural resources. Current studies are geared toward mitigation of unwanted fire effects, and understanding stand dynamics under the current fire regime.

Figure 1–Area under study in northeastern Nicaragua. The boggy lowlands of the Miskito coast region are predominately covered with Caribbean pine savannas.

Figure 2–A typical stand of Caribbean pine in the study area. The understory sedges are highly flammable.

References

Koonce, Andrea L.; Paysen, Timothy E.; Taylor, Edwin. 1993. **Fire protection and restoration of forests in Nicaragua**. OICD Proposal for joint research with Nicaragua. USDA Forest Service, Pacific Southwest Research Station, Riverside Forest Fire Laboratory, Riverside, California. 4 p.

Perry, Jessy P. 1991. **Pines of Mexico and Central America**. Portland, OR: Timber Press; 231 p.

---

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2] Research Forester, Research Forester, and Ecologist, respectively, Pacific Southwest Research Station, USDA Forest Service, 4955 Canyon Crest Drive, Riverside, CA 92507.

People—Fire Managers Must Talk With Them[1]

Arthur W. Magill[2]

Abstract: Fire managers know the wildland-urban interface fire problem is a people problem, but recognizing and addressing it are not the same. Managers have repeatedly stressed the need to avoid building with flammable materials and landscaping with fire-prone vegetation. Yet, residents continually fail to heed their warnings. Apparently, people not only respond poorly to warnings but tend to be oblivious to events that disastrously influence their property and lives. Also, the building trades build to satisfy people's desires, community plans do not address the interface fire issue, and governments have been unwilling to enact ordinances that control construction. Above all, fire managers would rather "talk" about public involvement than be immersed in it. These barriers may be removed, if fire managers overcome their reluctance to public involvement and become leaders in two-way communication with the people they wish to influence. These goals may be achieved if fire managers will seek training in the social sciences that emphasizes interpersonal relations, multicultural relations, and communication strategies.

Fire managers know the wildland-urban interface fire problem is a people problem, but recognizing the problem and addressing it in ways that are apt to cause interface residents to change their behavior are two different things. Fire managers recommend to people who move into the wildland-urban interface that they build fire-safe homes and protect them with defensible space. Yet, they are continually frustrated by residents who apparently do not hear or heed their warnings and recommendations to fireproof their homes and yards. Why, when taking action to protect their home from a wildfire seems obvious, do a majority of people fail to comply with fire-safe procedures?

Difficulties in Communication

Managers are quite comfortable dealing with "things," such as equipment, planning strategies, and fire behavior, but they gladly will let somebody else deal with people. Yet, the interface fire problem mandates that managers deal with people, like it or not. So, fire prevention managers need to become directly involved with their intended audience and to emphasize that building fire-safe communities can be profitable for business as well as environmentally pleasing to residents. However, accomplishing the task will require that managers reduce their concern with the technical and functional aspects of interface fires and become personally involved in two-way communication with homeowners, business people, and community leaders.

Communicating with homeowners is not easy, because people not only tend to respond poorly to warnings but tend to be oblivious to events that can have a disastrous influence on their property and lives. People tend to have varying awareness of environmental hazards. They tend to believe that various events "can't happen to them" whereas others' behavior demonstrates coping with or denial of hazardous events.

People in the building trades are aware that people want nice homes in attractive locations, so they have constructed attractive homes in the urban-wildland interface—homes that satisfy the locational, architectural, and landscape dreams of potential buyers, but contribute to the interface fire problem. If fire managers are to achieve their goals, they must confront and convince home building professionals to use fire-safe materials and designs.

Community plans frequently do not address the interface fire issue, and local governments have been unable or unwilling to enact ordinances that control development and construction. The unwillingness of governments to enact fire legislation may be related to an avoidance by politicians to be associated with actions that may be viewed unfavorably by their constituency (Sampson 1991). Regardless, fire managers must contact and encourage planners, local officials, and legislators to develop effective zoning ordinances.

In addition, managers should work with insurance companies to develop policy incentives that support local plans and ordinances. Overall, premiums for homes built in fire prone areas should reflect the higher costs associated with the greater risks, but they might be somewhat reduced for those homeowners who adapt to fire-safe road designs, architectural designs, and building materials.

Manager attitudes also bear on the communication problem as a consequence of their preference for working with "things" rather than people. They tend to "talk" more about public involvement rather than immersing themselves in it. For the most part, evidence of this preference by managers is rather subtle and is depicted by actual behavior as contrasted with professed behavior.

Recommendations and Conclusions

People—whether homeowners, design and construction professionals, or public officials—may be enticed to participate in fire safety programs provided they are given

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Principal Resource Analyst (retired), Pacific Southwest Research Station, USDA Forest Service, 4955 Canyon Crest Drive, Riverside, CA 92507.

clear messages, presented by credible individuals who specify necessary actions, and provided the messages are reinforced locally. Fire managers should be considered the credible authorities on interface wildfires. They are especially effective as authorities if they have established themselves in a community through direct involvement with public education and involvement programs, and by soliciting the help of community leaders through dialogue to fortify the meaning and importance of their messages. The factors proven effective for warning of imminent hazards suggest that warnings be clear, specific for the desired response, derived from a credible source, reinforced locally, and conveyed by a positive message on prime-time television.

Fire managers, like other resource professionals, tend to be disinclined to initiate social interaction and to avoid situations involving abstract concepts and alternative solutions. The barriers may be removed, however, if fire managers overcome their reluctance to be directly involved with citizen involvement programs and establish two-way communication with the people they wish to influence. These goals may be achieved if fire managers pursue continuing education in the social sciences that emphasizes interpersonal and multicultural relations, and communication strategies.

References

Sampson, R. Neil. 1991. **The politics of the environment**. Journal of Soil and Water Conservation 46(6):398-400.

The Effects of Forest Fire Smoke on Firefighters[1]

Richard J. Mangan[2]

Abstract: Each fire season, 20,000 to 30,000 firefighters are engaged in suppressing wildfires and conducting prescribed burns on federal lands, and many more are employed in fire suppression on State and private lands. Studies of firefighter exposure to smoke and carbon monoxide indicated only occasional exposure until the 1987-1988 fire seasons in the West. During the 1988 Yellowstone fires, 12,000 respiratory problems were reported to medical personnel. To address this problem, the National Wildfire Coordinating Group (NWCG) assigned the USDA Forest Service's Missoula Technology and Development Center (MTDC) the responsibility to coordinate the national effort looking at the health effects of smoke on wildland firefighters. An interagency Technical Panel has been formed to provide direction and set priorities, and semi-annual newsletters ("Health Hazards of Smoke") are distributed to more than 7,000 firefighters nationally and internationally.

Each year, tens of thousands of wildland firefighters are involved in wildfire suppression and prescribed burning on millions of acres in the United States. For many years, the effects of exposure to smoke and carbon monoxide has been a minor concern, but has never emerged as a high priority. But, in 1987 and 1988, serious smoke inversions lasting many days and weeks caused significant respiratory problems in large numbers of wildland firefighters.

In 1989, the National Wildfire Coordinating Group (NWCG) assigned the USDA Forest Service's Missoula Technology and Development Center to coordinate the national effort and serve as the focal point for ongoing and future studies on the effects of wildland fire smoke on firefighters.

Study Areas

At a 1989 workshop in San Diego sponsored by NWCG and Johns Hopkins University, participants representing firefighters, union leaders, fire management specialists, occupational medicine, toxicology, industrial hygiene, fire chemistry, and protective equipment identified eight major areas of study that would encompass the concerns about the health effects of smoke:

- Retrospective Cohort Mortality Study—to determine if the long-range health of a firefighter is adversely affected as a result of past exposures to smoke;
- Prospective Injury and Illness Study—to develop a current system of data collection regarding wildland firefighter injury and illness to prospectively assess the role of smoke in the etiology of acute and long-term injury and illness;
- Chronic Pulmonary Function Study—to determine if wildland firefighters experience a chronic, accelerated loss of lung function during multiple fire seasons;
- Integrated Field Study—to establish a mobile team of industrial hygienists, wildland fire experts and occupational medicine specialists to conduct an intensive, integrated 3-year field study;
- Combustion Product Characterization and Toxicity Study—to develop sampling techniques, study combustion conditions and test diverse fuel conditions;
- Expanded Field Exposure Study—to provide firefighters with efficient methods for monitoring exposure and detecting cumulative effects;
- Integrated Risk Assessment—to assess the risk of exposure among firefighters;
- Risk Management—to develop an interactive program for use by fire management personnel to select risk management options based upon local conditions.

Completed Studies

As of this time, completed studies of breathing zone air samples collected from wildland firefighters and prescribed burners indicated some potential for hazardous exposure (respirable particulates, carbon monoxide, formaldehyde, acrolein). While these exposures have occasionally exceeded short-term exposure limits, very few cases have approached or exceeded allowable time-weighted averages. Smoke exposure from wildfires is not considered immediately dangerous to life and health.

Studies on the respiratory effects of smoke exposure on wildland firefighters indicate that exposure during a fire season may result in small changes in lung function. The health implications of short-term exposure and the potential health effects of long-term exposures have not been quantified.

Laboratory and field studies of respiratory protective devices have been conducted. Laboratory studies have focused on the effects of air-purifying respirators on work performance

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in the Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Fire and Aviation Program Leader, Missoula Technology and Development Center, USDA Forest Service, Missoula, MT 59801.

and on ways to predict the ability of firefighters to work while wearing a respirator. Field studies have included a survey to determine the field use of respirators, other methods of risk management, and field trial to evaluate a wide range of respirators in actual working conditions.

Current Studies

Current projects under the NWCG study include continued efforts to characterize the hazards of smoke, and to determine the health effects of repeated exposures; laboratory studies of the use of respirators and their effects on upper body work performance; field trials of existing and prototype respirators, smoke monitoring devices, medical evaluation and surveillance; and risk management strategies.

Acknowledgments

Brian J. Sharkey, Project Leader at Missoula Technology and Development Center (MTDC) and Professor of Human Physiology at the University of Montana, has been primarily responsible for initiating and guiding the "Health Hazards of Smoke" effort sponsored by the National Wildfire Coordinating Group (NWCG).

Burning in Arizona's Giant Cactus Community[1]

Marcia G. Narog[2] Andrea L. Koonce[3] Ruth C. Wilson[4] Bonni M. Corcoran[2]

Abstract: Giant saguaro cacti (*Carnegiea gigantea*) and associated vegetation are being burned by numerous wildfires, especially in areas of high public use. Specific fire effects on affected plant species and ecosystem resilence need to be defined, and management techniques for restoration of burned areas need to be developed. A research effort was initiated at the Saguaro Natural Scenic Area, Tonto National Forest, Arizona to determine how fire impacts saguaro community structure and species composition; to monitor fire ignition and spread patterns; and to analyze saguaro survival, vitality and abundance, and genome variabilty. Results from this study should improve our understanding of fire in the saguaro community and facilitate implementation of a pro-active fire management program.

Saguaro cacti (*Carnegiea gigantea*) and associated vegetation attract national and international tourists to the Sonoran desert in Arizona. Saguaros are an integral component of the biodiversity of both flora and fauna in this desert. Unfortunately, numerous wildfires concentrated in areas of high public use are destroying the saguaro and severely degrading many popular vistas, especially along the Saguaro Natural Scenic Area, Tonto National Forest, Arizona.

Fire History

Although a historical fire regime for this vegetation type is not presently known, natural fires have probably not been a major selecting force for much of the vegetation in the Sonoran desert. However, anthropogenic impacts include the introduction and expansion of alien plant species, especially grasses. Their growth has been accompanied by an increase in fire frequency, intensity, and extent. This change in fire regime may now threaten many non-fire adapted species. Of particular concern is the tropically evolved saguaro.

In many locations on the Tonto National Forest, the combination of herbaceous and shrub layers, including the many introduced species, form nearly contiguous and highly flammable fuels in the saguaros' range. Increased growth is especially common during years with heavy precipitation. On the Tonto National Forest, precipitation averages 7.66 inches. Rainfall was recorded at 14.24 inches and 13.34 inches for 1992 and 1993 respectively. In 1993, after these 2 years of above normal rainfall, 104 fires (twice the yearly average) were recorded on the Mesa Ranger District, Tonto National Forest. These fires included both accidental and deliberate fire ignitions. One arsonist is believed to have been responsible for setting multiple fires that burned hundreds of acres. These acres included prime tourist attraction areas such as the Desert Vista View Observation Point on the popular Bee-Line Highway.

Saguaro and Fire

Saguaro can grow to heights of 18 m, weigh more than 2 tons, and is estimated to live about 200 years (Holden and Farrell 1991). Wildfire may kill significant numbers of cacti and succulents that characterize the saguaro communities (Thomas 1991, Rogers 1985, Mclaughlin and Bowers 1982). Specific fire effects on plant species and ecosystem resilience have yet to be defined (Ahlstrand 1982).

Fire affects saguaro reproduction and survival. Generally, only one seed in 1,000 may germinate; less than 1 percent of these will survive more than 6 weeks (Holden and Farrell 1991). Fire may contribute to an increase in juvenile mortality. Saguaro growth is slow, especially during the first few years. In nature, approximate size/age relationships for saguaro are 1 cm in height after 5 years, 1 m after 30 yr, and 10 m after 100 years (Holden and Farrell 1991). Fire injury may also lead to increased mortality of mature saguaro (Thomas 1991).

Nurse plants, such as the palo verde, are reported to be necessary for saguaro reproduction and survival (Gibson and Nobel 1986, McAuliffe 1984, Vandermeer 1980). Ironically, nurse plants may contribute to higher saguaro mortality from fire because of increased local fuel loading.

Fire Management

Rogers (1986) compared fire occurrence in desert and nondesert vegetation on the Tonto National Forest from 1955 to 1983; desert fires were fewer, larger, and unsuppressed, compared to the more numerous but smaller nondesert fires. A recent update of the fire frequency and acreage burned during the last recorded decade (1983 to 1992) showed similar trends (*figs. 1* and *2*). Ninety percent

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Ecologists, USDA Forest Service, 4955 Canyon Crest Drive, Riverside, CA 92507.

[3]Research Forester, Pacific Southwest Research Station, USDA Forest Service, 4955 Canyon Crest Drive, Riverside, CA 92507.

[4]Professor, Biology Department, California State University, San Bernardino, 5500 University Way, San Bernardino, CA 92407.

of this desert vegetation class is composed of the saguaro plant association. Cave and Patton (1984) evaluated wildfire versus controlled burning in the Sonoran desert. They provide evidence that fire alters species composition and dramatically reduces cacti presence. They concluded "that any efforts to use prescribed burning should remain experimental until a long-term data base exists on which to make more reliable predictions." Apparently, hundreds of fire ignitions occur and thousands of acres are burned in saguaro habitats. Although this fire problem continues, this vegetation type still has low priority for fire suppression resources, such as equipment, personnel, and dollars.

Current Research

To justify greater expenditures of fire suppression resources on the saguaro community, the Tonto National Forest requested that the Prescribed Fire Research Unit of the Pacific Southwest Research Station develop strategies that would be effective for the Tonto's fire management program. In order to evaluate alternatives, some basic research must first be conducted.

Our study area is located in the northeast section of the saguaro's range on the Mesa Ranger District, Tonto National Forest. For our preliminary investigations, we have defined four major objectives: examining fire effects on saguaro community structure and composition, including different plant strategies such as germination or resprouting after fire; monitoring fire ignition and spread patterns during prescribed burns; analyzing the impact of fire on saguaro survival, vitality and abundance; and studying fire effects on saguaro genome variability. We are currently designing study parameters and will be implementing a 5-year study evaluating prescription burning and areas previously burned by wildfire in the saguaro community.

Summary

We believe that fire suppression strategies need to be implemented to limit fire spread with minimal habitat disturbance. Currently, we need more information on factors that contribute to flammability and fire damage in this ecosystem. After our objectives in this study are met, management strategies and techniques need to be developed for aggressive restoration of fire degraded areas.

References

Ahlstrand, Gary M. 1982. **Response of Chihuahuan desert mountain shrub vegetation to burning**. Journal of Range Management 35(1): 62-65.

Cave, George H.; Patten, Duncan T. 1984. **Short-term vegetation responses to fire in the upper Sonoran Desert**. Journal of Range Management 37(6): 491-496.

Gibson, Arthur C.; Nobel, Park S. 1986. **The cactus primer**. Cambridge, MA: Harvard Univ. Press; 153-160.

Holden, Wesley; Farrell, Robert J., eds. 1991. **All about saguaros: Arizona highways book**. Phoenix: Arizona Department of Transportation; 6 p.

McAuliffe, Joseph R. 1984. **Sahuaro-nurse tree associations in the Sonoran Desert: competitive effects of sahuaros**. Oecologia 64: 319-321.

McLaughlin, Steven P.; Bowers, Janice E. 1982. **Effects of wildfire on a sonoran desert plant community**. Ecology 63(1): 246-248.

Rogers, Garry F. 1985. **Mortality of burned *Cereus gigantus***. Ecology 66(2): 630-632.

Rogers, Garry F. 1986. **Comparison of fire occurrence in desert and nondesert vegetation in Tonto National Forest, Arizona**. Madrono 33(4): 278-283.

Thomas, P.A. 1991. **Response of succulents to fire: a review**. International Journal of Wildland Fire 1(1):11-22.

Vandermeer, John. 1980. **Saguaros and nurse trees: a new hypothesis to account for population fluctuations**. The Southwestern Naturalist 25(3): 357-360.

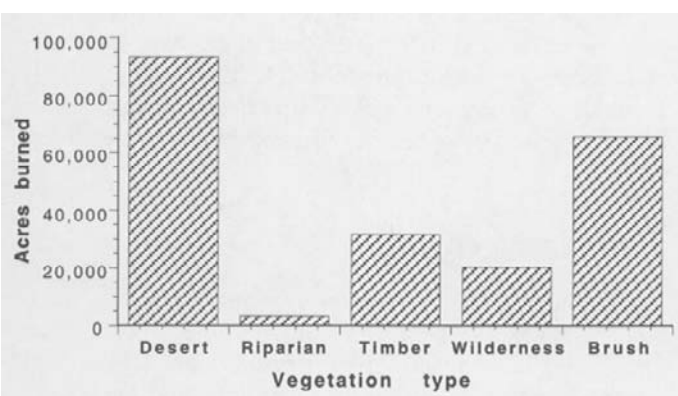


Figure 1–Total acreage burned on the Tonto National Forest, Arizona from 1973 to 1992.

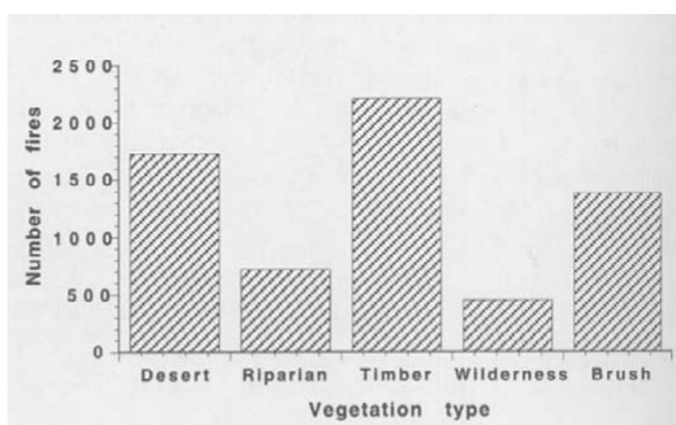


Figure 2–Total number of fires recorded on the Tonto National Forest, Arizona from 1973 to 1992.

A Computer Program for Evaluating Prescribed Fire Costs[1]

Philip N. Omi Douglas B. Rideout Stephen J. Botti[2]

Abstract: How much should prescribed fires cost? What are reasonable cost estimates for conducting a burn, in terms of site preparation, ignition, and containment? How might a manager ascertain if proposed costs are reasonable? Similar questions arise for any prescribed fire program that involves a large geographic area. A computer program was developed to answer such questions, based on regression analysis of historical records within regions of the USDI National Park Service (NPS). Although restricted to the NPS, we discovered a cost structure for fuel treatments that should apply generally. Cost estimates were found to be sensitive to management objectives, geographic region, project size, complexity of burn, and potential for escape. The computer program is written in PASCAL and designed to address the entire range of environmental, ecological, and economic factors considered in the NPS prescribed fire data base. This information is useful to land managers, but also should be of general interest for comparing fire with other alternatives for managing fuels in wildland and urban interface areas.

The USDI National Park Service (NPS) Hazard Fuel System was developed to aid prescribed fire management within the agency, particularly with respect to budgeting and tracking costs for reducing fuel combustibles on NPS lands. Before the development of this system, the NPS (or any agency) did not have a standardized procedure for assessing the accuracy of cost requests from field units for proposed prescribed fire projects.

This paper highlights one approach to assess the range of reasonable cost requests; this method can be applied regardless of public agency jurisdiction, geographic location and management situation.

Objective

Our goal was to develop cost target zones (i.e., ranges of reasonable costs) for fuel treatment projects, based on important predictors of cost variability. The computer program was designed to display these zones in an interactive format.

Methods

We obtained electronic data files maintained by the NPS Branch of Fire Management for recent and future hazard fuels projects submitted by park units. The Hazard Fuels data set contains specific information on project size, fuel model, project type, ranking score, administrative or legislative mandate, complexity score, and descriptive remarks. Hazard fuel projects are meant to lower the impacts of wildland ignitions that might originate in wildland vegetation types and pose a threat to public safety, structures, improvements, or cultural and natural resources.

Based on historical funding requests from field units, cost target zones were constructed for Hazard Fuel projects (Omi and others 1994) using standard regression procedures. The regression equation and 95 percent confidence interval were used in a computer program (written in PASCAL) to display the range of acceptable costs for Hazard Fuel projects. The program queries the user about relevant inputs related to the entire range of environmental, ecological, and economic factors considered in the NPS data base. This information is useful to land managers, but also should be of general interest for comparing fire with other alternatives for managing fuels in wildland and urban interface areas.

Results

Regression coefficients were derived from a step-wise procedure in which all variables in the Hazard Fuels data set were initially considered in terms of their contribution to explaining variation in cost requests. The regression coefficients explained 91 percent of the variation in (log-transformed) cost. All coefficients were significant ($p < 0.01$), as explained in Omi and others (1994).

A typical screen from the computer program (RXCOST) was developed from our regression analysis (*fig. 1*) (Stone and others 1992). Upon entering the program, a user is queried about size of project (ac), the National Fire Danger Rating System (NFDRS) fuel model, management type (fire, mechanical, biological, or chemical treatment), natural resource rank (1 to 9), and potential for escape (1 to 9). The cost per acre target and range correspond, respectively, to the regression prediction and upper (lower) 95 percent confidence limits. The user may also request a wider or narrower target zone than the 95 percent confidence interval by specifying a range greater or less than one. Future cost requests outside the range of acceptability are not necessarily invalid; rather, such requests may indicate the need for additional rationale.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Professors of Forest Science, Colorado State University. Ft. Collins, CO 80523; Fire Program Budget Manager, National Interagency Fire Center, USDI National Park Service, Boise, ID.

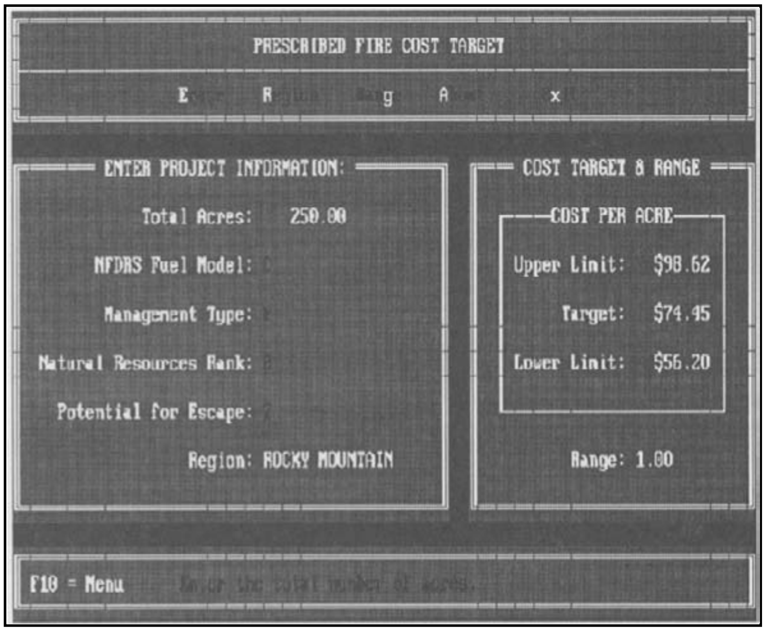


Figure 1–Representative screen from program RXCOST showing average (target) cost per acre of $74.45 for a 250-acre proposed prescribed burn (management type F) in NFDRS fuel model C, with natural resource rank 8 (high) and moderate potential for escape (7) in the Rocky Mountain region. The range specification of 1.00 uses the 95 percent confidence interval to set the upper and lower limit for the target. Proposed projects which exceed $98.62/acre or fall short of $56.20 (i.e., outside upper and lower limits) deserve additional scrutiny.

Conclusions

The cost target zones identified by the computer program RXCOST (Stone and others 1992) are those projects whose cost requests are either excessive or under-financed, that is, outside the range of historic acceptability. We believe the estimates from the computer program are applicable to a wide range of situations, including different geographic regions, fuel conditions, or other project descriptors.These cost ranges from the program should be considered as providing guidance for improved decision-making, but not as the sole criterion for assessing treatment cost. A cost request that falls outside the range of acceptability (based on the computer program) should not be rejected without further investigation. The resulting analysis might reveal that projected costs are justifiable because of extenuating circumstances associated with a proposed project, for example. Thus, the zones should be applied with the usual discretion and good judgment associated with crucial decisions.

Acknowledgments

Submitted in fulfillment of project objectives for contract CA 1268-1-1-9002, TO#9, Project BIFC-R91-0163, USDI National Park Service. Additional support for this project was provided by the McIntire-Stennis Cooperative Forestry Research Program.

References

Omi, P. N.; Rideout, D. B.; Stone, J.S.; Botti, S. J. 1994. **Controlling fuel treatment costs in the National Park Service**. In: Proceedings of the 12th conference on fire and forest meteorology; 1993 October 26-28, Jekyll Island, Georgia; Bethesda, Maryland: Society of American Foresters.

Stone, J. S.; Omi, P. N.; Rideout, D. B. 1992. **RXCOST ver 1.01**. USDI National Park Service, National Interagency Fire Center, Boise, ID.

Potential Nitrogen Losses due to Fire from *Pinus halepensis* Stands in the Alicante Province (Southeastern Spain): Mineralomass Variability[1]

Antonio Pastor-Lopez **Joaquin Martin-Martin** [2]

Abstract: Potential nitrogen volatilization during fire was calculated for *Pinus halepensis* plantations. The stands located in the Alicante province (southeastern Spain) represent a range of site qualities and are more than 25 years old. Biomass and nitrogen content for fractions smaller than 1 centimeter in diameter and for the total were determined. A 70 percent volatilization of the nitrogen in the biomass represents a loss of 8.2 to 116.5 kilograms per hectare for stands with total aboveground biomass of 5.06 and 151.12 tons per hectare. The percentage of nitrogen lost from the total biomass is larger in sites of lower site quality.

The effects of fire regimes on the sustainablility of ecosystems constitute one of the main aspects to consider. Nitrogen is a fundamental element for soil productivity even in drought-prone ecosystems where water has a dominant role. Nitrogen outputs through volatilization during fire events is very significant. During this century large extensions in the Mediterranean Basin were planted with different conifers after fire or other perturbation events. In Spain, Aleppo pine (*Pinus halepensis*) was used in most of these plantations. The modification of the fire regime, with an increase in fire events, caused by the nature of these monocultures and human actions, has completely modified the temporal scale and potentiality of recovery in many areas. These factors are fundamental in the sustainability of the long-term productivity of these systems. This paper characterizes the nitrogen pool available in the biomass in stands more than 25 years old along a range of site qualities. It estimates the potential nitrogen lost by applying the trends of volatization shown in the literature. This paper is directed toward defining the magnitude of nitrogen lost in these stands as an indication of the amount that would need to be restored in order to avoid a reduction in its total pool and therefore productivity of these ecosystems.

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Professors, T.E.U. (Titular de Escuela Universitaria) and T.U. (Titular de Universidad), respectively, Departamento de Ecología, Universidad de Alicante, Alicante, Spain. Ap. 99, Alicante-03080 (Spain).

Study Area and Methods

The study was conducted in Aleppo pine stands located in Alicante province. Alicante is located in the western coastal Mediterranean Basin in southeastern Spain (37º 50' to 38º 55' N and 1º 05' to 0º 10' E). The sites were selected out of a general survey for the province during 1985. A total of 120 stands were sampled in a range of age, climate, and site quality conditions. The age of the stands considered is representative of that of the plantations started during the national afforestation program for soil conservation purposes between 1945 and 1985. The silvicultural treatments that the stands have undergone include pruning of the lowest branch whorl 5 years after planting and a later pruning of 1 or 2 whorls in the following 10 years. The existing variability of the Aleppo pine stands in the Allicante province is representative of that in the Mediterranean Basin as to the range in climate between subhumid and semiarid Mediterranean conditions (Nahal 1981). From the 120 stands considered, 4 master stands were selected, along a site quality range, to elaborate equations describing destructive biomass sampling, as well as detailed nutrient contents analysis. Ten trees were cut down to obtain biomass equations in each one of the four stands selected. The stands were representative of the range of site qualities that can be commonly expected in the Alicante province (Pastor-Lopez 1992).

To determine the nitrogen pool that could be lost in a fire event, the biomass for four fractions was considered: leaves, shoots (stems holding leaves, always smaller than 1 centimeter in diameter), fine branches (stems not holding leaves and larger than 1 centimeter in diameter) and the rest of the aboveground structures. The first three constituted fraction I and the last fraction II. The reason for defining 1 centimeter in diameter as the limit is based on the statement by Wells and others (1979) that the plant stems remaining after a moderately intense burn or a severe fire are greater than 0.6 or 1.3 centimeters in diameter. All determinations of nitrogen contents were done by the Kjeldahl procedure.

To better define the limits of nitrogen available on a more extensive sample, 32 stands more than 25 years old were selected out of the above-mentioned sample of 120. Each fraction biomass for these 32 stands was determined by applying the equations from the master stands to the sample plot measurements obtained for every stand. Each stand was assigned a set of the four groups of biomass equations. The matching criterion was similarity in site index with one of the four master stands. Nitrogen content of leaf and shoot fractions was determined, using the Kjeldahl procedure, from a sample of 1-year-old leaves and shoots for each of the 32 stands. The nitrogen contents fine branch and fraction II were assigned by averaging from the master stands the different replicates analyzed by fraction (Pastor-Lopez 1992). Each stand was assigned the same master stand as for the biomass equations. Out of the 32 stands considered, those representing the limits of nitrogen accumulation on an age and site index spectrum are included in the following section.

Results and Discussion

The four stations where destructive biomass sampling was completed were also studied for nitrogen mineralomass as well as other nutrients (Pastor-Lopez 1992). The results obtained illustrate how nitrogen accumulated in different structures. *Table 1* gathers the information on the dendrometric and stand structure characteristics of these four master stands.

Nitrogen mineralomass and the percentage of it in the different structures included in the fraction smaller than 1 centimeter in diameter are included in *table 2*.

From the 32 stands considered for the more extensive and representative sample, 7 stands were selected as representative of the limits of variability for age and site index. *Table 3* includes the dendrometric characteristics of these stands.

Nitrogen contents for these stands and the potential maximum mineralomass available for fraction I and others are included in *table 4*. The percentage of the total above-ground nitrogen mineralomass, represented by the amount of nitrogen accumulated in fraction I, represents the potential maximum amount to be lost in a fire event. Nevertheless, there are different factors that influence this loss.

Woodmansee and Wallach (1981) indicated that two of the factors that determine the amounts of elements lost during a fire include the biomass and the elemental composition of the vegetation. This information has been shown already and would reflect a maximum to be lost; nevertheless, intensity and duration of the fire play a very important role in determining the limit. White and others (1973) determined that complete volatilization occurs at temperatures above 500 degrees Celsius and almost none below 200 degrees. Rundel (1981) pointed out with several examples the importance of the temperature of the fire in relation to the amount of nitrogen volatilization expected. The range given by him varies between 58 and 85 percent under laboratory conditions. Lobert and others (1990) give a value of 90 percent.

Bernard and Nimour (1993) determined, for *Pinus halepensis* in laboratory conditions, ignition temperatures between 235 and 330 degrees Celsius. They indicated that lignin, lipids, some or all the holocellulose and the ashes were the residues from combustion at these temperatures. On the other hand, they pointed out that volatization of the substances depended on the water content and chemical

Table 1—*Dendrometric characteristics of the four master stands*

Characteristics[1]	Stand codes 8601	6502	3702	1701
Age (years)	28	36	27	32
Density (trees/ha)	1550	1600	1682	1350
Site index (height in meters at 20 years)	4.8	3.2	1.4	1.5
Basal area (m^2/ha)[1]	34.86	23.61	3.45	9.77

[1]Measured at 0.5 m.

Table 2—*Nitrogen mineralomass and relative percentage by fractions*

Stands	8601	6502	3702	1701
Nitrogen mineralomass (kg/ha)				
Fraction I	161.4	61.4	14.9	30.0
Total	311.4	96.5	19.7	40.6
Percentage of total nitrogen mineralomass by fraction				
Leaves	28.83	38.71	45.23	47.92
Shoot[1]	8.26	5.44	6.30	7.87
Fine Branches[2]	14.74	19.49	23.95	17.99
Fraction II[3]	48.17	36.36	24.52	26.22

[1]"Shoot" refers to those holding leaves.
[2]"Fine branches" refers to stems with diameter smaller than one centimeter.
[3]Fraction II includes rest of the above-ground structures of the tree.

Table 3—*Dendrometric characteristics of sample stands.*

Stand	Age	Density	Site index[1]	Total Aboveground Biomass
	yr	*trees/ha*	*m*	*tons/ha*
191	25	2600	1.8	13.306
43	28	2700	0.6	5.060
211	39	2350	0.5	5.613
141	42	1289	2.7	38.554
551	42	1079	4.7	92.403
901	35	969	5.8	116.562
811	32	2720	5.4	151.120

[1]Site index (height in meters at 20 years).

composition of the structures burned, for which the phenological state had important consequences. No measurements had been done, in natural conditions, of the temperature reached during ignition for these stands, nor for Aleppo pine. The dense crown characteristic of the species and the low height (2 to 8 meters) due to limitations in soil productivity ensure that most fires in these stands will behave like crown fires. For the interval of 300 to 400 degrees Celsius the percentage of nitrogen volatilized represents 50 to 75 percent of the total amount in the biomass, according to White and others (1973). Rundel (1981) indicated losses of 70 percent for *Pinus*.

If we consider 70 percent as a compromise between the high levels obtained in the laboratory and the lower ones observed in natural conditions, the range of nitrogen lost for Aleppo pine in the plantations studied would be between 8.18 and 116.47 kilograms per hectare for stands with respective total aboveground biomass of 5.060 and 151.120 tons per hectare. Although not validated, this paper gives the first estimates on the potential losses of nitrogen in a broad range of site qualities. The frequent use of the species around the Mediterranean Sea and the new European economic community policy for afforestation of abandoned agricultural lands will increase the extension of these stands. The high incidence of fire along these areas, caused by arson or accidents, could be considered the most important source of atmospheric emissions in these areas. On the other hand, as Debano and others (1979) indicated, the total amount of nitrogen on an area basis is always reduced after a fire, in relation to the prefire status. The need to determine the agents that restore the original nitrogen levels and their rate is fundamental for maintaining the productivity of these sites. *Ulex parviflorus* is a typical leguminous evergreen species that responds with a prominent increase in cover after fire events. Its nitrogen-fixing capacity should be determined in order to define the magnitude and timing of its input. The magnitude and timing in the input of nitrogen fix that is mentioned in the previous sentence must define which are the potential management procedures to deal with *Ulex parviflorus*. The extended belief is that this *Ulex,* because of its high flammability and large accumulation of dead material, must be eliminated. This action could represent a depletion of the greatest input of nitrogen to the system during the growth periods following the fire.

The percentage of nitrogen lost from the total in the biomass is clearly larger in the sites with a lower site quality. These sites should show more efficient mechanisms to restore nitrogen or they will be much more susceptible to degradation by future fire events. In other words, under a similar fire perturbation regime, low-site-quality stands will be more susceptible to losses in long-term site productivity than other stands with higher site quality.

Table 4—*Nitrogen contents, mineralomass and percentage of nitrogen from aboveground total for plantations representing the limits of age and site index.*

Stand	Nitrogen content		Nitrogen mineralomass				
	Shoots	Leaves	Shoots	Leaves	Fraction I	Fraction II	Total N in Fraction I
	pct		*kg/ha*				*pct*
191	0.410	1.020	1.79	19.76	29.28	17.55	62.5
43	0.265	0.615	0.50	6.27	11.68	3.63	76.3
211	0.330	1.990	0.69	21.64	27.58	4.17	86.9
141	0.587	0.868	6.27	44.24	72.63	34.61	67.7
551	0.746	1.113	14.87	86.16	110.64	157.45	41.3
901	0.742	1.456	17.82	135.04	164.36	200.15	45.1
811	0.628	1.095	21.77	130.06	166.39	259.28	39.1

Acknowledgments

Funding for this research was provided by the Ministerio de Educacion y Ciencia, Conselleria de Agricultura y Pesca de la Comunidad Valenciana y Diputacion Provincial de Alicante. The Unidad Forestal de Alicante and his Agentes Forestales have played a fundamental role in site location and field sampling. We thank D. Juan Giner for his continued support. In particular, we thank Nicolas Gimenez, Silvia Ivars, M.C. Martinez, Manuel Valera for their contributions, and Edelmiro Zafra for his assistance in the chemical analysis.

References

Bernard, M.; Nimour, N. 1993. **Inflammabilité des végéteaux mediterranéens et feux de fôrets. (1ère partie): Rôle de l'eau sur l'exothermicité de leur reaction**. Science Technique Technologie 26.

Debano, L.F.; Rice, R.M.; Conrad, E. 1979. **Soil heating in chaparral fires: effects on soil properties, plant nutrients, erosion, and runoff**. Research Paper PSW-RP-145. Berkeley, CA: Pacific Southwest Forest and Experiment Station, Forest Service, U.S. Department of Agriculture; 21 p.

Lobert, J.M.; Scharffe, W.M.; Hao, W.M.; Crutzen, P.J. 1990. **Importance of biomass burning in the atmospheric budgets of nitrogen-containing gases**. Nature 346 (6284): 552-554.

Nahal, I. 1981. **The Mediterranean climate from a biological viewpoint**. In: Di Castri, F.; Goodall, D.W.; Specht, R.L., eds. Mediterranean-type shrublands. Ecosystems of the world. Volume 11. Amsterdam: Elsevier Scientific Publishing Company; 63-86.

Pastor-López, A. 1992. **Biomasa, Producción primaria y Flujo de Materia orgánica en Repoblaciones Forestales de la provincia de Alicante**. Aplicaciones a la Géstion Forestal. PhD Thesis. University of Alicante, Alicante, Spain; 309 p.

Rundel, P.W. 1981. **Fire as an ecological factor**. In: Lange, O.L.; Nobel, P.S; Osmond, C.B.; Ziegler, H., eds., Physiological plant ecology I. Responses to the physical environment. Encyclopedia of plant physiology. New Series Vol.12A. Berlin, Germany: Springer Verlag; 501-538.

Wells, C.G.; Campbell, R.E.; DeBano, L.F.; Lewis, C.E.; Fredricksen, R.L.; Carlyle Franklin, E.; Froelich, R.C.; Dunn, P.H. 1979. **Effects of fire on soil. A state-of-knowledge review**. General Technical Report WO-7.Washington, DC: U.S. Department of Agriculture, Forest Service; 34 p.

White, E.M.; Thompson, W.W.; Gartner F.R. 1973. **Heat effects on nutrient release from soils under ponderosa pine**. Journal of Range Management 26: 22-24.

Woodmansee, R. G.; Wallach, L. S. 1981. **Effects of fire regimes on biogeochemical cycles**. In: Clark, F.E.; Rosswall, T., eds. Terrestrial nitrogen cycles. Ecological Bulletin (Stockholm) 33: 649-669.

Susceptibility to Potential Erosion after Fire in Mediterranean Ecosystems in the Alicante Province (Southeastern Spain)[1]

Antonio Pastor-Lopez Joaquin Martin-Martin[2]

Abstract: Postfire precipitation regimes are important to the dynamics of the physical and biological processes occurring after fire. From 1972 through 1991, 143 fire events of at least 100 hectares occurred in Alicante province, Spain; 42.5 percent of the area burned in August. The trends for total, pregrowth season, October, and September through November precipitation for 1 year after each fire are shown. Half of the burned areas received more than 349 (and up to 880) millimeters of rainfall before the growing season and between 44 and 325 millimeters during the first October after fire. Erosion events before the beginning of the growing season and spatial relocation of ash layer materials on a watershed basis are major factors expected to contribute to post-fire erosion.

Fire has been an active agent in the evolution and shaping of the structure of vegetation in the Mediterranean Basin. Nevertheless, the increase in fire frequency by arson or management actions has modified disturbance regimes to a level that might exceed the resilience of the system.

Despite the difficulty of quantitatively linking precipitation and erosion, the frequency of erosion events has been clearly related to specific macroclimatic conditions. In the Alicante province in southeastern Spain, the highest erosion frequency has been observed in October. Fire may affect soil fertility via the export of large quantities of nutrients through debris flows and run-off. Identifying the rainfall regimes experienced by burned areas after a fire can help define the framework in which these ecosystems develop. This paper addresses the problem of susceptibility to erosion in postfire conditions.

Study Area and Methods

The province of Alicante is located in the western coastal Mediterranean Basin on the southeastern Iberian Peninsula (37º 50' to 38º 55' N and 1º 05'W to 0º 10' E), with 581,901 hectares and 140 municipalities. The province has an important wildfire problem. In 20 years (1972-1991), 62,074 hectares burned in 143 fires of at least 100 hectares each. This area represents 10.7 percent of the whole province and 26.7 percent of the naturally vegetated area. Sixty-eight municipalities were affected at least once (48.6 percent). For these municipalities, the area burned added up to 28.8 percent and 55.8 percent of their total and natural vegetation areas, respectively. Although information was not available on areas that suffered recurrent fires, it was evident that fire was an important perturbation in these ecosystems.

We studied fires 100 hectares or greater in area. Date of occurrence, area of extent, and location were used to characterize the fire regime. To define the precipitation regime, 15 climatological stations available from the area were used. The burned areas were assigned the climatological data from the closest station for the first year after fires, which is when the highest susceptibility to erosion occurs (Debano and others 1979), and we then evaluated four variables. First, total precipitation was examined for 1 year after the fire. In Mediterranean-type ecosystems in southern California, erosion during the first year can be as much as 35 times greater than normal (Wells 1982). Next we examined precipitation that had been measured between the fire and the beginning of the next growing season, which, unlike southern California, begins in March for most higher plants because of the cooler winters in the Alicante province. This information was used to evaluate both the possibility of high precipitation when the vegetation cover was minimal as well as the potential availability of water for plant regrowth and thus soil protection. We also evaluated precipitation during the first October after fire. Sanchez (1989) conducted a 5-year study in Alicante and found that 57 percent of the erosion events and 54 percent of the sediment accumulation occurred in October. And lastly, precipitation during the September-October-November period after the fire was examined because this season tends to have the greatest amount of precipitation, according to more than 30 years of observations collected by the network from the Centro Meteorologico de Levante.

Results and Discussion

During the 20-year period, two main peaks of the area burned (over 8,000 hectares per year), which were separated by 12 years with values below 4,000 hectares per year. The two maxima occurred in 1978 and 1990. On a monthly basis, 42.5 percent of the area burned in August, followed by 25.3, 15.1 and 10 percent in July, September and October respectively. The number of fires was 10 percent greater in September than in July, indicating larger fires in the latter. Fires did not occur in January and March, and no more than

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Professors, T.E.U. (Titular de Escuela Universitaria) and T.U. (Titular de Universidad), respectively, Departamento de Ecología, Universidad de Alicante, Alicante, Spain. Ap. 99, Alicante-03080 (Spain).

2.1 percent of the area burned in any other month. The median fire size was 225 hectares. Seventy-eight percent of the fires were smaller than 500 hectares and 8.4 percent were greater than 1,000 hectares. The largest fire was 6,800 hectares.

Total precipitation during the first year postfire ranged between 126 and 1,210 millimeters. Half of the fire areas received less than 523 millimeters and 25 percent received more than 775 millimeters. Most of the values in the lower quartile fell between 200 and 390 millimeters. This pattern is typical of the subhumid mediterranean climate of the area. The amount of rain falling between the fire and the start of the growing season (March) ranged between 6.4 and 880 millimeters with 75 percent of the fires receiving less than 478 millimeters. The upper limit of the lower quartile was 188 millimeters and 50 percent of the sites received more than 349 millimeters. The first October after a fire had precipitation totals between 0 and 325 millimeters, although 50 percent of the stands received less than 44 millimeters. Only 8 percent of the cases received no precipitation at all during this month, while just 5 percent received more than 200 millimeters. Fire events followed by zero precipitation did not occur during the September-October-November period, and just 5.6 percent received less than 50 millimeters. Although rainfall ranged between 9.6 and 761 millimeters, 75 percent of the cases had less than 210 millimeters and just 1.3 percent had more than 400 millimeters.

The amount of precipitation that fell before any vegetation covered the soils could be as high as the mean annual precipitation in the semiarid areas of the province. The rates of erosion during the pregrowth periods should be studied; if significant erosion occurs before plant growth begins, revegetation efforts would be ineffective because of phenological constraints. Some type of physical intervention would be the only way to reduce erosion. That 25 percent of the stands received more than 134 millimeters of rain in October should not be considered proof of high susceptibility to erosion—we found no evidence in the literature connecting higher precipitation with higher erosion. The erosion events recorded by Sanchez (1989) indicated that neither total precipitation nor maximum intensity explained the amount of sediment produced. A rainfall of 25 millimeters with a maximum intensity of 68 millimeters per hour produced 352.4 grams per square meter of sediment, while another event with a total of 45.4 millimeters and an intensity of 130 millimeters per hour produced 63.1 grams per square meter. This first postfire rainfall will determine the state and distribution of the ash layer. The importance of this layer due to the accumulation of nutrients is important for the microbial and plant postfire communities. The total nutrient status of the ecosystem could be largely modified depending on what happened with this layer. Movement of the ash layer by rainfall events should be studied to determine whether nutrients are actually lost from the system or simply relocated. The problem indicated by Debano and Dunn (1982)—that erosional losses of nutrients from on-site movement may differ considerably from those for the entire watershed—must be considered given the high amount of nutrients contained in the ash layer.

Acknowledgments

We thank Angel Mediavilla from the Unidad Forestal de Alicante; Carmen Elvira, Mavi Flor, Macu Gonzaga, Jesus Lara and Pepa Ibanez for data entry; the staff of the Centro Meteorologico de Levante, Valencia for help with the climatological data and Jan Beyers and Susan Conard for their comments and English revision that further improved the original version.

References

Debano, L. F., Dunn, P.H. 1982. **Soil and nutrient cycling in Mediterranean-type ecosystems: a summary and synthesis**. In: Conrad, E.; Oechel, W. Symposium on dynamics and management of Mediterranean-type ecosystems; 1981 June 22-26; San Diego, CA. Gen. Tech. Rep. PSW-58. Berkeley, CA: Pacific Southwest Research Station, Forest Service,U.S. Department of Agriculture; 358-364.

Debano, L.F.; Rice, R.M.; Conrad, E. 1979. **Soil heating in chaparral fires: effects on soil properties, plant nutrients, erosion, and runoff**. Research Paper PSW-RP-145. Berkeley, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 21 p.

Sanchez, J.R. 1989. **Estimacion de perdidas erosivas producidas por las tecnicas de reforestacion en la Comunidad Valenciana**. Dep. C.A.R.N. (Ciencias Ambientales y Recursos Naturales), Univ. Alicante. Informe Conselleria de Agricultura,G.V.(Generlitat Valenciana).

Wells, W.G. 1982. **Hydrology of Mediterranean-type ecosystems: a summary and synthesis**. In: Conrad, E.; Oechel, W. Symposium on dynamics and management of Mediterranean-type ecosystems; 1981 June 22-26; San Diego, CA. Gen. Tech. Rep. PSW-58. Berkeley, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 358-364.

Operational Fire/GIS Dilemmas—The Fire Report Form Example[1]

Lucy Anne Salazar[2] **Martha Shea Flattley[3]**

Operational applications of geographic information system (GIS) technology for fire management sometimes develop into dilemmas regarding data acquisition, compatibility, and accuracy. One major component of a Fire/GIS database is recorded fire history, such as the information contained in USDA Forest Service records collected since 1910. These fire report forms were revised approximately every decade and included different formats, entry items, naming conventions, and level of detail for maps (if maps were even included). To accommodate GIS needs, the challenge is to find, decipher, compare, and coalesce these fire data into a database that will be useful for incorporating into ecosystem management.

The Six Rivers National Forest was formed from the Shasta-Trinity, Klamath, and Siskiyou National Forests in 1947. After extensive searching, limited fire records have been found for the pre-1947 period. Fire summaries recorded general information such as origin date, fire size class, township, range and section, vegetation type, and general cause. Original fire report forms were found for portions of the Forest, and gaps in the data are obvious. For one Ranger District, fire history is recorded for over 80 years, in 12 different fire report forms. Fire atlases also exist for some Ranger Districts since 1936 and for others since 1910.

Differences in format and naming conventions exist among the eight decades of fire reporting. These differences need to be resolved so that the data, and issues such as ground truthing and ancillary information (e.g., weather records and narratives), can be incorporated into a GIS format.

Data Consistency

Forest management and activities have changed dramatically over the years; these changes are often also reflected in the fire report form entries. Representations of vegetation ignited or burned through by fires is one example of an entry item that has gone through several revisions. Entries for “character of cover” in the 1910’s were very general, including rocks, brush, timber (needles), reproduction, and oak leaves. Descriptions in the early 1920’s became more specific, splitting up cover types into timber, brush, ground cover under timber, and ground cover under brush. Later in the 1920’s and throughout the 1930’s the emphasis changed to entries of general categories, such as timber, brush, leaves, and needles. The 1940’s through the 1970’s focused on entries by species. The codes for the 1980’s returned to more general cover descriptions (e.g., over-mature timber, long needle plantations) and included age groupings for slash categories.

The National Interagency Fire Management Integrated Database (NIFMID) is currently being developed as a corporate fire database. This GIS compatible database will allow fire data to be shared, analyzed, and integrated into ecosystem analysis and management. NIFMID includes Forest Service fire report form entries back to 1970. Pre-1970 fire report form entries also need to be brought into NIFMID to include in the analysis. NIFMID currently has 667 possible entries for the principal vegetation cover at or near the point of origin of a fire. This list should accommodate the vast majority of historic entries, but descriptions such as needles or leaves will have to be included as valid data.

Ground Truthing

During the early 1900’s fire managers took great care in filling out fire report forms. This was reflected in the detail of their fire maps and the extent of their narratives. This detail has dramatically decreased so that, currently, a map is not even required for the fire report forms. In a GIS mode this can create problems, especially when the only locational data now recorded is the latitude and longitude of the fire’s origin. Maps are part of the documentation for large fires, but they are often stored in boxes in warehouses that never become part of a map database. Perimeters have become of little consequence for fire reporting, while for ecosystem analysis they are of utmost importance.

Ground truthing of fires can help determine the conditions under which certain areas did or did not burn. This is important information for large area natural fuel treatments and prescribed natural fires. Technologies such as global positioning systems (GPS) allow for fire perimeters to be easily mapped, including islands and different intensities within the perimeter. Aerial photos can also sometimes be used as a substitute for ground truthing, but timing and quality of the aerial photos can have an effect on their usefulness.

---

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Forester, Six Rivers National Forest, USDA Forest Service, Eureka, CA 95501.

[3]Forestry Technician, Six Rivers National Forest, USDA Forest Service, Eureka, CA 95501.

Ancillary Data

Early fire report forms are filled with interesting anecdotes and narratives. For example, some provide descriptions of forest guards who would leave for fires with four men and travel 28 miles by horseback to battle a 500-acre fire. These early fires might appear to have become large because of a lack of sufficient resources. Monthly precipitation records exist for many weather stations in California back to 1880. By combining these data with fire occurrence records, we see that often times the large fall fires occurred after periods with below-normal summer rains or above-normal spring rains. Currently, these same weather patterns combined with unnaturally high fuel loadings and the urban wildland intermix could result in catastrophic fire events. Knowledge of Native American historical uses of the forest can also provide an important component in determining how the ecosystem evolved into its current state. Thus, fire report forms contain a wealth of knowledge to assist us in our objectives of determining and managing fire's natural role in the ecosystem.

Recommendations

To analyze fire's natural role in the ecosystem, fire records and maps must be found and preserved as a vital part of the history of each National Forest, community, and local ecosystem. We also need to resolve differences in fire report form entries, and develop a method to incorporate fire occurrence data into the analysis. And fire managers must encourage detailed narratives and mapping of fires, including the use of global positioning systems (GPS) technologies. These data can be incorporated in a GIS for analysis of fire's natural role in the environment.

Progression of the Oakland/Berkeley Hills "Tunnel Fire"[1]

David B. Sapsis[2] Donald V. Pearman[2] Robert E. Martin[2]

On the morning of October 20, 1991, a fire originated in the Oakland/Berkeley Hills from rekindling materials of a 2-hectare brushfire that had occurred the previous day. The ensuing "Tunnel Fire" resulted in the greatest modern-era loss of life and property on record for North American urban-interface fires: 25 people died, 2,475 dwelling units were completely destroyed, an additional 302 units were badly damaged. Losses have been estimated in excess of 1.7 billion dollars.

This paper describes the spatial dynamics of the "Tunnel Fire" and provides insights into the interaction of environmental factors contributing to the catastrophic behavior of the fire.

Methods

All available direct physical evidence (e.g., photography, video, communication transcripts) were systematically reviewed to ascertain the position of the fire and apparent mechanisms of spread. These data were then corroborated by interviews with witnesses and public service personnel, as well as reviews of agency incident reports documenting the fire. Particular attention was placed on cross-referencing known timed events (e.g., phone calls, transformer explosions) with the position of the fire. From these data, points of maximal extent were spatially defined, and lines of common time were estimated by interpolating between known points, using general knowledge of factors affecting fire behavior. These "isochrons," or time lines of spread, reflect both spreading wave front advance and spot fire spread resulting from burning brand deposition. Particularly during the initial "blow-up" period, much of the fire's growth was attributable to spot ignitions, indicating significant unburned areas within a given time-step.

The positions of the fire's maximal extent at a given time and known locations of spot fires were then digitized into a geographic information system (GIS) over base layers reflecting the fire zone's topography and infrastructure (roads, parcel ownership, etc.). These spatial features were then used to help spatially define the fire's spread. This effort resulted in two maps of the fire: a map documenting the early spread period covering the first hour after escape (10-minute isochrons), and a complete spread map showing the entire spread period (1-hour isochrons).

Results and Discussion

The topography of the origin area can be described as very steep (30 to 70 percent slope), with a mixture of fuels of both wildland and domesticated vegetation types. Understory vegetation resulted in a well developed surface fuel layer, with added fuel continuity in both horizontal and vertical dimensions coming from an abundance of intermediate and mature Monterey pine (*Pinus radiata*). Significant areas of blue gum Eucalyptus (*Eucalyptus globulus*) were in the fire area, although not within the immediate (200 m) area of the fire origin. Interspersed throughout the fire area on all sides except the east were residential structures, contributing significantly to the total fuel load. We have estimated that the forested/residential areas where the fire started had in excess of 100 mg/ha of available vegetation fuels, with at least an equal mass of structural fuels in discrete, isolated areas (Sapsis and Martin 1994). Finally, the weather patterns on the morning of the fire showed classic extreme high hazard conditions associated with easterly "Diablo" winds. This meso-scale induced weather pattern resulted in high temperatures (>80^{o} F), very low relative humidity (<15 percent), and strong, gusty winds, with average sustained ridgetop winds of 20 mph, and gusts likely at 30 to 40 mph. Also, a relatively strong inversion layer at 600 m is thought to have contributed both to accelerated downslope winds and complex local wind patterns (Pagni 1993). Thus, all three sets of fire environment variables (fuels, weather, topography) could be characterized as being in extreme conditions.

After numerous hot spots became evident during the morning of October 20, active flaming fire escaped from the original burn perimeter at 10:58 a.m., with escape fronts occurring from both the lower south and middle west areas of the fire perimeter. The east flank fire expanded both south and east into a mixture of north coastal scrub and intermediate pine, causing the latter to partially crown and drive short-scale spotting to the southwest. The east flank expanded toward Grizzly Peak Boulevard fairly rapidly, indicating complex surface wind patterns, with significant eddying generating upslope (westerly) surface winds that drove surface fire spread, and overstory ambient winds determining direction

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Graduate Assistants and Professor Emeritus, Department of Environmental Science, Policy, and Management, University of California, Berkeley, CA 94720.

of spotting materials. The west flank escape appears to have moved slower and to the west before getting into a ravine and working upslope toward Marlborough Drive at approximately 11:25 a.m. By this time, the fire had closed in around itself on the south flank and had spotted across Buckingham Drive into the area between Buckingham and Tunnel Road. Thus, at about 30 minutes after escape, the fire had moved significantly to the east, crossing over Grizzly Peak Boulevard; however, it was relatively contained on its westerly front, with isolated short-scale spotting and wind-driven frontal advance causing the ignition of a few houses along Buckingham.

During the ensuing 30 minutes (11:30 to 12:00) , the fire was to show an extreme “blow-up” phase, with long-range spotting coming initially from crowning trees, and later from structural fuels as houses became fully involved. During the 11:30 to 11:40 period, pines crowning on the east flank contributed to rapid spot development on the southwest area near Highway 24, while pine and eucalyptus crowning dictated the ridge spotting that eventually resulted in fire crossing Hwy 24 near the Lake Temescal parking lot, and the rapid ignition of the Hiller Highlands subdivision. We estimate that, by 12:00, in excess of 700 homes were burning, and the fire was spreading as three discrete fronts: flanking to the south toward Horse Ridge, backing to the north into upper Vicente Canyon, and moving directly with the overstory winds into the Rockridge area behind Lake Temescal.

During the next 2 hours, the fire continued to grow rapidly in size, both in wildland-dominated areas on the eastern and northern flanks, as well as in residential areas toward the west and south. Particularly in the dense residential areas, with relatively poor surface fuel continuity, individual homes ignited because of spot deposition, and then fire would spread to adjacent homes because of radiation and direct flame contact. In many instances, spot fires formed well downslope of an unburned area, then grew upslope during periods of favorable winds. The complexity of the wind pattern cannot be underestimated; strong evidence indicated surface winds varied in all directions, because of fire-induced winds, as more and more areas became involved and energy release rates increased (Pagni 1993).

By 2:00 p.m. most of the pure wildland areas had been consumed, and fire spread slowed considerably, owing to the discontinuous and coarse nature of the residential fuel complexes, and somewhat flatter terrain. By 5:00 p.m. the northern perimeter of the fire was determined, but spread continued in residential areas on the southern flanks, despite reduced winds. The Upper Broadway Terrace area showed a remarkably discontinuous spread pattern, with fire advancing by clusters of homes, then returning some hours later. By about 10 p.m., the final perimeter was determined, covering about 520 ha.

Conclusions

The Tunnel Fire showed extreme fire behavior due to complex interactions amongst fuels, topography, and weather, with early expansion or “blow-up” driven by a diffuse set of mass fires resulting from abundant deposition of burning brands into unburned areas. Later spread in more dense residential areas was slower and more discontinuous because of differences in fuel structure, suppression efforts, reduced weather severity, and more moderate topography. Further research is required to investigate specific relationships between fuel, terrain, and weather on extreme fire behavior. Specifically, the intermix of wildland and structural fuels across complex landscapes subjected to periods of extreme fire weather presents a challenge for fuel/fire behavior modeling. In particular, investigations of crown fires, and associated spotting and rapid fire expansion, should not be restricted to purely wildland settings (Anderson 1968, Rothermel 1991).

Acknowledgments

We thank all the many individuals and agencies who contributed time and data to this study. Partial funding for this work was provided by the National Science Foundation mini-grant program for mitigation of natural and human hazards.

References

Anderson, H.E. 1968. **Sundance fire: an analysis of fire phenomena**. Gen. Tech. Rep. INT-122. Ogden, UT: Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 39 p.

Pagni, P.J. 1993. **Causes of the 20 October 1991 Oakland hills conflagration**. Fire Safety Journal 21:331-339.

Rothermel, R.C. 1991. **Predicting behavior and size of crown fires in the Northern Rocky Mountains**. Res. Paper. INT-RP-438. Ogden, UT: Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 46 p.

Sapsis, D.B.; Martin, R.E. [In press]. **Fire, the landscape, and diversity: a theoretical framework for managing wildlands**. In: Proceedings of the 12th conference on fire and forest meteorology; 1993 October 26-28; Jekyll Island, GA. Bethesda, Maryland: Society of American Foresters.

Comparison of Fuel Load, Structural Characteristics and Infrastructure Before and After the Oakland Hills "Tunnel Fire"[1]

Scott L. Stephens Domingo M. Molina Ron Carter Robert E. Martin[2]

Abstract: Structures rebuilt after the Oakland Hills "Tunnel Fire" in 1991 are different in many aspects when compared to their predecessors. Data obtained from the city of Oakland indicate homes have been rebuilt 28 percent larger (square feet). About 50 percent of the homes destroyed have been rebuilt, and building permits have been issued for an additional 16 percent. New construction mandates facilitated by local and State laws have resulted in the following requirements: class A roofs, chimney spark arrestors, 1-hour siding for exterior walls, 30-foot clearance of wildland vegetation. Domestic vegetation is not regulated. Average structural fuel load consumed in the fire was 11.5 kg/m^2. Larger homes built after the fire will produce higher structural fuel loads. Improvements in infrastructure such as roads and water supplies have not occurred. Improvements have occurred in communication systems. Increases in structural fuel load accompanied by modest improvements in infrastructure may increase the fire risk in this urban/wildland intermix.

Vegetation is a critical fuel component in urban/wildland intermix fires. Without an active fuel management program, vegetative fuels will accumulate. Many vegetative fuels also have a large amount of fine fuels with a high degree of horizontal and vertical continuity; fuels of this type can produce extreme fire behavior when conditions are dry.

The structural fuel component of the urban/wildland intermix is often neglected. In many cases the structural fuel load can be larger than the adjoining wildland fuel load. Combustion characteristics are much different in structural and wildland fuels but both can affect fire behavior of intermix fires.

Changes in infrastructure, building materials and vegetation management have been slow or non-existent following most urban/wildland intermix fires. The public as well as local and State agencies have short memories after such events. Several positive steps have been taken after the Oakland Hills "Tunnel Fire" in northern California that will reduce the probability of such an event occurring again, but many other problems remain.

This paper will review the changes which have occurred and will summarize the structural and wildland fuel consumed in the Tunnel Fire.

Methods

Wildland vegetation inventory was accomplished by using NASA false infrared aerial slides (1:6,000 and 1:12,000) taken after the Tunnel Fire. The slides were projected over a 1.0 by 1.3 meter map of the fire area and perimeters were drawn around each vegetation type. Numerous trips were then taken to the burned area to improve the map. This information was used to create a second map that was further improved by the use of a set of 32 aerial color prints (1:6,000) taken after the fire by Pacific Aerial Surveys. The final map was digitized, and areas of each polygon were calculated, by using the geographical information system ATLAS.

Structural fuel load was calculated by using the average amount of lumber used to build a home in the western United States (American Forest and Paper Association 1990). The land area occupied by structures was determined using the geographical information system. Structural fuel load was assumed to be homogeneous over the area occupied by the structures.

Information was obtained on post-fire construction from the City of Oakland. Local fire officials were contacted to determine concerns in this post-fire urban/wildland intermix.

Results

The fire perimeter enclosed 615.2 hectares and was divided into categories:

Vegetation Category	*Area (ha)*
Eucalyptus (*Eucalyptus globulus*)	132.1
Monterey pine (*Pinus radiata*)	56.3
Northern California coastal scrub	109.7
Grassland	2.9
Coastal scrub and grassland mosaic	28.5
Monterey pine and coastal scrub mosaic	2.3
Coast live oak (*Quercus agrifolia*) and coastal scrub mosaic	19.2
Structures	246.2
Highways	18.0

The number of structures totally destroyed by the fire was 2,305 (Gordon 1994). Assuming the average home uses 13,000 board feet of lumber to construct (American Forest and Paper Association 1990), this results in a structural fuel load of 11.5 kg/m^2 (50.8 tons/acre). This value of structural

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994. Walnut Creek, California.

[2]Graduate Research Assistant, Department of Environmental Science, Policy, and Management, University of California, 145 Mulford Hall, Berkeley, CA 94720; Department of Plant Production and Forest Science, University of Lerida, 25006 Lerida, Spain; Battalion Chief, Oakland Fire Department, 1605 Martin Luther King Jr. Way, Oakland, CA 94612; Professor, Department of Environmental Science, Policy, and Management, University of California,145 Mulford Hall, Berkeley, CA 94720.

fuel load is conservative because it does not include any of the interior components of a structure, although it is in accord with the average United States structural fuel load of 14 to 21 kg/m^2 (Bush and others 1991).

Examination of post-fire construction permits indicates homes have been rebuilt on average 28 percent larger. Local requirements of new construction include class A roofs, chimney spark arrestors and 1-hour siding for all exterior walls. State and local requirements of a 30-foot clearance between structures and wildland vegetation are also enforced.

Domestic vegetation is not regulated by local or state agencies. Some domestic vegetation is highly flammable. The heat released from one mature tam juniper (*Juniperus sabina* var. *tamariscifolia*) surpassed 2 megawatts within 1 minute of ignition (Stephens and others 1993). In that study mature junipers were harvested and burned at different moisture contents. Results from that study (Stephens and others 1993) along with videotape of the Oakland Hills fire demonstrate that domestic vegetation can provide an efficient vector for transmitting fire into a structure.

Conclusion

Structures in the post-fire urban/wildland intermix in the Oakland Hills will be built with more flame-resistant materials, but increases in the size of the structures will increase structural fuel load. Infrastructure such as water supply and road systems has not been improved, increasing the fire risk in this urban/wildland intermix.

Wildland and structural fuels must be managed to reduce risk in the urban/wildland intermix. Domestic vegetation must also be managed to reduce risk in the intermix. Emergency infrastructure must be improved to reduce the loss of life and property from these fires. Firefighting helicopters could be used for initial attack on urban/wildland intermix fires. Early detection and response would be required for effective fire suppression using helicopters.

References

American Forest and Paper Association. 1990. **Housing affordability and timber supply**. Unpublished.

Bush, B., Anno, R; McCoy, R.; Gaj, R; Small, R.D. 1991. **Fuel loads in U.S. cities**. Fire Technology 27(2): 5-32.

Gordon, D.A. 1994. **Categorical data analysis of the Oakland hills fire**. Berkeley: University of California, Department of Environmental Science, Policy and Management. M. S. Thesis; unpublished draft supplied by author.

Stephens, Scott L.; Gordon, D.A.; Martin, R. E.; 1993. **Combustibility of selected domestic vegetation subjected to desiccation**. In: Proceedings of the 12th conference on fire and forest meteorology; 1993 October 26-28; Jekyll Island, Georgia. SAF publication 94-02. Bethesda, MD: Society of American Foresters; 796 p.

FireNet —A Forum for International Curriculum Development in Fire Science and Management?[1]

A. Chris F. Trevitt[2] David G. Green[3] David B. Sapsis[4]

Internet, a world-wide information technology network, provides the opportunity to set up the exchange and retrieval of problem-oriented information. FireNet, an international information retrieval and exchange network for those interested in landscape fires, is one such forum, among many hundreds now in operation (Green and others 1993). Anyone with access to a networked computer system, or with a desktop computer and modem, can subscribe to FireNet. The network allows free correspondence among all subscribers on the list—land managers, researchers, educators—wherever they are located. In April 1994, FireNet maintained 200 subscribers from a number of countries around the world. In December 1994, there were 370 subscribers.

In addition to real-time communication possibilities, FireNet is also potentially a valuable educational tool, particularly as more organizations outside the university sector gain access to Internet. This expanded access implies that individual faculty or professional trainers take on the role of "education moderator," filtering material so that it is customized to their particular need or context (Green and others 1993). Thus, FireNet not only complements the role of the textbook by providing a window on current issues under debate—thereby affording access to more up-to-date supplementary material and ideas—but also encourages feedback to help ascertain the value of this information in the workplace. Further, it provides an enticing medium for fostering the cooperative development of computer-based curriculum materials in fire science and management.

Background

The development of computer assisted learning applications has been ongoing for the last few years, many taking advantage of new technologies for dispersal and presentation of information. For example, in Canada, Thorburn (1990) and Hirsch and others (1993) have pioneered fire-related developments using videodisk and hypermedia technologies for education and training purposes. In the United States, a new training development group (Cooperative Program for Operational Meteorology, Education, and Training), affiliated with the National Weather Service, has been charged with the responsibility for developing new computer-based distance education modules for in-service training, and they hope to begin work on a new fire-weather module in 1994 (Lamos 1993, personal communication). At the Australian National University, we have recently acquired experience in the design, development and implementation of a computer-based graphical analysis package for use by students in analyzing fire weather histories (Trevitt and others 1993), and fire management planning within a problem-based learning context (Trevitt and Sachse-Åkerlind 1994).

At the same time as these separate developments have been underway, increasing financial constraints have been experienced at public educational institutions and other principal national research and management organizations. Training sections in operational groups concerned with fire science and management are often highly understaffed, and updated course material development is frequently lacking. In the future, we need to exploit opportunities to work together more closely, pooling development efforts where appropriate, and saving on overheads incurred during on-going curriculum development. FireNet provides a unique opportunity to realize these gains by facilitating the transfer of digital materials over the Internet and thereby achieving savings for everyone.

Implications of Developing a Digital "Fire" Curriculum

As computer hardware becomes more and more economical, it makes inroads into more and more organizations. Simultaneously, the software that is now becoming available allows more and more sophisticated and cost-effective data and information storage, transfer and manipulation. FireNet provides a practical demonstration of some of the emerging ways to facilitate text and image retrieval and interchange between organizations and individuals. Hypermedia links via Internet are now also becoming feasible using the Hyper Text Markup Language (HTML) protocol implemented, for example, by the public domain browser application "mosaic," and this facility is

[1]An abbreviated version of this paper was presented at the Biswell Syposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994. Walnut Creek, California.

[2]Senior Lecturer, Department of Forestry, School of Resource and Environmental Management, Australian National University, Canberra ACT 0200, Australia.

[3]Professor of Information Technology, School of Environmental and Information Science, Charles Short University, PO Box 789, Albury, NSW 2640, Australia.

[4]Graduate Assistant, Department of Environmental Science Policy, and Management, University of California, Berkeley, CA 94720.

also provided on FireNet (Green and others, 1993). This means that digital curriculum resources (e.g. text, images, video, sound) resident in the public domain on a computer node connected to the Internet in, for example, Victoria, Canada, can be accessed by managers, researchers, academics, or others with access to a similar networked computer environment in Canberra, Australia, and vice-versa.

What form could these "digital curriculum resources" take? Currently, some examples on FireNet are essentially text-only student reading materials used in the undergraduate unit "Fire Science and Management" at the Australian National University. Text is the simplest form to deal with. However, line diagrams and photos are urgently needed to supplement this text. A range of text, black-and-white images, and line-drawings are already available at Australian National University on a local Macintosh network, and these have been used for study purposes by undergraduate students since 1993. Copies of personal lecture notes as well as supplementary material have also become available (Trevitt and Sachse-Åkerlind 1994). Eventually, a library of relevant color slides, video, and sound segments is envisaged as well. Animated graphics, in a true multimedia environment, hold considerable promise for communicating particularly challenging abstract concepts such as those associated with diurnal variations in fuel moisture and fuel moisture changes at different depths below the fuel and soil surface. Developments of this sort have no real book-based analogs, and, like the work by Hirsh and others (1993), represent some of the new ways in which information technology can expand and extend the educational process.

In a subject-area such as "Fire Science and Management," an extraordinarily wide range of relevant material can serve as an information base for training and education. This breadth of material alone is good reason for institutions to share the burden of collation, synthesis, preparation of overheads for lectures, images, development of problem-based tutorials, etc. Most of us with similar professional interests and shared educational goals work in geographic isolation from one another and can benefit enormously from exposure to the ideas and experiences of others working with common educational objectives.

For those of us who are in academics, it also makes considerable sense to work closer to our operational counterparts, and learn about, and from, some of the frustrations and joys experienced in ongoing programs of professional training. Relevant contacts can be found across the board in forest and land management agencies, as well as in groups such as National Parks and National Weather services. Shared responsibility in developing relatively small (e.g., two to five pages of text plus a few diagrams) modules, dealing with one specific science topic or management aspect, or a case study of a past fire means that, together, we would quickly build up a repertoire of relevant resources that each of us could access. Provided these materials conform to certain recognized and established international standards, there should be minimal difficulty in ensuring that they are transferable by digital, computer-based means.

Conclusions

FireNet provides an opportunity for much cross-disciplinary, cross-institutional and international collaboration. The curriculum development effort required to comprehensively address all of the relevant science and management issues for training and education in "fire" exceeds the capacity of a single individual operating in isolation. By using digital media as a default standard, and the communication and information-exchange afforded by new computer networks, new opportunities are created for cooperative curriculum development.

References

Green, D.G.; Gill, A.M.; Trevitt, A.C.F. 1993. **FIRENET—an international network for landscape fire information**. Wildfire: Quarterly Journal of the International Association of Wildland Fire 2: 2-30.

Hirsch, K.G.; Hoskins, J. A.; Hoskins, W.D. 1993. **A hypermedia system for interactive fire behavior training**. Paper presented at the 12th conference on fire and forest meteorology; 1993 October 26-28; Jekyll Island, Georgia. SAF publication 94.02. Bethesda, MD: Society of American Foresters.

Thorburn, R.W. 1990. **Videodisc/microcomputer technology in wildland fire training**. In: Alexander, M. E.; Bisgrove, G.F., eds. The art and science of fire management. Forestry Canada Northwest. Information report NOR-X-309; 100-101.

Trevitt, A.C.F.; Sachse-Åkerlind, G. 1994. **A District Fire Committee Simulation in the professional forestry curriculum: a case study of computer-facilitated problem-based learning**. In: Chen, S.E.; Cowdroy, R.; Kingsland, A.; Ostwald, M., eds., Reflections on problem-based learning, Sydney: Australian Problem Based Learning Network; 347-369.

Trevitt, A.C.F.; Stals, L.; Sachse-Åkerlind, G. 1993. **Education and training in fire meteorology and climate: a role for computer-assisted learning?** In: Proceedings of the 12th conference on fire and forest meteorology; 1993 October 26-28; Jekyll Island, Georgia; Bethesda, Maryland: Society of American Foresters; 399-408.

Lightning Strikes and Natural Fire Regimes in San Diego County, California[1]

Michael L. Wells[2] **David E. McKinsey**[3]

Abstract: Data from the Automated Lightning Detection System were analyzed for the years 1985-1990 for San Diego County, California. The density of lightning strikes was found to be positively correlated with elevation. Temporal analysis revealed that lightning occurs most frequently in the months of July, August, and September preceding the peak of Santa Ana wind activity in October, November, and December. This suggests that a natural fire regime for this region would be typified by frequent, low-intensity fires and that large, high-intensity fires would be relatively rare.

Lightning is the only significant natural source of wildfire ignition in southern California (Keeley 1981, Krausmann 1981, CDF 1986-1991, USFS 1985-1990). Therefore, in order to understand the characteristics of wildfire occurrence in the absence of human influences (i.e., natural fire regimes), it is necessary to determine the distribution and frequency of lightning strikes. Researchers have used meteorological records and reports of lightning-caused fires to estimate the distribution of lightning and its importance to regional fire regimes. However, weather reports tend to underestimate lightning activity (Wells and McKinsey 1993), and artificial structures interfere with the establishment of lightning ignitions (Minnich 1987). Reliance on these methods leads to underestimation of lightning activity and lightning-caused ignitions.

The advent of the Automated Lightning Detection System (ALDS) in 1985 by the Bureau of Land Management has given researchers a new source of information to evaluate the distribution of lightning strikes. ALDS uses a network of radar lightning detectors to triangulate the location of lightning strikes (German 1990). Studies utilizing ALDS data have been made for northern Baja California, Mexico (Minnich and others 1993) and Yosemite National Park (Van Wangtendonk 1991).

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Associate State Park Resource Ecologist, California Department of Parks and Recreation, San Diego Coast District, 3990 Old Town Ave., Ste. 300C, San Diego, CA 92110; Doctoral student, Department of Geography, San Diego State University, San Diego, CA; and Research Associate, Department of Biology, University of San Diego, CA.

[3]Technical Manager, The Mary and Steven Birch Center for Earth Systems Analysis Research, Department of Geography, San Diego State University, San Diego, CA.

Analysis

An Arc/Info geographic information system (GIS) was used to analyze the temporal and spatial distribution of ALDS recorded strikes. Density of lightning strikes was found to be positively correlated with elevation (Pearson's r = +0.902). The mean annual densities of strikes were calculated for 305-meter (1,000-foot) increments in elevation:

Elevation (Meters)	Strikes per Square Kilometer
0 - 305	0.228
305 - 610	0.297
610 - 915	0.313
915 - 1220	0.860
1220 - 1525	1.063
1525 - 1830	1.367
1830 - 2135	2.767

The temporal analysis revealed that lightning activity is concentrated in the late summer. August alone accounts for approximately 42 percent of the mean annual total of strikes. The strikes recorded for the months of July, August, and September account for 85 percent of the mean annual total. No other month accounts for more than 5 percent of the mean annual total. This high activity period precedes the season of most extreme fire weather, which is frequently coincident with hot, dry Santa Ana winds.

Studies of the occurrence of Santa Ana winds in southern California from 1951 to 1960 (Schroeder 1964) and in San Diego County from 1970 to 1979 (Latham 1981) reveal the following frequencies of Santa Ana winds:

Month	Schroeder and others (1964) 1951-60	Latham (1981) 1970-79
July	2	0
August	0	0
September	11	4
October	19	13
November	26	15
December	18	13

The three peak months of Santa Ana wind occurrence are October, November, and December. July and August, which are the peak months for lightning activity, have the lowest frequency of Santa Ana winds.

Conclusions

The following conclusions summarize the findings of this study:

- The density of lightning strikes is positively correlated with elevation.
- The period of maximum lightning activity is during the late summer months of July, August, and September.
- Lightning is much less frequent during the months of October, November, and December when the frequency of Santa Ana winds peaks.

From these conclusions, we can infer the characteristics of hypothesized natural fire regimes in San Diego County and how those characteristics have been altered by human influences. Fire records from San Diego County demonstrate that current fire regimes are dominated by human-caused ignitions (Krausmann 1981, CDF 1985-1990, USFS 1985-1990). Data collected by Krausmann (1981) and Keeley (1981) reveal that frequency of ignition in the current human-dominated fire regime peaks at between 300 and 900 meters elevation (1,000 and 3,000 feet). This alteration is due to human influences such as destruction of wildland habitats at low elevations, increases in human-caused ignitions near the urban interface, and the placement of electrically grounded artificial structures at high elevations (Minnich 1987).

Additional inferences can be drawn relating natural fire regimes to climatic variables. Lightning activity peaks during the months of July, August, and September when wildland fuels are usually dry enough to burn. Santa Ana winds occur infrequently during these months. This suggests that a lightning-dominated natural fire regime would be characterized by frequent, summer season fires of relatively low intensity. Less frequent, late season lightning storms could be followed by Santa Ana winds resulting in larger and more intense fires. In the recent past, the coincidence of human-caused ignitions and Santa Ana events has resulted in large, highly destructive fires. In a natural, lightning-dominated fire regime such episodes would be rare.

References

California Department of Forestry and Fire Protection. 1986-1991. **Wildfire Activity Statistics (1985-1990)**. Sacramento, California: California Department of Forestry and Fire Protection.

German, S.C. 1990. **Initial attack management system (IAMS), information package**. Boise, Idaho: Boise Interagency Fire Center; 21 p.

Keeley, J.E. 1981. **Distribution of lightning- and man-caused wildfires in California**. In: Conrad, C.; Oechel, W., technical coordinators. Proceedings of the symposium on dynamics and management of Mediterranean-type ecosystems; 1981 June 22-26; San Diego, California. Gen. Tech. Report PSW-58. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 431-436.

Krausmann, W.K. 1981. **An analysis of several variables affecting fire occurrence and size in San Diego County, California**: San Diego State University. Master's thesis.

Latham, V.O. 1981. **500 millibar circulation patterns related to Santa Ana weather in San Diego County, California**: San Diego State University. Master's thesis.

Minnich, R.A. 1987. **Fire behavior in southern California chaparral before fire control: the Mount Wilson burns at the turn of the century**. Annals of the Association of American Geographers 77: 599-618.

Minnich, R.A.; Franco-Vizcaino, E.; Sousa-Ramirez, J.; Chou, Y. 1993. **Lightning detection rates and wildland fire in the mountains of northern Baja California, Mexico**. Atmosfera 6: 235-253.

Schroeder, M.J. 1964. **Synoptic weather types associated with critical fire weather. Berkeley, CA**: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 421 p.

U.S. Department of Agriculture, Forest Service. **1985-1990. Fire records, Cleveland National Forest**. On file. San Diego Ranger Unit, Monte Vista, California.

Van Wagtendonk, J.W. 1991. **Spatial analysis of lightning strikes in Yosemite National Park**. In: Andrews, P.; Potts, D., eds. Proceedings of the 11th conference on fire and forest meteorology. Bethesda, Maryland: Society of American Foresters, 11: 605-611.

Wells, M.L.; McKinsey, D.E. 1993. **The spatial and temporal distribution of lightning strikes in San Diego County, Calif**. In: Proceedings GIS/LIS, volume 2; 1993 Nov. 2-4; Minneapolis, Minnesota. Bethesda, Maryland: American, Congress on Surveying and Mapping; 768-777.

Modern Fire Test Methodologies for Building Materials[1]

Robert H. White Mark A. Dietenberger[2]

Abstract: New fire test methodologies for building materials and related theoretical models are leading to improved fire hazard methodologies for a variety of situations, including structures in the wildland/urban interface.

Traditional fire test methods have represented the first step toward replacing material-specific code requirements with performance-based requirements for building materials. These traditional methods have provided data for only one specific exposure (White and Nordheim 1992). By testing materials at various external heat fluxes (Tran and White 1992), the data obtained are more useful in fire models and hazard assessments. The parallel developments of theoretical fire models and state-of-the-art test methodologies have made it possible to improve fire hazard assessments (DiNenno and Beyler 1992). The development of performance-based fire safety requirements that specify design objectives was a major topic at a recent conference (Worcester Polytechnic Institute 1991).

Fire Test Methodologies

Three modern fire test methodologies are: the lateral ignition and flame spread test (LIFT), the American Society for Testing and Materials (ASTM 1993a); the cone calorimeter (ASTM 1992); and the intermediate scale calorimeter (ICAL) (Shaw and Urbas 1993). At the USDA Forest Service's Forest Products Laboratory (FPL) in Madison, WI, we are using a LIFT apparatus to develop ignition criteria for the Structure Ignition Assessment Model (SIAM) (Cohen 1995, Tran and others 1992). SIAM is being developed jointly by the FPL and two USDA Forest Service Research Stations: Southern and Pacific Southwest. Test results from the LIFT include minimum external heat flux for and surface temperature at piloted ignition, and minimum surface temperature and flame heating parameter for lateral flame spread. Oxygen consumption technique provides a convenient way to obtain heat release data. The best known apparatus using this technology is the cone calorimeter. At FPL, we have modified our Ohio State University (OSU) apparatus (ASTM 1993b) to obtain heat release rates using oxygen consumption (Tran 1990). Reduced heat release rate is an important characteristic of fire-retardant-treated wood (LeVan and Tran 1990, Sweet and others 1993). We have used heat release data to predict test results (Tran 1992) for ASTM E 84 (ASTM 1991). Because of its small specimen size, the cone calorimeter can provide data only for materials. With its 1-m^2 specimen, the ICAL provides the ability to test assemblies (Urbas and Shaw 1993) and specimens that include joints and other nonhomogeneous characteristics of building materials in the field. The ICAL is being developed at the Weyerhaeuser Fire Technology Laboratory in cooperation with the American Forest and Paper Association. The method is currently being considered by ASTM Committee E-5 on Fire Standards.

Concluding Remarks

Modern fire test methodologies provide data suitable for theoretical models and a range of fire exposures. As a result, we are better able to develop fire hazard assessments for a variety of situations, including structures in the wildland-urban interface. Better fire hazard assessment methodologies and specific design objectives will lead to code requirements that provide a high level of fire safety and design flexibility.

References

ASTM. 1991. **Standard test method for surface burning characteristics of building materials**. Designation E 84-91a. Philadelphia, PA: American Society for Testing and Materials.

ASTM. 1992. **Standard test method for heat and visible smoke release rates for materials and products using an oxygen consumption calorimeter**. Designation E 1354-92. Philadelphia, PA: American Society for Testing and Materials.

ASTM. 1993a. **Standard test method for determining material ignition and flame spread properties. Designation E 1317-93**. Philadelphia, PA: American Society for Testing and Materials.

ASTM. 1993b. **Standard test method for heat and visible smoke release rates for materials and products. Designation E 906-83 (Reapproved 1993)**. Philadelphia, PA: American Society for Testing and Materials.

Cohen, Jack. 1995. **Structural ignition assessment model (SIAM)**. In: Proceedings of the Biswell symposium: fire issues and solutions; 1994 February 15-17; Walnut Creek, CA.

DiNenno, P.J.; Beyler, C.L. 1992. **Fire hazard assessment of composite materials: The use and limitations of current hazard analysis methodology**. In: Hirschler, Marcelo M., ed. Fire hazard and fire risk assessment, ASTM STP 1150, Philadelphia, PA: American Society for Testing and Materials; 87-99.

LeVan, Susan L.; Tran, Hao C. 1990. **The role of boron in flame-retardant treatments**. In: Hamel, Magaret, ed. Proceedings of the 1st international conference on wood protection with diffusible preservatives, Proceedings 47355; 1990 November 28-30; Nashville, TN. Madison, WI: Forest Products Research Society; 39-41.

[1]An abbreviated version of this paper was presented as a poster at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, Walnut Creek, California.

[2]Supervisory Wood Scientist and Research General Engineer, respectively, Forest Products Laboratory, USDA Forest Service, One Gifford Pinchot Drive, Madison, WI 53705-2398.

Shaw, James R.; Urbas, Joe. 1993. **An intermediate-scale calorimeter for building materials and assemblies**. Fire and Materials 17: 259-263.

Sweet, Mitchell S.; LeVan, Susan L.; White, Robert H.; Tran, Hao C.; DeGroot, Rodney. 1993. **Fire performance of wood treated with a combined fire retardant and preservative system**. Unpublished draft supplied by senior author.

Tran, Hao C. 1990. **Modifications to an Ohio State University apparatus and comparison with cone calorimeter results**. In: Quintiere, J.G.; L.Y. Cooper, eds. Heat and mass transfer in forest: Proceedings of the AAIA/ASME thermophysics and heat transfer conference; 1990 June 18-20; Seattle, WA. New York. The American Society of Mechanical Engineers: 141: 131-139.

Tran, Hao C. 1992. **Experimental data on wood materials**. In: Babrauskas, V.; S. J. Grayson, eds. Heat release in fires. New York: Elsevier Applied Sciences, chapter 11, part b. Tran, Hao; Cohen, Jack D.; Chase, Richard A. 1992. **Modeling ignition of structures in wildland/ urban interface fires**. In: Proceedings of the first international fire and materials conference; 1992 September 24-25; Arlington, VA. London, UK: Inter Science Communications Limited: 253-262.

Tran, Hao C.; White, Robert H. 1992. **Burning rate of solid wood measured in a heat release rate calorimeter**. Fire and Materials 16: 97-206.

Urbas, Joe; Shaw, James R. 1993. **Testing wall assemblies on an intermediate-scale calorimeter**. Fire Technology 29(4): 332-349.

White, R.H.; Nordheim, E.V. 1992. **Charring rate of wood for ASTM E 119 exposure**. Fire Technology 28(1): 5-30. Worcester Polytechnic Institute. 1991. Proceedings of the conference on fire safety design in the 21st century; 1991 May 8-10; Worcester, MA: Worcester Polytechnic Institute; 382 p.

Brush Fire Hazard: An Analysis of the Topanga Fire Storm[1]

James A. Woods[2]

In the fall, the annual Santa Ana winds blow from the high deserts of the Western United States, over the San Gabriel Mountains and through the greater Los Angeles Basin. When fire is introduced into the chaparral ecosystem of southern California, these hot, dry, nearly hurricane force winds can generate immense fire storms. This is precisely what happened for a 2-week period starting in late October and ending in early November 1993. More than 20 major brush fires burned during this time. One devastating fire, in particular, was the Topanga Fire Storm. This fire was started by an arsonist around 10:40 a.m. on November 2, and over the course of the next 5 days, burned over 16,500 acres, destroying or damaging nearly 350 homes.

Fire is an integral part of the chaparral environment of California, and as urban areas expand and encroach into wilderness regions, the need to establish the level of fire hazard in a region increases. Geographic information system (GIS) technology is a valuable tool in fire management (Gronlund and others 1994, Salazar 1989). One application of GIS technology to the wildland/urban interface problem has been the replication of fire hazard models (Woods 1992).

GIS Technology

Woods (1992) used two different GIS's—IDRISI, a raster-based GIS, and Atlas GIS, a vector-based system—to replicate several fire hazard models. He showed that the distribution of fire hazard can be vastly different for a given area, depending on which methodology is used. The three models used were: the Burning Index model, used by the California Department of Forestry and Fire Protection (Phillips 1983); Schmidt's Fireline Intensity model (Schmidt 1978); and the Los Angeles County Fire Department's Brush Fire History Hazard model (Pierpont 1991).

A portion of the Santa Monica Mountains, in Los Angeles County, was used as the study area. The geographic variables which each model used (topography, vegetation, brush fire history, etc.) were digitized and stored as separate images and layers in both IDRISI and Atlas GIS, respectively. These images and layers were then analyzed, combined, and compared on the basis of each hazard model's guidelines, to replicate the hazard models. The final models were then stored as images and layers.

Because the Topanga Fire Storm was located wholly within the confines of the study area used by Woods (1992), all of the data necessary for an analysis was pre-existing in his data base. The only operation necessary was for the perimeter of the Topanga Fire Storm to be digitized and stored in both GIS's. That portion of each fire hazard model which fell within the confines of the Topanga fire could then be extracted to create new images and layers. These new images and layers represent what the level of fire hazard was, per each original fire hazard model, within the fire zone.

Comparison of Fire Hazard Models

The three models use different criteria for determining the level of hazard, but each of them divides fire hazard into three categories, making a comparison relatively easy. Though each model uses different terms to describe their level of hazard, for this paper, the terminology will be: Low, Medium, and High.

Analysis of each of the models indicates that the Fireline Intensity model and the Brush Fire History model are much closer to each other in the percent of land in each hazard category, while the Burning Index model was quite dissimilar to each of the other two. The Fireline Intensity model places 38.2 percent of the land in the Low hazard category, 25.1 percent in the Medium, and 36.7 percent in the High, while the Fire History model places 21.9 percent of the land in the Low hazard level, 37.4 percent in the Medium, and 40.7 percent in the High. The Burning Index model, on the other hand, places only 2.7 percent of the land in the Low hazard level, 50.2 percent in the Medium, and 47.1 percent in the High fire hazard level.

However, a visual analysis of each of the maps indicates that there is great disparity between all three models. The Fireline Intensity model (*fig. 1*) and the Burning Index model (*fig. 2*) have a similar underlying pattern, since vegetation is one of the most important factors in each model. The Burning Index model also incorporates slope, which accounts for the discontinuity of hazardous areas. Since the Fire History model (*fig. 3*) is based solely on the fire history of the region, there is no influence from either vegetation or topography. The Low category, in the original model, represents 1-10 years since the last brush fire. Medium represents 11 to 29 years, and High represents areas which have not burned in

[1]An abbreviated version of this paper was presented at the Biswell Symposium: Fire Issues and Solutions in Urban Interface and Wildland Ecosystems, February 15-17, 1994, at Walnut Creek, California.

[2]Geographer, Geo-Cart Systems, 3014 Nipomo Avenue, Long Beach, CA 90808-4225.

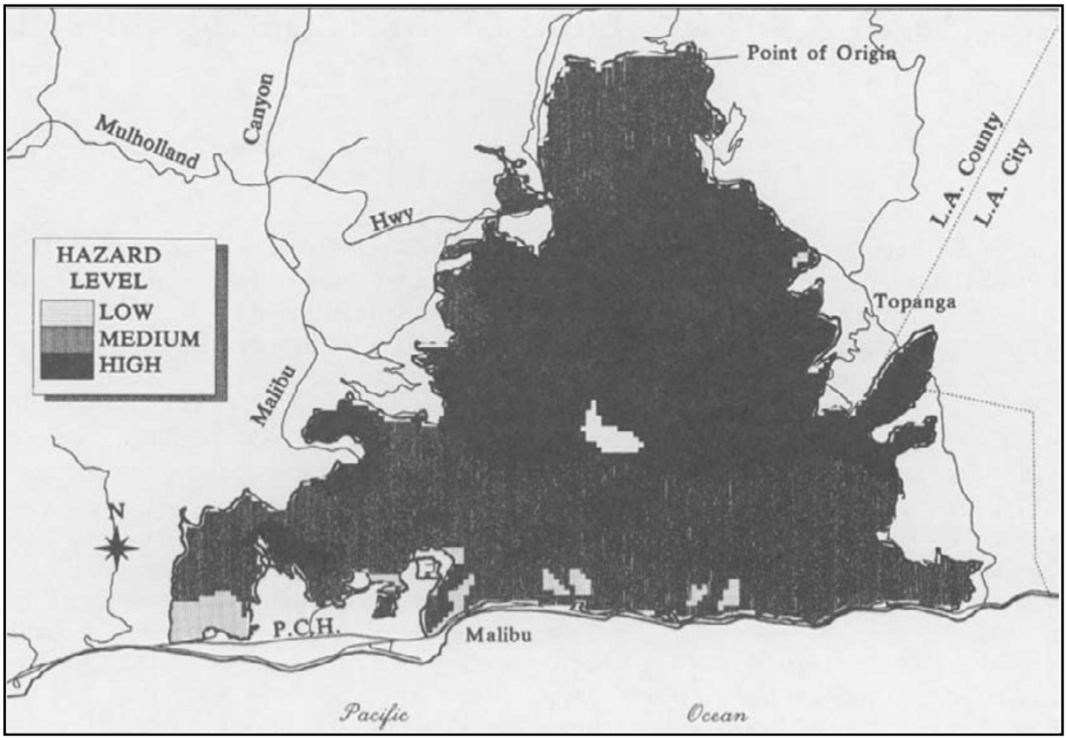


Figure 1– Fireline Intensity fire hazard model of the 1993 Topanga Fire Storm.

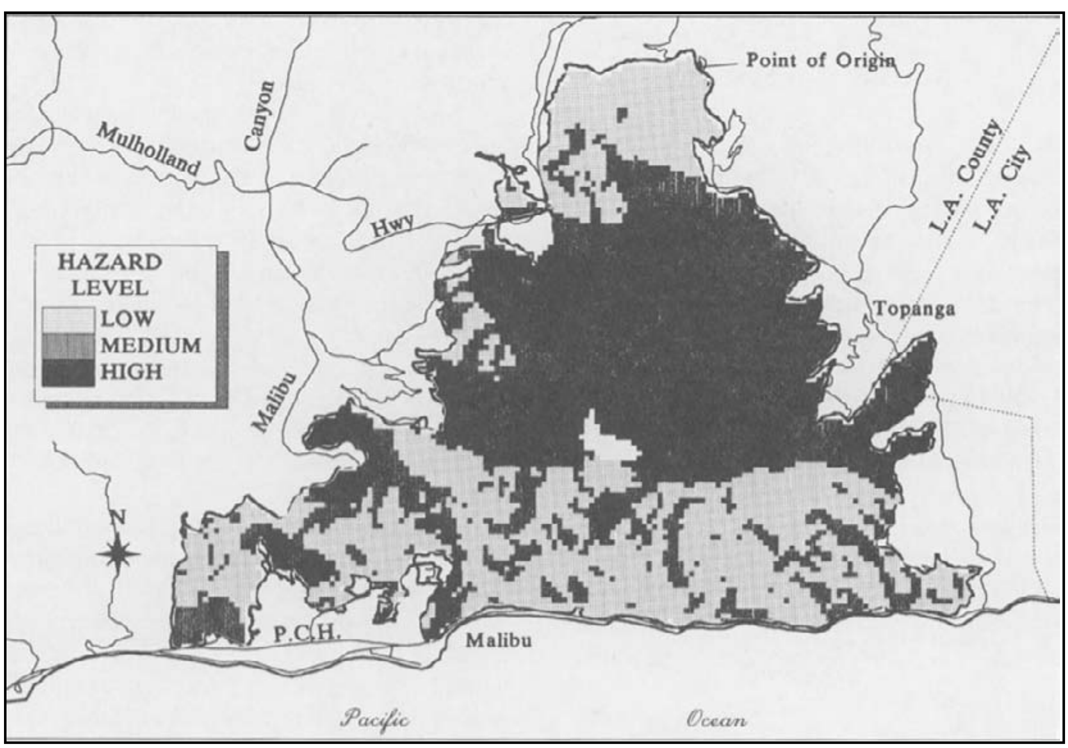


Figure 2– Burning Index fire hazard model of the 1993 Topanga Fire Storm.

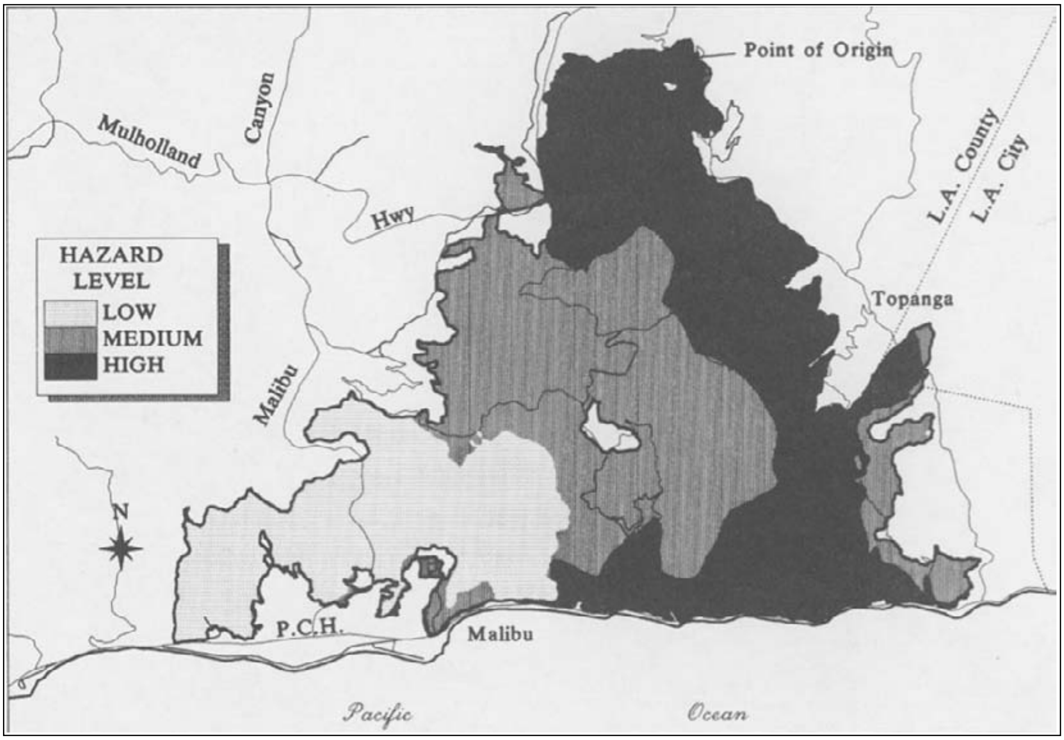


Figure 3– Brush Fire History fire hazard model of the 1993 Topanga Fire Storm.

more than 30 years. As a result, the fire history map becomes a vegetation age map.

None of these models are designed for use as a predictive tool. The Burning Index model is designed to define where the potential fire hazard is so that building codes can be implemented, whereas both the Fireline Intensity and Fire History models are designed to help with fire response planning. Further research would be to implement a fire simulation model, such as FIREMAP (Ball and Gurtin 1991), and then make a comparison between the actual fire and the computer-simulated fire.

References

Ball, George L.; Gurtin, D. Phillip. 1991. **FIREMAP**. In: Nodvin, Stephen C.; Waldrop, Thomas A., eds. Fire and the environment: ecological and cultural perspectives. Proceedings of an international symposium; 1990 March 20-24; Knoxville, TN. Gen Tech. Rep. SE-69. Asheville, NC: Southeast Forest Experiment Station, Forest Service, U.S. Department of Agriculture; 215-218.

Gronlund, Amy Goulstone; Xiang, Wei-Ning; Sox, Joseph. 1994. **GIS, expert system technologies improve forest fire management techniques**. GIS World 7(2): 32-36.

Phillips, Clinton B. 1983. **Instructions for zoning fire hazard severity in state responsibility area in California**. Sacramento, California: Resources Agency, California Department of Forestry.

Pierpont, Don. 1991. Captain, Vegetation Management Division. Los Angeles County Fire Department. Personal conversations and phone calls.

Salazar, Lucy A. 1989. **Fire management on the frontier of GIS technology**. In: Forestry on the frontier. Proceedings of the 1989 Society of American Foresters Convention; 1989 September 24-27; Spokane, WA. Bethesda, Maryland: Society of American Foresters; 64-69.

Schmidt, R. Gordon. 1978. **An approach to hazard classification**. Fire Management Notes 39(3): 9-11,19.

Woods, James A. 1992. **A geographic information system for brush fire hazard mapping and analysis**. Long Beach: California State University; 65 p. Master’s Thesis.