Chapter 8

FIRE

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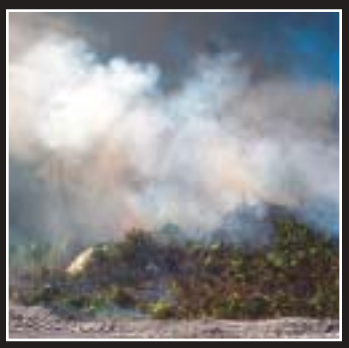
Geoff Babb, a Florida wildland fire manager, was asked to be a spotter for a fire detection flight one morning in June 1998. Fires had been burning in the State since May, but central Florida had not yet seen widespread fire activity. The summer thunderstorms were beginning, bringing the threat of lightning strikes to the dry forests. As the plane became airborne that day, the horizon filled with streams of smoke rising in the morning sun. At only 500 feet in the air, individual 5- to 10-acre fires were easy to see; orange flames licked at each perimeter, and smoke coalesced above the canopy. Geoff jotted down latitudes and longitudes for every fire they passed, quickly filling a steno notepad page and missing as many as he noted. The local forestry office had reported 88 lightning-started fires from the previous night's storm, and many were still burning. ▶



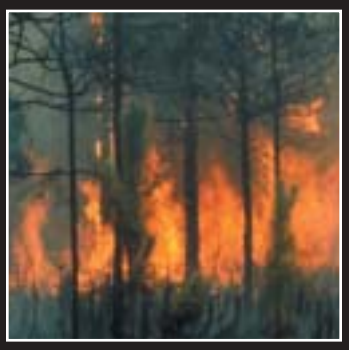


Photo courtesy of Florida Division of Forestry

Figure 8.1
Wildland fire helps to maintain fire-dependent ecosystems in the South.

At the southern Volusia County line, the plane turned around and headed north. By then, the sea breeze had picked up, intensifying every fire and lifting smoke columns higher into the air. It was an impressive sight. A mile-wide swath of fire and smoke, approximately 10 miles from the ocean, stretching as far as he could see, and one that Geoff won't forget. "If left to burn, those fires would scorch a million acres from Cape Canaveral to St. Augustine, stopped only by the St. Johns River to the west and the Atlantic Ocean on the east."

It had probably happened many times in Florida's prehistory, but it would not happen again. Below them, a power line to Miami, timber plantations, ranches, homes, towns, highways, and cities like Daytona Beach represented human lives and resources that would be protected from fire.

Introduction

Perhaps more than any other wildland-urban interface challenge, the interface makes wildland fire an issue. Some lightning-started wildland fires might be left to burn and maintain natural ecosystems if human lives and structures were not threatened, but they are threatened. Second homes and villages dot the region. Nearly every major fire threatens human establishments, requires suppression efforts, causes heartache among evacuees, and grabs newspaper headlines. Every State forestry agency has a wildland fire suppression division. Communication efforts abound to educate the citizenry about reducing risk, preparing for fire, and managing the emergency.

Any number of issues could be used to illustrate the complexity of managing natural resources and people in the wildland-urban interface, but for the sake of simplicity this report uses one: wildland fire. This term refers to fires that occur in natural areas that are not purposefully set for land management activity. They are usually started by human carelessness, though many are sparked by lightning or arson. Wildland fires also include prescribed fires that run out of control for any reason. This chapter reinforces the concepts presented throughout this Assessment. It demonstrates how demography, public attitudes, political and economic conditions, ecology, and resource management techniques influence our efforts to manage and protect both people and natural resources from wildland fire in the interface.

The Way It Was

Across the South, different forest ecosystems experience different natural wildland fire regimes (**fig. 8.1**). Swamps, marshes, bottomland hardwoods, and Appalachian forests tend to burn infrequently after a windstorm or drought increases the amount of combustible vegetation (Pyne and others 1996). Sandy, flat, or hilly regions dominated by pine trees may burn as often as every 3 years. An oak (*Quercus* spp.) and grass (*Gramineae* spp.) savanna in Texas may burn every 7 to 10 years. These relatively short cycles are possible in much of the South because relatively high rainfall and long growing seasons favor rapid vegetation growth. Some understory plant species contain oils and resins that fuel fire. The southern landscape evolved with lightning-induced fires during dry seasons; the ecosystems burn readily and recover quickly. Soon after a fire, roots send up new shoots, seeds germinate and establish roots in the newly exposed mineral soil, and wildflowers proliferate (Myers and Ewel 1990).

Some areas of the South experience more cloud-to-ground lightning than elsewhere on the continent, and most of the South was experiencing a great deal of human-induced fire when Europeans arrived. Without a layer of snow, southern forests and grasslands could burn during any month of the year. Native Americans frequently used fire to protect themselves from wildfires, improve wildlife habitat, and clear land for cultivation. Seasons and burning intensities were selected for each chore (Pyne and others 1996, Wade and others 2000). Fires helped to fell trees and smoke out raccoons; burned patches launched new cycles of berry and tuber production; light surface fires exposed and singed chestnuts; rolling grass fires drove deer to a river. European settlers adopted these practices as well, maintaining a relatively open landscape.

From the earliest European settlement to the early 1900s, industrial logging, gum tapping for turpentine, cotton plantations, railroads, and livestock transformed the southern pine forest into an agrarian region that flourished, then collapsed with economic change. Fire suppression programs were developed in the 1930s to stop the deeply held practices of woodsburning to protect the regenerating forest. As forestry agencies began to replant cutover land, fire protection activities eventually halted the widespread use of fire in landscape management.

The Way It Is

The exclusion of purposeful fire from the South, however, created an enormous fuel load for the eventual wildland fires. Whether it is sparked by lightning, arson, or human carelessness, wildfire cannot be excluded forever. The increasing population and the expanding wildland-urban interface both create and complicate the issue of wildland fire. Fires no longer regularly sweep great expanses and maintain the southern forests because human development necessitates that fires be suppressed. Lack of regular fire increases the chances of catastrophic wildland fire, and greater numbers of people in the wildland-urban interface increase the chances that such fires will be ignited (Irwin 1987).

Prescribed fires reduce fuel buildups, making wildfires smaller and less damaging[1] if used repeatedly every 5 years (Davis and Cooper 1963) (**fig. 8.2**). Yet, as fragments of forest habitat more urgently need fire to reduce fire hazards and restore or maintain endangered species populations, citizens have been known to shun the use of prescribed fire (Myers and Ewel 1990, Wade 1993). Policies to enable managers to use prescribed fire to manage their land must first win the support of the public, which has been predisposed to believe that forest fires are dangerous. Secondly, these policies must resolve the conflict with competing policies that protect air quality.

Complicating the issue is the obvious fact that even prescribed fires can be dangerous and destructive. Changes in weather or human error may cause prescribed fires to escape human control. It would seem that at least in the southern fire-dependent ecosystems, we couldn't live without fire; we will either have to learn to live with fire, or forfeit having these ecosystems in the wildland-urban interface.

There are no simple answers to the issue of fire in the wildland-urban interface, but by teasing out the tangled threads, it may be easier to understand why some programs have begun to see some success and what other solutions may be needed.

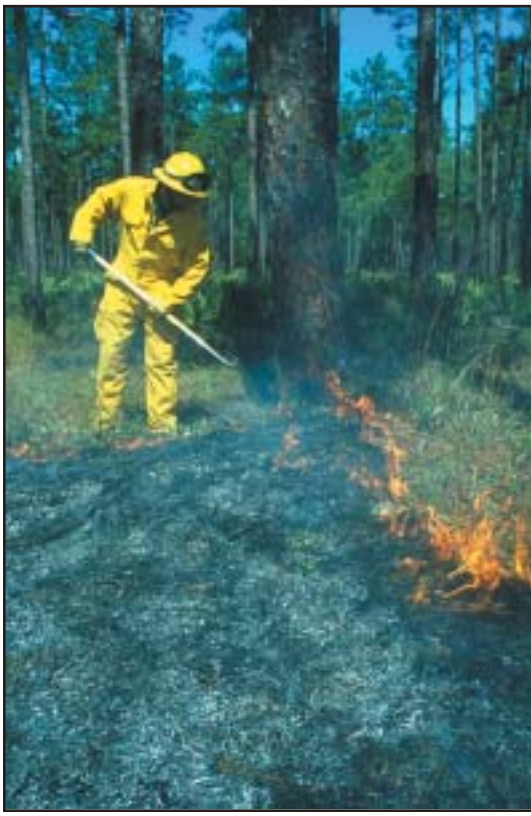


Photo by Larry Korhnack, University of Florida

Figure 8.2
Prescribed fire is a fuel reduction option that can be used in the wildland-urban interface to reduce the risk of wildland fire.

[1] Koehler, J.T. 1991. The use of prescribed burning as a wildfire prevention tool. 28 p. Unpublished report submitted to the National Fire Academy from the Florida Division of Forestry. On file with: Annie Hermansen, Southern Center for Wildland-Urban Interface Research & Information, U.S. Department of Agriculture, Forest Service, Southern Research Station, 408 W. University Ave, Gainesville, FL 32601.

Photo by Ken Outcalt, USDA Forest Service

Figure 8.3
Longleaf pine seedlings in the grass stage can withstand a low-intensity fire that singes needles but does not harm the growing bud.

Integrating Interface Issues

Ecological Structure and Function

Fire plays an important role in the ecology of southern forest ecosystems. Some 90 million acres of the South's Coastal Plain were once covered with longleaf pine (*Pinus palustris* Mill.) forests. It has been called "the forest that fire made." From the mineral soil required for seedling establishment to the thick bark of scaly plates that insulates and dissipates heat, every stage of the longleaf pine life cycle relates to fire (Myers and Ewel 1990). Unlike most pines, the longleaf seedling spends an undetermined number of years in the "grass stage," which affords the young tree protection from fire by surrounding the terminal bud with a tuft of long needles (**fig. 8.3**). A substantial root system is developed during this stage, enabling the sapling to bolt above the most lethal fire zone in two to three growing seasons. Despite the many adaptations, a wildland fire can kill even large, mature trees, particularly if it burns dry duff. During drought, a low-intensity ground fire can burn into this duff layer and damage tree roots to the point of mortality.

Other southern pine ecosystems have different fire regimes. A vigorous, intense, stand-replacement fire, for example, is the normal regime for sand pine [*P. clausa* (Chapm. ex Engelm.) Vasey ex Sarg.] forests. A fire every 10 to 100 years typically reduces the trees to cinders, from which a new sand pine forest grows (Myers and Ewell 1990).

The appearance of pine in the overstory of many southern forests indicates a potential for wildland fire, but even forests with an oak-hickory (*Carya* spp.) canopy are susceptible. Estimates for fire return intervals in these forests are complicated by the use of fire by Native Americans and settlers, but could range from 15 to several hundred years (Harmon 1982 as cited in Wade and others 2000). Oaks and hickories succeed in areas with periodic fire, protected by their thick bark. Sprouting from a large seed, these trees develop a substantial root system and are able to resprout (Wade and others 2000). In the mountainous region of the South, when a lack of rain dries out the leaf litter layer and vegetation has not yet leafed out in the spring or just dropped leaves in the fall, exposed southern slopes are at considerable risk of fire. Plants such as mountain laurel (*Kalmia latifolia* L.) and rhododendron (*Rhododendron* L.) can burn with surprising intensity, nearly exploding into flame (Wade and others 2000).

Fire consumes aboveground litter, mineralizing phosphorus and other nutrients and making them available to plants. Fires can also volatize nitrogen, causing a reduction in this nutrient. On balance, however, it appears that frequent light fires result in the release of small pulses of nutrients (Myers and Ewel 1990). These nutrients are used by sprouting vegetation, and then consumed by wandering herbivores. Removal of leaf litter increases soil movement during rains, but in the South where vegetation regrowth is quite fast, this increase in soil erosion is generally not significant.

The balance of pine and oak in the forests of the South has changed over the last 20,000 years so much that it is impossible to know the composition of the "original" forest (Myers and Ewel 1990). Soil types, moisture levels, climate, and fire at different frequencies and seasons worked in concert to shape and reshape the forest ecosystem. Some might see the recent resurgence of oak in fire-excluded pine forests, and of maple (*Acer* spp.) in oak forests, as merely additional steps in the natural system of change. While this change might dampen or reduce the

incidence of wildland fire in a protected forest, it is not likely to affect the intensity of the occasional catastrophic fire that follows a drought. A forest without fire is likely to have a great deal of understory fuel. Ground cover, shrubs, and ladder fuels sustain and drive wildland fires. However, regardless of the overstory composition, the real question is how do we best manage the existing forests to maintain species diversity, enhance ecosystem goods and services, and still protect interface dwellers?

Forest Resource Management

Managing forest resources in the interface is a challenging game of balance. Certain activities are important to maintaining healthy ecosystems, but these activities might be difficult for nearby neighbors to accept. Efforts to reduce deer herds to viable levels by opening a hunting season has generated conflict in a variety of States, leaving managers with a frustrated "I can't implement the management strategy I believe is best" feeling. Fire is no different.

"The risk of using prescribed fire has just grown exponentially. You can be totally within the prescription, do everything 100 percent right, and then 12 hours later have a smoke-related incident because we have an increase in traffic we didn't have 10 or 20 years ago. " Mississippi

Managing for forest health often means using fire in the landscape. The ability of managers to use prescribed fire is limited by weather and by public opinion. Managers across the South have worked to educate the public about the benefits of prescribed fire in reducing the hazards from wildfires.

In areas where prescribed fire is not an acceptable treatment, the alternatives of mechanical fuel reduction and herbicide application have been explored. Thinning with tree removal or chipping helps reduce the remnant woody material and speed decomposition (Kalabokidis and Omi 1998). A herd of goats is used at a Florida 4–H Camp because of the risk of smoke on a nearby interstate highway. Herbicides are often used in managed plantations to reduce competition from nondesired species. Where decomposition occurs quickly and where rainfall reduces the threat of drought, herbicide application might be a reasonable alternative. Herbicide treatment, however, may be even less acceptable to the public than fire.

"The interface is overgrown—overgrown due to lack of fire." Mississippi

A recent study on the public's willingness to pay for various alternatives rated herbicide the least popular treatment.[2] In a comparison of different fuel reduction techniques, Brose and Wade (2001) suggested that combinations of thinning, herbicide application, and prescribed fire could reduce the short-term and long-term risks from wildland fires.

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[2] Loomis, J.B.; Bair, L.S.; Gonzales-Caban, Armando [and others]. 2000. A survey of Florida residents regarding three alternative fuel treatment programs. Fort Collins, CO: Colorado State University. 89 p. Unpublished study. In cooperation with: University of Georgia, Survey Research Center, Athens, GA. On file with: John Loomis, Department of Agriculture and Resource Economics, Colorado State University, Fort Collins, CO 80523.

Photo courtesy of Florida Fish & Wildlife Conservation Commission

Figure 8.4
Wildlife may return rather quickly to burned forests in order to nibble on the new vegetation.

In Assessment focus group discussions, resource managers in most States mentioned the problems of using prescribed fire in the interface. They spoke of common experiences and challenges in managing forests near residents who did not understand the use of fire. They feared liability if a prescribed fire led to vehicle accidents or property damage. Managers seemed caught in a tightening vise of growing vegetation, unyielding attitudes, and increasing population. They were concerned for both the resource and the impending danger to residents, and they did not have ideas for solutions (Monroe and others, in press).

"One of the reasons we have wildfires is a direct result of the litigiousness of society. If a private landowner is doing a controlled burn and somebody down the road has a car accident, regardless of whether or not smoke actually caused the problem, if they can smell smoke, they're going to sue and that stops controlled burning." Florida

Invasive exotic plant species are often quick to colonize a recently burned area and many, such as Old World climbing fern [*Lygodium microphyllum* (Cav.) R. Brown], magnify the fire hazard. In the interface, managers may have to reduce invasive plant seed sources before a prescribed fire, or physically remove vegetation to reduce the threat of wildland fire. For threatened and endangered plants that inhabit fire-dependent ecosystems, the use of prescribed fire is imperative to restore critical habitat.

Wildlife represents another complication for interface managers. Some wildlife populations respond favorably to frequent, low-intensity fires, though not all individuals survive (Main and Tanner 1999) (**fig. 8.4**). Most endangered species in the South require periodic fire; herbicide and mechanical methods of reducing vegetation do not provide the same benefits as fire for wildlife habitat (Brennan and others 1998). The public, however, believes that harming wildlife is one of the greatest risks in prescribed burning even though newspaper reports generally do not reinforce this misperception. In an analysis of 272 newspaper articles on fire in Florida printed in summer 1998, only one of the 44 articles that discussed prescribed fire mentioned a risk to wildlife (Jacobson and others 2001).

Demographics

Across the Nation, the increasing human population in the wildland-urban interface has exacerbated the issue of wildland fire. Though relatively few lives

Photo courtesy of Virginia Department of Forestry

Figure 8.5
Homes in the woods are at risk of wildland fire.

have been lost, damage to homes and businesses is a significant risk of living in the interface, and one that new residents are not likely to realize at the time they move (Gardner and others 1987) (**fig. 8.5**). While leaving one set of problems in the urban areas, such as smog, congestion, crime, and noise, some migrants merely exchange them for other problems, like the lack of public services, questionable water quality, trash along roadsides, and wildland fire. **Table 8.1** represents a partial history of interface fires, indicating the scope and breadth of the problems.

The expanding interface represents different challenges as it grows. The first homes there are at substantial risk because of limited fire protection services in

Table 8.1—A selected history of wildland-urban interface fires in the United States

Location	Year	Structures lost	Area burned
		– – Number – –	*– – Acres – –*
Pine Barrens, NJ	1963	383	183,000
Laguna, CA	1970	382	175,425
Sycamore, CA	1977	234	805
Panorama, CA	1980	325	23,600
Palm Coast, FL	1985	99	13,000
Burke County, NC	1985	76	2,000
Onslow County, NC	1986	0	73,000
Monterey County, CA	1987	31	160
Nevada County, CA	1988	90	33,500
Sisters, OR	1990	22	3,300
Paint Cave, CA	1990	641	4,900
Oakland Hills, CA	1991	2,900	1,500
Chelan Cty, WA	1992	32	2,400
Craven County, NC	1994	0	24,600
Millers Reach, AK	1996	344	37,336
Poolville, TX	1996	141	16,000
Florida	1998	330	500,000
Juniper, CA	1998	44	6,000
St Lucie, FL	1999	43	759
Los Alamos, NM	2000	235	47,650
Russell County, AL	2000	6	4
Chambers County, AL	2001	2	30
Talledega County, AL	2001	1	347

Photo courtesy of Virginia Department of Forestry

Figure 8.6
Steep, winding, narrow roads to residences may not be accessible by large fire engines or may become blocked with debris during a wildland fire.

Table 8.2—Recent fire history in Texas[a]

Year	Fires	Area Burned	Structures Saved	Value	Structures Lost	Value
	No.	*Acres*	*No.*	*M $*	*No.*	*M $*
1996	2,800	236,000	3,170	158,500	165	3,000
1997	650	8,400	105	5,300	9	400
1998	2,793	198,000	4,087	238,000	147	2,700
1999	2,313	172,000	2,739	129,500	52	3,400

[a] Forest resource protection department fire database. On file with: Texas Interagency Coordination Center, Route 5, Box 3650, Lufkin, TX 75904 [936.875.4786].

sparsely populated areas and limited access on winding, narrow roads not built for heavy equipment (**fig. 8.6**). A scattering of summer homes, mobile homes, or secluded mansions is difficult to protect because of the large area involved. In 1988, Texas Forest Service officials were concerned that while 80 percent of the population lived on 3 percent of the land, an increasing number of people lived in areas without full-time fire protection (Miles 1988). Over 1,400 communities of <10,000 people had no fire department serving the town. **Table 8.2** provides a recent fire history in Texas and indicates the value of the homes and other structures that are found in this risk-laden interface.

As the interface becomes more populated, zoning codes may require water sources, road clearances, and emergency services. Where existing communities are expanded or infilled, however, the additional homes may be approved under the old regulations that governed the less-dense development (Rice and Davis 1991). In other regions, planning for increased growth is woefully inadequate, and the people who are selling new homes or building schools may not have even considered fire services. Even if new developments are zoned more appropriately with forethought for fire, they are still at enormous risk if a fire from an adjacent wildland approaches. During fire suppression, the demand for water, access, equipment, and firefighters may overwhelm the available system (Davis 1990).

Residents of the South represent a diverse and changing mixture of ethnic and cultural groups. A recent study of English- and Spanish-speaking residents who lived in areas exposed to recent large-scale Florida wildland fires reveals that knowledge and perception of risk varies between these groups, but not their willingness to pay for fuel reduction strategies (see footnote 2). Efforts to educate the public must take into account the variety of groups and their potentially different values and perceptions.

In some parts of the South, retirees dominate interface communities. People who are new to the fire regimes of southern forests may not be aware of the fire risk, or may not understand the use of prescribed fire. Furthermore, the elderly are more likely to suffer from lung disease and, therefore, are at greater risk of medical complications from the particulate matter in smoke. More people, more kinds of people, and more people with different needs in the wildland-urban interface help shape the strategies used to manage fire.

Economics

Wildland-urban interface fire is costly. There are replacement costs for lost structures, opportunity costs of reduced tourism or cancelled events, and the costs of suppression. In California alone, the average annual losses to wildland fires between 1985 and 1989 amounted to $41,678,800, including 79 destroyed structures (Anderson and others 1991). Suppression costs for only one complex of fires in Florida, which burned from June 29 to July 16, 1998, near Orlando, totaled $5,211,500.[3] Of this total, 28 percent was spent on bulldozers, water tenders, and fire engines; 23.4 percent on food, lodging, communications, transportation, and toilets; 18.5 percent on personnel; and 15 percent on air support (see footnote 3). Fifty-one fires in five counties broke out during that period, destroying 40 homes (see footnote 3). In 2000, wildland fires in the South destroyed more structures than wildland fires in the rest of the country, even though the acreage burned was relatively small.[4] The housing density in the wildland-urban interface of the South explains this substantial loss.

Because of high housing density, any wildland fire in the South is likely to put interface homes at risk. Protecting these homes usually comes at a cost to other resources. In recent years, the largest loser has been the forest industry. An economic study estimates at least $620 million were lost in the 1998 wildland fires in Florida (Mercer and others 2000). Timber revenues increased for landowners who had to salvage their burned timber. Salvaged trees have less value than unburned logs, and with the large amount of salvaged timber on the market, prices dropped even further. Total pine losses were estimated between $354 and $605 million, with hardwood losses presumed to be $100 million (Mercer and others 2000). Sales tax receipts increased for the months during the wildland fires, perhaps due to supporting firefighters; they dropped immediately after the fires, perhaps due to the drought or media exposure. The net change in tourist and sales tax revenue was a loss of $138 million (Mercer and others 2000). Suppression and disaster relief efforts cost the government more than $120 million (Mercer and others 2000). A study of medical treatment noted an increase in emergency room visits for asthma, bronchitis, and other respiratory ailments, but no increase in hospital admissions during the months of wildland fire (Mercer and others 2000). Finally, the loss of insured property totaled $10 to $12 million (Mercer and others 2000).

There are costs to prevention, as well. In Arizona, the national forests have identified 237,000 acres in their wildland-urban interface in need of vegetation reduction to reduce the risk of wildfire to nearby residents. In 1998, 5,016 acres were treated with thinning, chipping, fuel breaks, prescribed fire, and timber sales at a cost of $1,213,720 (U.S. Department of Agriculture Forest Service 1997). This treatment is not a permanent remedy, of course. Some ecosystems require additional burns to reduce fuel loads within 5 years (Davis and Cooper 1963).

The economic cost of using prescribed fire in the interface is greater than the cost of using fire in wildlands. While burning costs are $3 per acre in wildlands, they rise to $50 per acre in the wildland-urban interface because more preparation and public contact are needed.[5]

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[3] Birch, K.; Brown, M. 1998. Orlando complex fire narrative summary and discussion of incident management operations. 25 p. Unpublished report. On file with: Annie Hermansen, USDA Forest Service, Southern Research Station, Southern Center for Wildland-Urban Interface Research and Information, 408 W. University Ave. Suite 101, Gainesville, FL 32601.

[4] Personal communication. 2001. William R. Sweet, Program Manager, U.S. Department of Agriculture, Forest Service, Southern Region, Fire Prevention and Wildland-Urban Interface, 1720 Peachtree Rd., NW, Atlanta, GA 30309.

[5] Greenlee, J.M.; McGarrahan, F.; Namlick, T. [N.d.]. Wildfire mitigation in the 1998 Florida wildfires. FEMA-1223-DR-FL. Federal Emergency Management Agency. 9 p. [After action report]. On file with: Annie Hermansen, U.S. Department of Agriculture, Forest Service, Southern Research Station, Southern Center for Wildland-Urban Interface Research and Information, 408 W. University Ave. Suite 101, Gainesville, FL 32601.

Insurance rate structures have been used to encourage improved health, better driving habits, and hurricane preparedness; similar strategies could be employed to encourage wildland fire prevention, such as the cost of retrofitting homes with fire-resistant materials. Unfortunately, there is some indication that disaster loans and low premiums subsidize inappropriate and high-risk construction (Davis 1990). Homeowner insurance premiums do not currently compensate homeowners for the cost of all the firewise improvements they might make to their home. Unlike improvements to reduce the risk of hurricane or earthquake damage, damage from wildland fire has not been a large enough cost to the insurance companies to encourage changes in the premium structure in most States.

Land Use Planning and Policy

Policies and recommendations about wildland fire suppression, the use of prescribed fire, zoning, and building construction abound. For example, because of the predominance of a fire-prone ecosystem, high fire risk, and large population, Florida's Division of Forestry aggressively uses prescribed fire to manage natural areas. They also use a full complement of policies and regulations to guide who can burn, when burns occur, when burners are liable, how burners are trained, and how burns are authorized. This proactive wildland-urban interface fire program is certainly a model for other States.

"Traditional forest management practices, like prescribed burning, have to be changed because of conflicts between management and people." Texas

Councils

Building awareness for using prescribed fire to reduce wildfire hazards starts with increased communication among the agencies and organizations that manage wildlands and joint efforts on publicity. Prescribed Fire Councils have been successful avenues for maintaining contact among those interested in using prescribed fire and for coordinating media efforts. By creating posters and brochures, speaking to civic groups and schools, conducting workshops and field trips, obtaining press coverage, and maintaining a presence at the State capital with exhibits during Prescribed Fire Awareness Week, the councils in Florida perform an important service in public education (Wade and Brenner 1995). Periodic regional meetings in Florida have attracted nearly 300 participants.

It is the policy of land management agencies to protect human life and structures before natural resources during a wildland fire (Cortner and Lorensen 1997). In the interface, this policy often means that Federal and State forest agency firefighting personnel and equipment must work with structural fire crews to protect homes rather than focusing on suppression of the spreading fire. The differences between these two groups of firefighters, in firefighting procedures, clothing, tools, and equipment, mean that communication is essential. Some structural fire departments with repeated experience in interface fire have obtained wildland fire equipment and training, making the job of fighting fires together much more successful.[6]

At the institutional level, wildland-urban interface firefighting requires communication and cooperation among a broad array of agencies. In most States, the responsibilities for forest fires, structural fires, firefighting training and certification, emergency management, transportation and highway safety, smoke and air quality, insurance rates, building codes and development regulations, and growth management fall within several different agencies. They may also be addressed at different levels of government. In Texas, for example, local fire departments are the primary initial response force for fighting wildland fires; the State forestry agency is called when the conditions exceed the capabilities of the local resources.

Such a wide variety of disciplines, interests, and perspectives on fire create challenges for communication and joint policy initiatives, particularly in the heat of a crisis. Many fires in the wildland-urban interface are approached through a multiagency incident command system, which requires each agency to operate under a common set of guidelines.

[6] Personal communication. 2000. Will May, Chief of Emergency Management, Alachua County Fire and Rescue, P.O. Box 548, Gainesville, FL 32602.

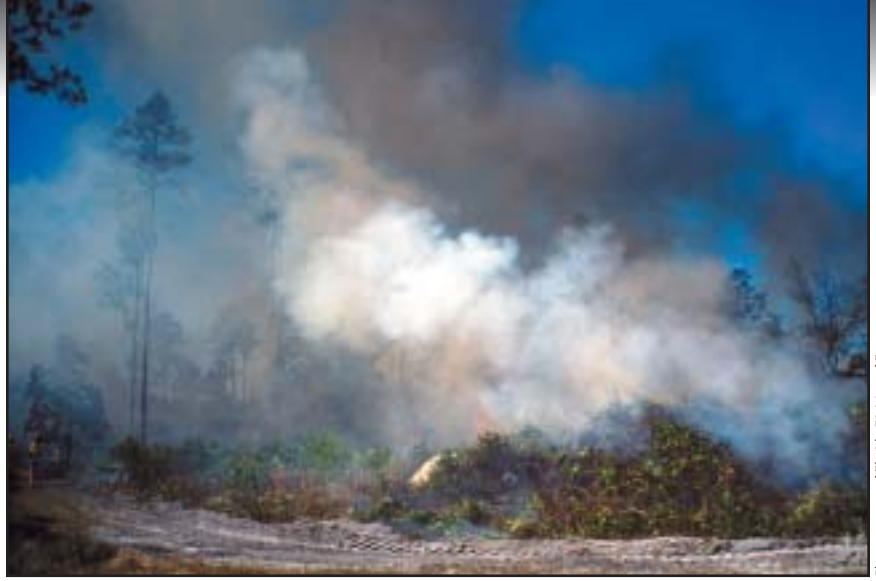

Photo courtesy of Florida Division of Forestry

Figure 8.7
People in both rural and urban areas are exposed to smoke from prescribed fire. Concerns about air quality and traffic hazards are very real.

The State of Florida recognized the value of prescribed fire for ecological and resource management purposes and charged the division of forestry with the responsibility to develop rules to regulate its use (Wade and Brenner 1995). Also known as the "right to burn" law, it requires written prescriptions for each burn and protects the burner from liability unless negligence is proven. A well-constructed lobbying effort of industry, conservation organizations, and State agencies helped to pass this groundbreaking legislation.

Local governments also have the power to establish ordinances that address wildland-urban interface fire. Flagler County, FL, the site of a countywide evacuation during the 1998 fires and where over 200 homes have been destroyed by interface fires, recently enacted an ordinance requiring brush mowing and selective thinning of mature pine trees (Flagler County Ordinance No. 98-14). Property owners of "nuisance brush and pine trees" are required to clear the property or reimburse the division of forestry for the service. A similar effort at the State level, the Hawkins Bill, was passed in 1977 to allow the Florida Division of Forestry to use prescribed fire to reduce fuel loads on properties owned by absentee owners (Wade and Brenner 1995). To alert new residents to the probability of nearby smoke, several Florida counties use an ordinance requiring that prospective homebuyers be notified about the use of prescribed fire to manage State-owned natural areas (Wade and Brenner 1995). The ongoing challenge is in balancing private property rights and public safety.

Prescribed fire is necessary and valuable, but it raises liability questions if property is damaged or vehicle accidents can be blamed on smoke (**fig. 8.7**). The State of Florida has wrestled with these issues for several years and currently offers legal protection to individuals who have completed a training course in prescribed fire, become certified prescribed burn managers, and are conducting a prescribed burn within prescription and in accordance with appropriate regulations (Long 1999, Wade and Brenner 1995).

Smoke from prescribed fire generates significant public concern, particularly when it drifts into urban areas where residents have little appreciation for the benefits of prescribed fire. Smoke from wildland fire also contains particulate matter that is a pollutant regulated by the U.S. Environmental Protection Agency (EPA) (**fig. 8.8**). If a region is approaching the maximum allowable standard for particulate matter, prescribed burning activities could cause the area to exceed the daily limits on air quality (Monroe 1999). Violation of daily limits would trigger a required implementation plan under the Clean Air Act with activities to reduce particulate matter. Under an agreement between the EPA and the Federal land management agencies, however, in these cases State smoke management plans may be reviewed for appropriate parameters to reduce smoke problems (U.S. Environmental Protection Agency 1998). If a city is already a nonattainment zone, prescribed fire may be banned during seasons of peak ozone production.

TECHNOLOGY

Technology can help protect structures from wildland fire. Foams and gels can be sprayed over a home several hours before a fire approaches to protect the structure. Siding made from a concrete mixture (Hardiplank®) is virtually inflammable, and even wooden shingles can be treated with chemicals to render them as fire resistant as asphalt shingles.

Photo courtesy of Florida Division of Forestry

Figure 8.8
Smoke plumes signal a growing wildland fire in the wildland-urban interface.

Photo courtesy of Florida Division of Forestry

Figure 8.9
Vinyl soffits and siding are quick to melt in the heat of a wildland fire. In Florida, one identifiable cause of destroyed homes was sparks entering the attic through exposed soffit vents.

TOOLKIT

The cooperative extension service is a likely partner in a communication effort with interface residents. Extension agents conduct programs throughout rural counties across the South. In Florida, the extension service teamed up with the Florida Division of Forestry and The Nature Conservancy to prepare extension agents and forestry staff to develop public programs, work with the media, and establish prescribed fire demonstration areas in high-risk communities. The Wildland Fire Education Toolkit was developed to provide agents with programming tools such as videos, fact sheets, brochures, press kits, and slides. Within the first 4 months of the program, county agents and forestry staff reached over 2,000 residents in direct programs, contacted 23,000 people at county fairs and displays, and used the local media to reach over 2.1 million citizens with messages about wildland fire mitigation activities (Monroe, M.C. 2000. Increasing public awareness and knowledge of wildland fire through county programs. 41 p. Unpublished final report. On file with: Martha Monroe, School of Forest Resources and Conservation, University of Florida, P.O. Box 110410, Gainesville, FL 32611-0410).

Preventing the loss of life and the loss of structures in wildland-urban interface fires may begin with changes in land use planning, zoning, structural codes, and development design. An improved connection between land use planning and ecosystem dynamics may begin to resolve a variety of wildland-urban interface challenges. Many Western States have used all of these tools to manage interface fire, with varying degrees of success (Davis 1990, Irwin 1987, Pumphrey 1993, Rice and Davis 1991). The most common guidelines represent a common sense approach to prevention: create firebreaks from retention ponds or golf courses around subdivisions, assure access roads and water supplies, use fire-resistant building materials, and avoid steep slopes (Monroe and Marynowski 1999, Smith 1987) (**fig. 8.9**). Unfortunately, few of these recommendations are easy to implement after homes are built, and few seem to be heeded during the planning phase.

A series of recommendations, known as NFPA 299: Standard for the Protection of Life and Property, was developed by the National Fire Protection Association (NFPA) to guide developers, builders, planners, and decisionmakers who approve developments in the wildland-urban interface. The recommendations include dimensions for roads, distances to water, and building materials that can improve homeowners' abilities to protect themselves from fire. Some of these building materials, such as aluminum soffits, are not widely available; others are usually more expensive than the traditional materials. Neither case makes it likely that homeowners will seek out these materials.

Finally, successful policies will be those that the public supports. In a study of attitudes held by interface residents in 2 California communities, respondents rated 16 public policies that would help reduce their risk of wildland-urban interface fire. Policies that regulate industries and agencies (building material restrictions and prescribed burning program) tended to be more favored. Policies that restrict homeowner choice (density requirements and fire insurance) were ranked low (Cortner and others 1990). A policy to encourage homeowners to clear vegetation on their property was ranked high, though few of the respondents had done so.

Social Dimensions

Public reactions to wildland fire have become more sophisticated over the last 20 years, evolving from a "fire is bad" perspective to a more rich understanding that fire plays an important role in many forest ecosystems (Cortner and others 1990). Despite growing support for the use of prescribed fire in a wilderness, however, there is mixed reaction to the use of prescribed fire in the interface. Florida residents may have expressed this "not in my backyard" sentiment when 79 percent responded that people who live near natural areas should tolerate some smoke from wildland fire and 53 percent agreed that protecting air quality is more important than burning natural areas (Jacobson and others 2001). The respondents (sample excluded urban dwellers) lived an average of 7 miles from the nearest natural area.

The attitudes and preferences that support migration to the wildland-urban interface also support particular choices about the homesite, construction, and landscaping that directly oppose firewise recommendations. In the Assessment focus groups, resource managers commented that these homeowner choices also put firefighters in jeopardy (Monroe and others, in press). A study of homes that burned in Florida's Palm Coast fire of 1985 revealed that one of three significant factors was clearing the brush near the house. Homes within 10 feet of brush burned more often than homes with 30 feet of brush clearance (Abt and others 1987).

"We've got steep, dead-end roads that go up hillsides to homes. Firefighters are at risk trying to reach these people's homes." Georgia

If new migrants situate their home on a high ridge to enjoy a scenic view or behind a screen of vegetation to insure privacy, they have increased their risk of a wildland fire consuming their home. If they wish to design a home that blends in with the surroundings and use wooden siding, unrated wooden shingles, and wooden decks, they also increase the risk. Narrow, winding driveways, while appealing to the homeowner, discourage emergency vehicles from approaching a home (Davis 1990). Native plants that attract wildlife, thick shrubbery that shelters birds, windbreaks and shade-providing trees that overhang the home, and little lawn to maintain are all landscape elements preferred by environmentally concerned interface residents. All of these elements increase their risk of wildland fire. In fact, many agencies lend to the confusion by recommending these elements in home landscapes. Subdivision ordinances may require homeowners to maintain privacy screens of vegetation. The risks of fire are rarely obvious when residents move to the interface (Gardner and others 1987), but must be communicated in a manner that is sensitive to the homeowners' preferences and values.

Reactions to messages about wildland fire portray some of the same responses as other risks involving personal behavior, like smoking and drinking alcohol. Convinced that fire won't strike twice in the same place, recent survivors tend to discount their risk, even if their ecosystem burns at a regular and frequent interval (Gardner and others 1987). A basic ignorance of wildland fire leads many residents to underestimate their fire risk. Residents who believe that forest fires are, basically, random events that no one can control may be less likely to support protective measures or take actions to reduce their risk (Winter and Fried 2000).

Education programs have increased awareness and knowledge about wildland fire in several different ecosystems (Marynowski and Jacobson 1999, Taylor and Daniel 1984). In the wildland-urban interface, residents have increased their knowledge and developed attitudes that are more positive about prescribed fire, because of educational activities (Monroe and others 1999a). Residents with an increased awareness and understanding of fire and risk are often willing to take some actions to protect their homes and property (Cook 1997). A recent Florida survey found that 42 percent of those surveyed had already taken precautionary actions, such as removing shrubs and branches from near the home and moving flammable objects like woodpiles away from the house (**fig. 8.10**) (Monroe and others 1999b). Another survey in Florida found that the more respondents believe in the effectiveness of prescribed fire to reduce wildland fire risk, the less concerned they are with the cost of the mitigation effort (see footnote 2).

Meeting the Challenge

Increasing communication with the public is part of nearly every recommendation from any report on wildland fire written in the last 20 years. Fire in the wildland-urban interface cannot be managed by government agencies alone; homeowners must become responsible partners. A more knowledgeable public can contribute to improved policies, zoning and building regulations, home maintenance, and landscaping. Fortunately, some programs have begun to make a dif-

FIRECAP

In Texas, the program Fire-Citizen's Advisory Panel (FireCAP) helps involve local residents in efforts to raise awareness of fire and emergency-related issues, support the fire departments, improve emergency response networks, and engage citizens in wildfire mitigation activities. The program began in Bastrop County, where a partially built subdivision (600 homes on 4,000 acres) in a steeply sloped, pine/juniper forest with narrow, unimproved roads appeared to be a disaster in the making. Local fire officials and citizens worked together to better communicate the challenges of interface fire and promote fire prevention and mitigation. An outgrowth of FireCAP was the Tahitian Village Wildfire Mitigation Project, which aggressively promoted the use of defensible space around homes. Several homeowners volunteered their properties to become demonstration areas to help alert other neighbors to the feasibility of the recommendations. They also organized a MulchFest, giving residents a chance to learn about wildland fire and defensible space, order 911 numbers, and dispose of brush, leaves, and needles while enjoying the camaraderie of their neighbors. One goal of the program is to enable residents to safely dispose of the slash they create from their mitigation efforts. The program has expanded to explore permanent ways to deal with brush, pine needles, and leaves and has spread to encompass the 80,000-person county.

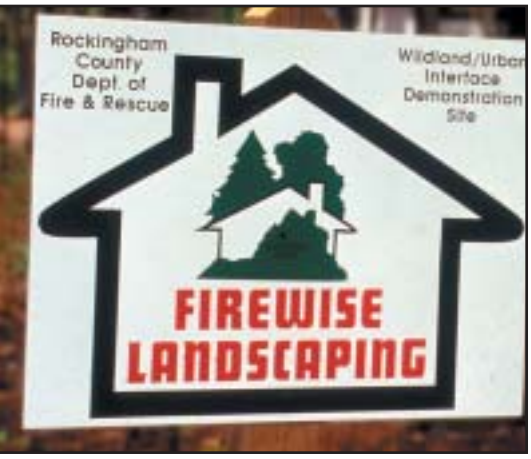

Photo courtesy of Virginia Department of Forestry

Figure 8.10
Homeowners can create firewise landscapes to reduce their risk of wildland fire.

ference by improving agency partnerships, raising public awareness, developing demonstration yards, and putting interface fire protection in the news. Examples include FireCAP, Firewise, fire councils, and the Wildland Fire Toolkit. Additional staff, additional training, interagency training, cooperative programs, and new publications are also employed to help educate citizens and managers working in the interface.

Positive results from some efforts might be copied by other agencies and States. Some of the more creative ideas that have been well received and shared with other locations are:

- training sessions for local media including attendance at a prescribed fire (**fig. 8.11**);
- trained fire prevention education teams that share key wildland-urban interface fire messages with high-risk communities and homeowner associations;
- courses for special audiences, like cattlemen, native plant society members, or natural area managers;
- regular newspaper columns;
- educational materials for students, distributed through workshops with teachers;
- demonstration areas next to public hiking trails with interpretive signs on the role of fire;
- prescribed fires around golf courses to expose interface residents to the value of fire; and
- billboards, pencils, mugs, T-shirts, and caps advertising the benefits of prescribed fire.

Firewise

At the national level, the Firewise program has created a set of materials, an interactive Web site (www.firewise.org), and a model workshop for local agencies to use to build support for fire mitigation activities. The program recognizes that builders, mortgage lenders, utility agencies, firefighters, elected representatives, educators, planning commissions, and land managers must be involved in preventative planning in the interface. The workshop engages this diversity of participants in discussions about rating and reducing fire hazards in existing and proposed developments. Several States have adapted the national recommendations to their own situations and organized their own series of workshops.

Needs

Some land managers are very enthusiastic about prescribed fire to mitigate wildland fire effects in the interface, but it cannot be the only solution. Weather patterns often make it difficult to safely conduct prescribed fires in the South, and there will be schools, hospitals, retirement villages, highways, and airports in the airshed of natural areas that make smoke management difficult. There is an urgent need to better understand fuel management in the South. Some specific needs are to:

- monitor urban expansion into hazardous fuels, rating fuel loads, and prioritizing reduction efforts;
- develop cost-effective and environmentally benign combinations of fire, grazing, mowing, thinning, and herbicide application to reduce vegetation over time in the interface and enhance the ecosystem;
- improve prediction of smoke movement;
- improve communication strategies to inform all fire, safety, and transportation personnel about smoke movements; and
- improve predictability of fire behavior in the southern wildland-urban interface so that vegetation removal and housing design can reduce the need for firefighters.

Photo by Martha Monroe, University of Florida

Figure 8.11
Allowing television crews to cover a prescribed fire in a residential area for the evening news allows the public to become more accustomed to this land management tool.

Similarly, more work needs to be done on the defensible space guidelines. Research needs are to:

- explore flammability and develop a rating system for landscape plants and types of mulch in the South;
- develop guidelines for appropriate density of trees (particularly pines) in a wooded housing development and appropriate distance of vertical and horizontal separation of landscape vegetation to reduce ignition potential of structures while providing shade and other benefits (**fig. 8.12**);
- better understand residents' values that determine landscape priorities, so their desires for wildlife, energy conservation, privacy, and reduced lawn maintenance can be accommodated while maintaining defensible space; and
- identify segments of the wildland-urban interface publics that are more likely to perceive a realistic risk of wildland fire and take actions to reduce their risk.

Reducing the risk of damage from wildland fires in the interface may be best accomplished by communities, homeowner associations, community-based fire department auxiliaries, and groups of landowners. More research is needed to understand:

- the most effective strategy to engage groups of people in fire-mitigating activities;
- how agency partners can nurture and support community leaders;
- how the social capital in a community of neighbors can be used to support land management activities;
- which tasks can be expected of citizens, and which fuel reduction activities they would find most acceptable;

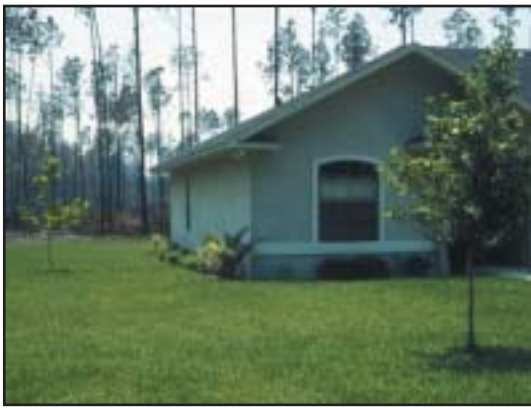

Photo courtesy of Florida Division of Forestry

Figure 8.12
Increasing the vertical and horizontal space between plants and branches will help reduce the risk of wildland fire.

- the roles of policy, tax, and insurance incentives in motivating citizens;
- the most useful educational assignments, materials, or activities that help students take wildland fire messages home to parents;
- the design characteristics of interface structures and developments that will make them more survivable in a wildland fire and safer for prescribed fire; and
- the key characteristics of a successful homeowner education program—one that engages individuals to work in concert with their neighbors to reduce wildland fire risk.

Public agencies can work to improve communication, coordination, and organization during wildland fire preparation activities. Agency staffers are important links to information and resources. We need to better understand:

- the best ways for agencies to support communities and communicate the urgency of the message in a manner that will be heard by residents;
- how agencies can better work with companion agencies on overlapping turf, like water management, transportation, and energy conservation;
- how agency staffers can become integral components of community planning and development decisions that affect the risk of wildland fire in the wildland-urban interface; and
- how agency staffers can better integrate community leaders in the planning and design of prescribed fire activities and incorporate their expertise as residents into management activities.

Conclusion

Fire is only one issue in the wildland-urban interface, but it attracts attention. The challenges associated with managing wildland fire in the interface—interagency communication, growth management, fire-dependent ecological systems, Federal-State-local cooperation, public education, behavior change, and organizational development—are not unique to fire. They are challenges for every interface issue.

Literature Cited

Abt, R.; Kelly, D.; Kuypers, M. 1987. The Florida Palm Coast fire: an analysis of fire incidence and residence characteristics. Fire Technology. 23(30): 230-252.

Anderson, P.J.; Martin, R.E.; Gilless, J.K. 1991. Decision analysis in the evaluation of wildfire hazard reduction by prescribed burning in the wildland-urban interface. In: Proceedings of the 11th conference on fire and forest meteorology. [Place of publication unknown]: [Publisher unknown]: 291-298.

Brennan, L.A.; Engstrom, R.T.; Palmer, W.E.; Hermann, S.M. 1998. Whither wildlife without fire? In: Transactions 63rd North American wildlife and natural resource conference. [Place of publication unknown]: [Publisher unknown]. 63: 402-414.

Brose, P.; Wade, D. 2001. Potential fire behavior in pine flatwood forests following three different fuel reduction techniques. Forest Ecology and Management. 5581: 1-14.

Cook, J.L. 1997. Homeowner protection efforts can and do work. Fire Management Notes. 57(3): 24-26.

Cortner, H.J.; Gardner, P.D.; Taylor, J.G. 1990. Fire hazards at the urban-wildland interface: what the public expects. Environmental Management. 14(1): 57-62.

Cortner, H.J.; Lorensen, T. 1997. Resources versus structures: fire suppression priorities in the wildland/urban interface. Wildfire. 6(5): 22-33.

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

Davis, L.S.; Cooper, R.W. 1963. How prescribed burning affects wildfire occurrence. Journal of Forestry. 61(12): 915-917.

Gardner, P.D.; Cortner, H.J.; Widaman, K. 1987. The risk perception and policy response toward wildland fire hazards by urban home owners. Landscape and Urban Planning. 14: 163-172.

Irwin, R.L. 1987. Local planning considerations for the wildland-structural intermix in the year 2000. In: Symposium on wildland fire 2000. Gen. Tech. Rep. PSW-101. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest Experiment Station: 38-46.

Jacobson, S.J.; Monroe, M.C.; Marynowski, S. 2001. Fire at the wildland interface: the influence of experience and mass media on public knowledge, attitudes, and behavioral intentions. Wildlife Society Bulletin. 29(3): 1-9.

Kalabokidis, K.D.; Omi, P.N. 1998. Reduction of fire hazard through thinning/residue disposal in the urban interface. International Journal of Wildland Fire. 8(1): 29-35.

Long, A.J. 1999. Prescribed burning regulations in Florida. FOR 67. Gainesville, FL: University of Florida, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, School of Forest Resources and Conservation. 4 p.

Main, M.B.; Tanner, G.W. 1999. Effects of fire on Florida's wildlife and wildlife habitat. WEC 137. Gainesville, FL: University of Florida, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, School of Forest Resources and Conservation. 4 p.

Marynowski, S.; Jacobson, S. 1999. Ecosystem management education for public lands. Wildlife Society Bulletin. 27(1): 134-145.

Mercer, D.E.; Pye, J.M.; Prestemon, J.P. [and others]. 2000. Economic effects of catastrophic wildfires: assessing the effectiveness of fuel reduction programs for reducing the economic impacts of catastrophic forest fire events. 68 p. Final report. [Topic 8 of the Research Grant "Ecological and economic consequences of the 1998 Florida fires," funded by the Joint Fire Science Program]. http://www.rtp.srs.fs.fed.us/econ/pubs/misc/fl-fire-report2000-lores.pdf. [Date accessed: February 15, 2002].

Miles, B. 1988. Overview of the fire problem in Texas. Wildfire strikes home in Texas: the report of the Governor's conference on rural/suburban fire protection. [Place of publication unknown]: [Publisher unknown]. 17 p.

Monroe, M.C. 1999. Where there's fire, there's smoke: air quality and prescribed burning in Florida. FOR 62. Gainesville, FL: University of Florida, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, School of Forest Resources and Conservation. 4 p.

Monroe, M.C.; Babb, G.; Heuberger, K.A. 1999a. Designing a prescribed fire demonstration area. FOR 64. Gainesville, FL: University of Florida, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, School of Forest Resources and Conservation. 4 p.

Monroe, M.C.; Jacobson, S.; Marynowski, S. 1999b. Audience needs assessment: awareness and attitudes about fire in Florida. Gainesville, FL: University of Florida. 17 p. http://www.sfrc.ufl.edu/Extension/needsurv.htm. [Date accessed: February 15, 2002].

Monroe, M.C.; Bowers, A.W.; Hermansen, L.A. [In press]. The moving edge: perspectives about southern interface. Gen. Tech. Rep. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.

Monroe, M.C.; Marynowski, S. 1999. Developing land in Florida with fire in mind: recommendations for designers, developers, and decision makers. FOR 63. Gainesville, FL: University of Florida, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, School of Forest Resources and Conservation. 4 p.

Myers, R.L.; Ewel, J.J. 1990. Ecosystems of Florida. Orlando, FL: University of Central Florida Press. 764 p.

Pumphrey, L. 1993. Wildfire lessons learned: include fire protection in growth planning. Wildlife News and Notes. 7(2): 10-11.

Pyne, S.J.; Andrews, P.L.; Laven, R.D. 1996. Introduction to wildland fire. 2d ed. New York: John Wiley. 769 p.

Rice, C.L.; Davis, J.B. 1991. Land-use planning may reduce fire damage in the urban-wildland intermix. Gen. Tech. Rep. PSW-127. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 13 p.

Smith, B.B. 1987. The wildland residential fire problem: a fire engineer's perspective. In: Symposium and workshop on protecting people and homes from wildfire in the interior West. [Place of publication unknown]: [Publisher unknown]. 105-111.

Taylor, J.T.; Daniel, T.C. 1984. Prescribed fire: public education and perception. Journal of Forestry. 82(6): 361-365.

U.S. Environmental Protection Agency. 1998. Interim air quality policy on wildland and prescribed fires. 43 p. http://www.epa.gov/ttn/oarpg/t1/memoranda/firefnl.pdf. [Date accessed: February 15, 2002].

U.S. Department of Agriculture, Forest Service. 1997. Arizona's wildland-urban interface: national forest fuels reduction treatment proposals. [Albuquerque, NM]: U.S. Department of Agriculture, Forest Service, Southwestern Region. 9 p.

Wade, D.D.; Brenner, J. 1995. Florida's solution to liability issues. In: Fire issues in urban and wildland ecosystems: the Biswell symposium. Gen. Tech. Rep. PSW-GTR-158. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 131-137.

Wade, D.D.; Brock, B.L.; Brose, P.H. [and others]. 2000. Fire in eastern ecosystems. In: Brown, J.K.; Smith, J.K., eds. Wildland fire in ecosystems: effects of fire on flora. Gen. Tech. Rep. RMRS-GTR-42. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station: 53-96. Vol. 2.

Wade, D. 1993. Societal influences on prescribed burning. In: Hermann, S.M., ed. The longleaf pine ecosystem: ecology, restoration, and management: Proceedings of the 18th Tall Timbers fire ecology conference. Tallahassee, FL: Tall Timbers Research Station: 351-355.

Winter, G.; Fried, J.S. 2000. Homeowner perspectives on fire hazard, responsibility, and management strategies at the wildland-urban interface. Society and Natural Resources. 13: 33-49.