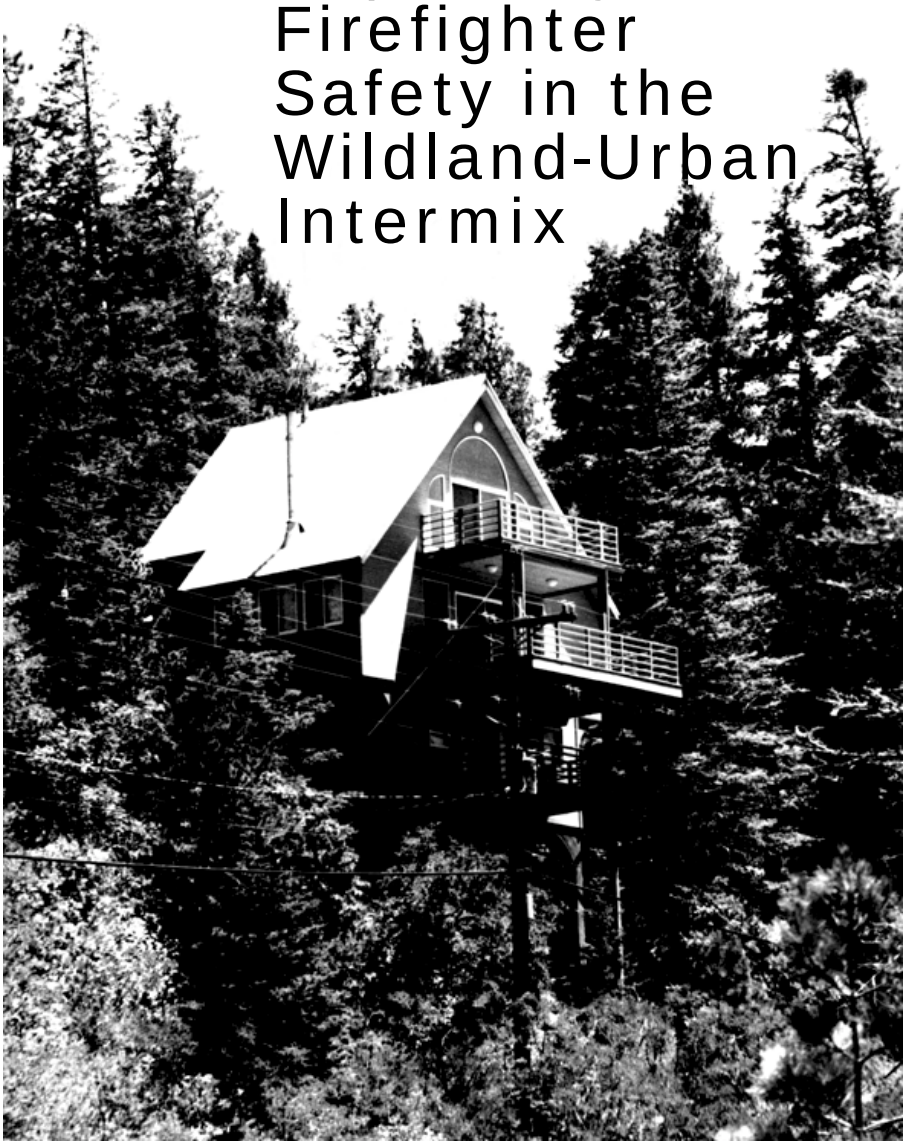
United States
Department of
Agriculture

**Forest Service**

**Technology &
Development
Program**

5100 Fire
February 2000
0051-2811-MTDC

# Improving Firefighter Safety in the Wildland-Urban Intermix



**Richard J. Mangan**
*Program Leader*

**USDA Forest Service
Technology and Development Program
Missoula, Montana**

**TE02P16—Tech Services–Fire Aviation Management**

**February 2000**

# Table of Contents


**Introduction** ____ 3

**Defining the Players** ____ 4

- **The Community** ____ 4
- **The Homeowner** ____ 4
- **The Fire Agency** ____ 5
- **The Firefighter** ____ 7

**During the Fire** ____ 9

- **Access** ____ 9
- **Civilian Population** ____ 9
- **Special Hazards** ____ 9

**Mix of Forces** ____ 11

**Command and Control** ____ 11

**Protective Clothing and Equipment** ____ 12

**Conclusions** ____ 13

**References** ____ 14

# Introduction

Each year, the incursion of private residences in wildland increases the chance that wildland and structural firefighters will battle an uncontrolled fire in the "wildland-urban intermix," where homes and naturally occurring vegetation are the fuels at risk. Although much of the general population believes that wildland-urban intermix fires are unique to Southern California, they exist across the United States, and are threatening to destroy valuable natural resources and structures at an ever-increasing rate. The past several years have seen these intermix fires (Figure 1) occur from Florida to Alaska, from Long Island to Montana, and from Maine to Southern California. While the natural fuel types of these fires may differ based on geographic and climatic conditions across the country, one factor remains constant: the risks to firefighters battling these fires. Since 1990, numerous firefighters (both wildland and structural) have been entrapped, burned, and sometimes killed while suppressing fires in the intermix.

With lands in the wildland-urban intermix continuing to increase, it is time to clearly define all the groups involved in these areas, and to identify the factors that must be addressed to ensure firefighter safety when the inevitable wildland-urban intermix fires do occur.

Figure 1—A firefighter removes hose while fighting a wildland-urban intermix fire in San Diego County (Los Angeles Times Syndicate Photo, Don Barletti).

# Defining the Players

Four distinct groups are key players in the wildland-urban intermix. Their relationship to firefighter safety—before an ignition and once a fire is burning—is critical. These groups include the community, the individual homeowners, the fire agency, and the individual firefighters (Figure 2).


Figure 2—A variety of factors influence firefighter safety.

## The Community

For this paper, the "community" is defined as the level of government (town, village, county, State) that is responsible for the laws, regulations, statutes, and ordinances that control development, planning, and law enforcement in areas defined as intermix.

Perhaps the most important function the community can play to ensure firefighter safety is through planning. By requiring developers and builders to adhere to strict standards for building materials, clearing limits, and fire-resistant plant species for landscaping, the community can help ensure that firefighters have a reasonable chance to safely fight a fire (Figure 3).

Other important roles for the community include enforcing existing ordinances for vegetation, conducting fire prevention inspections on a timely basis, and enforcing the approved standards for fire-safe building construction practices.

Access is a critical component of suppressing any fire, and becomes even more critical in wildland-urban intermix fires. Road width, traffic flow, curve radius, and bridge weight limits all impact the timeliness and ability of fire apparatus to reach a fire, or to gain access to protect a structure. Careful consideration of design criteria to match roads with access and egress needs of the civilian population as well as the needs of fire equipment are essential during the early stages of an area's development.

Once residences are in place, the community is responsible for developing fully integrated evacuation plans for the civilian population should a fire occur, and for coordinating the efforts of fire control and law enforcement to ensure that both are able to achieve their objectives in a timely manner.

## The Homeowner

Although many of the factors that help ensure firefighter safety are responsibilities of the community, the homeowner who chooses to live in the intermix has an important role. Before a home is built, the choice of the construction design and building materials can significantly affect a residence's fire safety, even when the residence is constructed in accordance with appropriate community guidelines and ordinances. Once the structure is constructed, maintaining the defensible space, reducing naturally occurring hazards, and preventing unwanted fires are all responsibilities of the homeowner (Figure 4).

Even though these steps and the actions of the community should greatly reduce the risk of wildfire threat to homeowners in the intermix, homeowners have one additional responsibility: planning for evacuation in times of extreme fire behavior. Homeowners must maintain accountability for all family members, remove important papers and family heirlooms, evacuate pets and livestock, and know the best transportation routes away from the fire. All these aspects of

Figure 3—Planning is the first step to making a home site in the wildland-urban intermix safe from wildland fire.

Figure 4—Defensible space around a home helps ensure firefighter safety.

evacuation must be planned by the homeowner long before the threat of fire. Failure to do so will delay evacuation, and may threaten the safety of firefighters trying to access the area to suppress the fire, protect property, or save the lives of entrapped residents.

## The Fire Agency

The overall responsibility for ensuring the safety of firefighters lies with the fire agency having jurisdiction for the area. Once a fire ignition occurs, it is too late to take the steps that are essential to ensure a safe and efficient fire suppression operation. Each fire agency must address several key areas as part of its preplanning effort for fires in the wildland-urban intermix.

First, the training and qualifications of firefighters and fire officers must be focused for the wildland fire suppression job. These skills are often significantly different than those required in the structural fire arena. Failure to address those differences can result in close calls, injuries, and even fatalities because threats are not recognized. Fire agencies can address these requirements by referring to both ICS 310-1 (Incident Command System Wildland Fire Qualification Subsystem Guide) and NFPA 1051 (National Fire Protection Association Standard for Wildland Fire Fighter Professional Qualifications). Recognition of the effects of the weather, terrain, and fuels on fire behavior and the effectiveness of suppression activities is especially critical in the wildfire environment. Also, chief officers in traditional structural fire agencies often are not trained in wildland operations to the level that a wildland firefighting division supervisor might be: assigning individuals in critical positions who were not qualified or experienced in wildfire has resulted in firefighter burnovers and entrapments (Figure 5).

The equipment selected by the fire agency for the wildfire component of their fire protection responsibility is also an important factor in firefighter safety. Engines and other apparatus that cannot maneuver on narrow, curving roads, or that exceed the load limits on bridges can put firefighters at risk in fast-moving wildfires (Figure 6). Close coordination by the fire agency with the community to adapt the transportation system and new equipment to meet the existing and planned conditions is important in ensure that firefighters can safely perform on an intermix fire.

Communications have always been identified as a critical component in firefighter safety. The *18 Situations That Shout Watch Out, 10 Standard Fire Orders, Downhill Line Construction Guidelines and L.C.E.S. (Lookouts, Communications, Escape Routes and Safety Zones)* all include communications as a cornerstone. In the wildland-urban intermix environment, the capability of a communications system to function across jurisdictional boundaries is even more critical. These fires nearly always involve numerous fire agencies, often operating under a unified command structure. Agencies must provide their firefighters with communications systems capable of functioning in these environments. Failure to do so threatens firefighters' safety and limits their ability to perform

Figure 5—Wildland firefighting has specific requirements for training and equipment.

Figure 6—The size and weight of firefighting apparatus can present problems for firefighters in the wildland-urban intermix.

Fire shelters may be the most critical piece of PPE for firefighter safety in the wildland-urban intermix. Although the fire shelter is intended as a tool of last resort, it has saved the lives of hundreds of firefighters in both the wildland and wildland-urban intermix environments. Fire agencies must provide all firefighters who may be working in the wildland-urban intermix with both the fire shelter and the training needed to use it as intended.

Physical fitness, the physical ability to do the job at hand, is another key area where fire agencies can have a positive influence on firefighter safety (Figure 8). Management support for individual firefighter fitness will help reduce heat stress injuries and heart attacks, while

effectively. Communications failures or overload have been identified as a serious problem on both the Oakland Hills Fire and the Spokane, Washington, Fire Storm Fires in 1991, and as a causal factor of the 1993 Glenallen Fire fatalities in Los Angeles County.

Personal protective equipment affects the firefighter in several ways in the wildland-urban intermix. The necessary level of protection from radiant heat must be balanced against the risk of heat stress from too many layers of protective clothing. While most agencies are feeling the pressure of reduced budgets, it is essential that firefighters be supplied with the proper protective clothing and equipment. *NFPA 1977 Standard on Protective Clothing and Equipment for Wildland Fire Fighting*, (Figure 7) specifies the performance and design requirements for wildland fire Personal Protective Equipment (PPE). Wildland fire PPE generally is not interchangeable with the PPE needed for structural fire suppression. High temperatures, low humidity, and high levels of physical activity are extremely demanding on firefighters. Their protective clothing and equipment should not increase the heat stress. Australian studies on "Project Aquarius" emphasize that wildland PPE should be designed "to let the heat out, not keep the heat out."

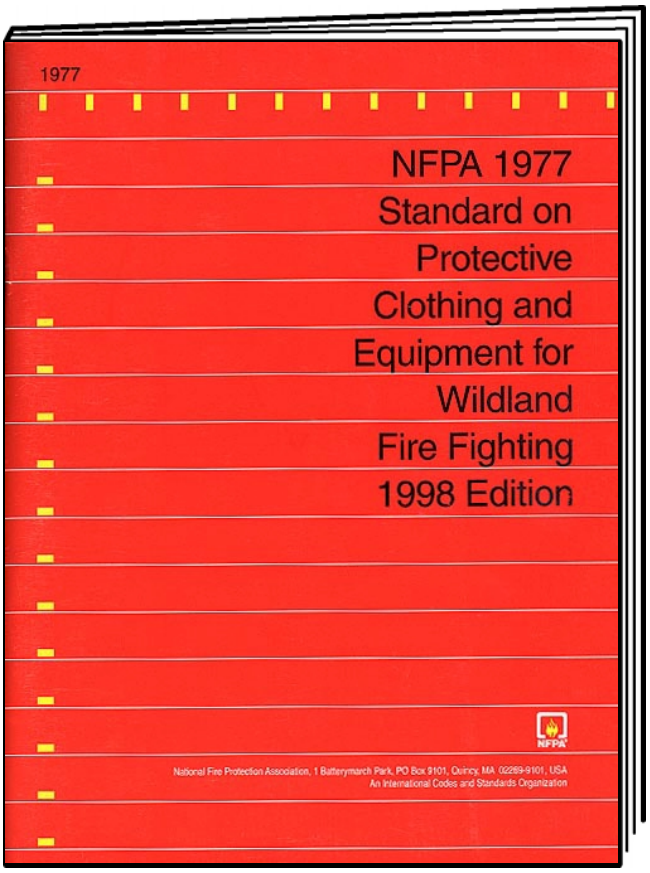



Figure 7—National Fire Protection Association Standard 1977 sets the requirements for wildland fire personal protective equipment.

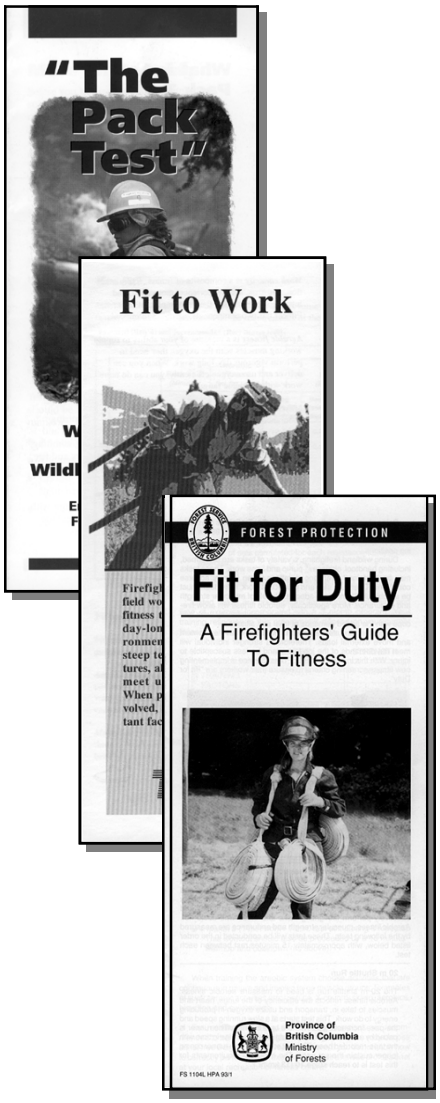



Figure 8—Physical fitness is essential to safe operations on all wildfires.

increasing firefighters' ability to move quickly along escape routes to safety zones. Heart attacks were among the leading causes of firefighter fatalities on both wildfires and structural fires during the 1990's.

The last area where the fire agency has a major role in firefighter safety is in developing policies and standard operating procedures (SOP's) specific to the wildland-urban intermix fire operations. Because these intermix fires may not be a daily occurrence for some fire agencies, it is essential that their firefighters have clear direction when these events do occur. Specific items included in these policies and SOP's must include chain of command, communications practices and frequencies (including interagency coordination), suppression priorities, and safety practices. A critical question that must be addressed in training deals with the best place to survive a burnover or entrapment: in an engine cab or in a fire shelter. Firefighters were forced to make split-second decisions to deploy fire shelters or remain with their engines during several entrapments in Southern California during 1993 and 1996. Those choices should be well explained in department policy, and reinforced through training, long before firefighters have to make such a decision.

## The Firefighter

Although firefighters are the last of the four groups discussed, they are the most critical players in affecting their own safety on wildland-urban intermix fires. Shakespeare said: "To thine own self be true." This is especially applicable to the individual firefighter. Although many of the actions of the community, homeowner, and fire agency can help ensure firefighters' safety, firefighters as individuals, or as members of a team, are ultimately responsible for their own safety.

**Fitness**—Whether or not a fire agency has fitness requirements or sponsors a voluntary fitness program, firefighters have the responsibility to ensure that they are physically fit for the job. A review of wildland fire fatalities from 1990 to 1998 shows that 28 fatalities, or 21% of the total, were due to heart attacks (Figure 9). Firefighters must be in good condition to successfully function on long, hot shifts exceeding 12 hours for several days in a row, especially if they then have to move quickly along an escape route to reach a safety zone. Failure to move quickly in such a situation may endanger not only the firefighter, but fellow firefighters as well.

**Training**—Firefighters involved in structural and wildland fire suppression

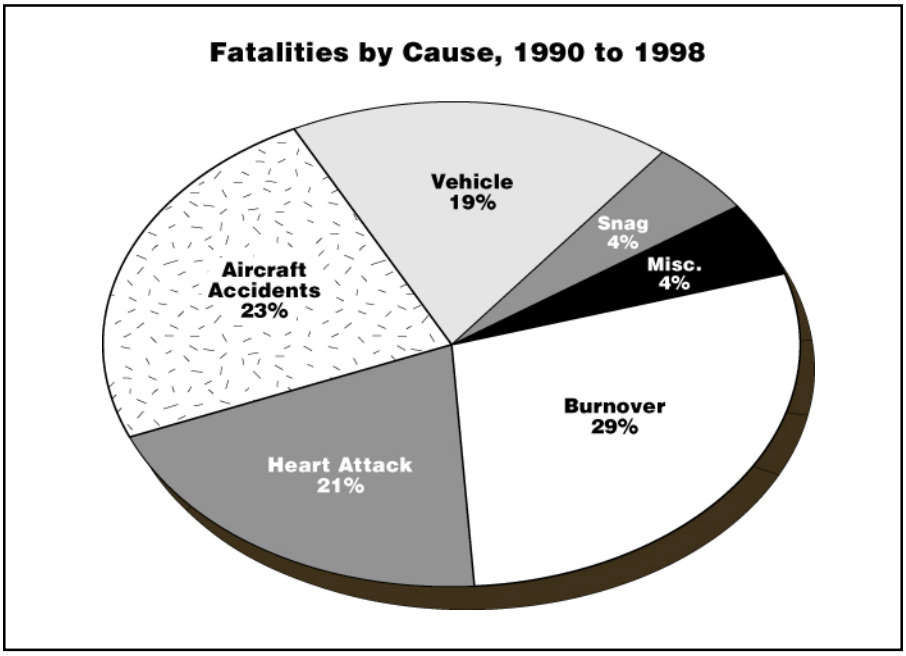



Figure 9—Heart attacks are a leading cause of death for wildland firefighters.

must be trained in both areas of fire suppression. If they lack that training, or are uncomfortable with its adequacy, individual firefighters must address that concern with their supervisor. Failure to understand the fundamentals of topography, strategies, tactics, behavior, or weather has been recognized as a causal factor leading to several burnovers that resulted in serious injuries or death. Numerous avenues are available for firefighters to increase their knowledge of wildland fire. Failure to learn about wildfires could cost firefighters their lives.

**The Human Factor**—The best training is wasted if the individual involved in a wildland-urban intermix fire is unable to apply that training and respond appropriately. Situational awareness—knowing what is happening around you—is important for firefighters in the intermix if they are to safely and efficiently perform their job. A number of guidelines (*10 Standard Fire Orders, 18 Situations that Shout Watch Out, LCES*, etc.) can help, but they all require firefighters to recognize and respond to the situation in an approved manner to ensure their own safety.

All firefighters, regardless of their position in the fire organization, must do all they can to foster communications with other individuals above and below them. The constant, open channel of communications established in ordinary circumstances will be especially important when conditions develop that are out of the ordinary, or that may become life threatening. Firefighter safety is enhanced when all members of a fire crew can offer observations or share concerns about developing situations (Figure 10).

**Personal Protective Equipment**—Wildfires expose the firefighter to a series of hazards different from those faced on structural fires. The PPE is unique to each job, but neither structural nor wildland PPE protects the firefighter if it is used improperly or, worse yet, if it is not used at all. Each firefighter has an individual responsibility to use the appropriate PPE on a wildland-urban intermix fire. Failure to do so may result in heat stress, burns, or death.

Figure 10—Maintaining constant communications is a cornerstone of fire safety.

# During the Fire

Up to this point, we have discussed firefighter safety before a wildland-urban intermix incident occurs. Once such a fire starts, a whole new group of factors comes into play (Figure 11).


Figure 11—During a fire a number of interacting factors affect firefighter safety.

## Access

Although access was discussed earlier as a responsibility of both the community and the fire agencies in the planning phase for wildland-intermix fires, access can quickly become a critical factor once a fire occurs. If the civilian population is attempting to leave an area on the same narrow, curving roads that firefighters are using to enter the area, the result can be traffic jams, unsafe driving practices, and, ultimately, gridlock for both the civilian vehicles and the fire apparatus. When this occurs during active fire behavior, firefighters may become trapped in dangerous locations, as they were on the Calabasas Incident in Los Angeles County during the 1996 fire season. On that incident, firefighters trying to cross a midslope road were prevented from leaving a "chimney" by a civilian vehicle attempting to leave the area. When the fire made a strong uphill run through the chimney, the firefighters were burned over. To mitigate the risks posed by access problems during wildland-urban intermix fires, close coordination between the fire commanders, dispatch centers, and law enforcement agencies is essential. Traffic control, specialized road signing, and road closures will help ensure that fire personnel can safely enter a fire area and can reduce the hazards inherent with two-way traffic in an emergency environment. Local knowledge of the road systems is also an essential factor in avoiding dangerous situations. Local firefighters may need to be assigned with firefighters from other areas to help them move throughout the fire area.

## Civilian Population

Despite all the public service announcements about fire safety, onsite inspections, and good intentions by homeowners, it is likely that the majority of the residents threatened by a wildland-urban intermix fire will be grossly unprepared for evacuation. Some may be unwilling to leave their property. Their chaotic exodus, or their refusal to leave, may pose a serious risk to firefighter safety. Fire agencies must coordinate with the other local agencies responsible for enforcing mandatory evacuation orders in areas where there is a high likelihood of fire activity.

## Special Hazards

Firefighters entering the wildland-urban intermix area for fire suppression activities face a variety of hazards that differ from the typical hazards in either wildfires or structural fires. Although intermix fires may appear to be simply wildfires that threaten to burn residences, such fires represent unique, high-risk hazards that require special attention to prevent injury or death.

### Powerlines

Overhead powerlines, found throughout wildland-urban intermix areas, pose several threats to firefighters. The risk of electrocution from downed lines is the most obvious (Figure 12). Electrocution caused the only death of a firefighter during the 1991 Oakland Hills Fire. A more insidious risk comes from electrical current transferred through smoke, a risk that may not be as obvious as a downed wire, but can be just as deadly.

Figure 12—Power lines can be a safety hazard in the wildland-urban intermix.

## Propane Tanks

Propane tanks and natural gas lines are found in many areas of the intermix, and can become an explosive hazard when they are burned over, or when they are damaged by equipment used in the suppression effort. Natural gas lines should be identified on preattack hazard maps. Dispatch centers must alert firefighters entering intermix areas to such hazards. If natural gas lines are believed to be in an intermix fire area, the gas distributor should be requested to shut down service to the area affected. Propane storage tanks at residences can't be mapped as easily, so firefighters must be on the lookout for them, especially in areas of heavy smoke.

## Abandoned Vehicles

Vehicles abandoned during evacuation may catch fire, posing a hazard from the increased fire intensity when gas tanks rupture or melt, and from the toxic smoke they generate. While the risk of explosion from a vehicle fire is minimal, the hazards identified are such that firefighters attempting to suppress a vehicle fire must be properly trained and equipped, and should have training in the use of an SCBA (self-contained breathing apparatus).

## Hazardous Materials

Hazardous materials, such as farm chemicals, are commonly found in many intermix areas. When they burn, hazardous materials are often highly toxic. Fires in barns and storage sheds should not be approached without appropriate respiratory protection. Explosives, such as dynamite or gunpowder, are often found in intermix areas. Any indication of explosives should be viewed as an extreme risk, and firefighters should not be nearby unless they are specially trained and equipped.

# Mix of Forces

Nearly every wildland-urban intermix fire results in responses from a number of fire agencies, both wildland and structural. Unless properly coordinated, the mix of forces that responds to a fire can be a risk to firefighter safety. The variety of equipment (Figure 13), differing levels of training and experience, and the integration of hand crews, mechanized equipment, and air operations all offer opportunities for a breakdown in safe work practices. In that environment, firefighters and fire officers must be especially alert to the coordination required in using this mix of forces, and must follow their own agency's safe practices and procedures despite differences with the practices and procedures used by cooperators.

Figure 13—Selecting proper equipment is a key to safe operations.

# Command and Control

The command and control structure on intermix fires is often complicated. Factors that can cause confusion and conflicts and increase risks to firefighter safety include: multiple jurisdictions, unified command, structural versus wildfire training and experience, lack of coordination with law enforcement agencies, and the sense of urgency that finds multiple dissimilar resources assigned to a common protection objective. Close and timely coordination of responsible agencies is essential as soon as intermix fires occur. Although much of the needed coordination can take place during the off season, the critical interchange of information and agreements on operating procedures must occur on the fire ground between the designated fire officers from each involved agency. Especially sensitive areas include areas of responsibility, communications links between resources, coordination of air resources, clear definition of boundaries such as division breaks, and emergency medical evacuation procedures.

# Protective Clothing and Equipment

When all else fails, the "fall-back position" for individual firefighters is the proper use of their personal protective clothing and equipment. Fires in the intermix may require that some firefighters are dressed in wildland PPE while others wear structural PPE. The rapidly changing fire conditions often require that firefighters switch from a wildfire mode into structural protection, and then back again. It is critical that firefighters and fire officers have the "situational awareness" that allows them to don the appropriate PPE (Figure 14) for their immediate situation. Failure do so can, and has, caused firefighter injuries and fatalities. All firefighters entering the wildland-urban intermix zone must be equipped and trained in the proper use of the fire shelter. The shelter's use (or the failure to use it) has been a factor in fire-fighter survival on intermix fires from California to Alaska over the past decade.

Failure to adequately plan and execute the steps necessary to ensure firefighter safety in the wildland-urban intermix has resulted in close calls, injuries, and even fatalities across the United States:

- On the Dude Fire (1990) in Arizona, six firefighters died when extreme fire behavior, terrain, and poor command and control resulted in a burnover (Figure 15).

- On the California Fire (1990), two firefighters died when they were unable to reach the fire shelters inside their backpacks when the fire spread increased rapidly.

- On the Wasatch Fire (1990) in Utah, two firefighters died while trying to cut dozer line along a fire threatening a subdivision. Communication was difficult because of the amount of the radio traffic on the operating frequency. Only one of the firefighters had protective clothing or a fire shelter.

- On the Sunrise Fire (1995) on Long Island, New York, where numerous firefighters in full structural turnout gear experienced heat stress injuries while attempting to fight a fast-moving intermix fire on a hot August day.


Figure 14—Protective clothing must be appropriate for the fire, and must be used as intended.

Figure 15—Fatalities have occurred on fires in the wildland-urban intermix across the United States.

# Conclusions

Fires in the wildland-urban intermix (Figure 16) will occur more and more frequently, in all areas of the United States. Injuries and fatalities to firefighters must be reduced or eliminated on these fires in the years ahead. Coordinated efforts between the community, homeowners, fire agencies, and firefighters before the fire occurs are essential to ensure firefighter safety. These measures must be reinforced by safety-conscious performance by both firefighters and fire officers once fires are being fought in the wildland-urban intermix.

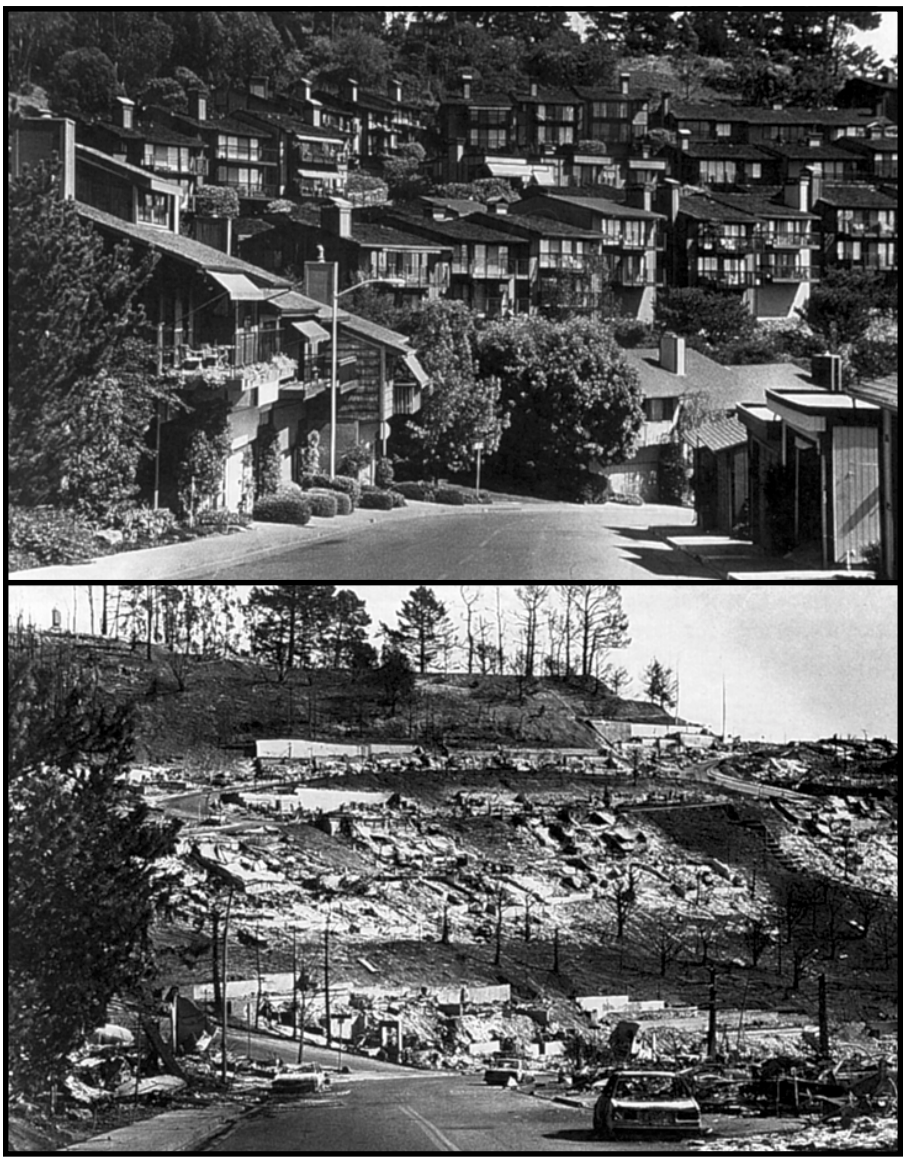


Figure 16—The results of the 1991 East Bay Firestorm in Oakland, CA. Photos used with permission of the *Oakland Tribune.* Before: Robert Warwick, After: Michael Macor.

# References

Baden, Bill; Swinford, Robert; Erb, Roger; Bethea, John. 1990. Fire fighter safety in wildland/urban interface fires. PMS 417-1. Boise, ID: National Wildfire Coordinating Group. 24 p.

Butler, Bret W.; Bartlette, Roberta A.; Bradshaw, Larry S.; Cohen, Jack D.; Andrews, Patricia L.; Putnam, Ted; Mangan, Richard J. 1998. Fire behavior associated with the 1994 South Canyon Fire on Storm King Mountain, Colorado. Res. Pap. RMRS-RP-9. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 82 p.

Hawkins, John R. 1996. Save the structure, but don't get killed. Fire Chief. June: 43-50.

International Fire Code Institute. 1997. 1997 Urban-wildand interface code: first edition. Whittier, CA: International Fire Code Institute. 49 p.

Mangan Richard. 1999. Wildland fire fatalities in the United States: 1990 to 1998. Tech. Rep. 9951-2808-MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 14 p.

National Fire Protection Association. 1995. NFPA 1051 standard for wildland fire fighter professional qualifications: 1995 edition. Quincy, MA: National Fire Protection Association. 22 p.

National Fire Protection Association. 1998. NFPA 1977 standard on protective clothing and equipment for wildland fire fighting: 1998 edition. Quincy, MA: National Fire Protection Association. 70 p.

National Wildland/Urban Interface Fire Protection Program. 1997. National Wildland/Urban Interface Fire Protection Program. 16 p.

North Idaho Fire Prevention Cooperatives. 1990. Wildfire and the suburban home: a formula for disaster! Bonners Ferry, ID: The North Idaho Fire Prevention Cooperatives of Boundary, Bonner, Kootenai, Shoshone, and Benewah Counties. 23 p.

Plevel, Steve Randolph. 1996. Factors affecting local government adoption of wildland-urban interface fire policies. Tucson, AZ: University of Arizona. 73 p. Thesis.

Sharkey, Brian. 1997. Fitness and work capacity, second edition. Tech. Rep. 9751-2814-MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 78 p.

Western Fire Chiefs Association. 1991. Development strategies in the wildland/urban interface. Billings, MT: International Association of Fire Chiefs and Western Fire Chiefs Association. 213 p.

***Notes:***

***Notes:***

## About the Author…

Dick Mangan has been Program Leader for Fire, Aviation, and Residues at MTDC since 1989. Before coming to the center, he spent more than 20 years working on Ranger Districts and National Forests in Oregon and Washington, participating in the full range of wildland fire activities. He serves on the National Wildfire Coordinating Group (NWCG) Fire Equipment and Safety and Health Working Teams and is chairperson of the National Fire Protection Association (NFPA) 1977 Technical Committee for Wildland Fire Personal Protective Clothing and Equipment. Dick remains active in the field, representing MTDC on fire entrapment investigations and serving as Operations Section Chief on a National Type 1 Overhead Team.

## Library Card

Mangan, Richard J. 2000. Improving firefighter safety in the wildland-urban intermix. Tech. Rep. 0051-2811-MTDC. Missoula, MT: U.S. Department of Agriculture, Forest Service, Missoula Technology and Development Center. 14 p.

Each year, the incursion of private residences into wildlands increases the potential for the devastating loss of important natural resources and private property from wildfire. Structural and wildland firefighters are working side-by-side in a setting that is not typical of their traditional workplaces. These wildland-urban intermix fires have proven to be a special risk to the safety of the firefighters battling them. In the 1990's alone, firefighters have been seriously injured or killed on intermix fires in Arizona, California, Utah, Kentucky, and other States. This report discusses key areas of concern for firefighter safety in the wildland-urban intermix: command and control, mix of forces, access, civilian population, personal protective clothing and equipment, and special hazards.

Keywords: Fire fighters, fire fighting, fire suppression, structural firefighting, wildland firefighting.

**Additional single copies of this document may be ordered from:**

USDA Forest Service
Missoula Technology and Development Center
Building 1, Fort Missoula
Missoula, MT 59804-7294
Phone: (406) 329-3978
Fax: (406) 329-3719
IBM: pubs/wo,mtdc
E-mail: pubs/wo_mtdc@fs.fed.us

**For additional technical information, contact Dick Mangan at the address above.**

Phone: (406) 329-3849
Fax: (406) 329-3719
IBM: dmangan/wo,mtdc
E-mail: dmangan/wo_mtdc@fs.fed.us

**An electronic copy of this document is available on the Forest Service's FSWeb Intranet at:**

http://fsweb.mtdc.wo.fs.fed.us

This manuscript was presented at the symposium on Fire in California Ecosystems: Integrating Ecology, Prevention, and Management, November 17-20, 1997, University of California, Davis.