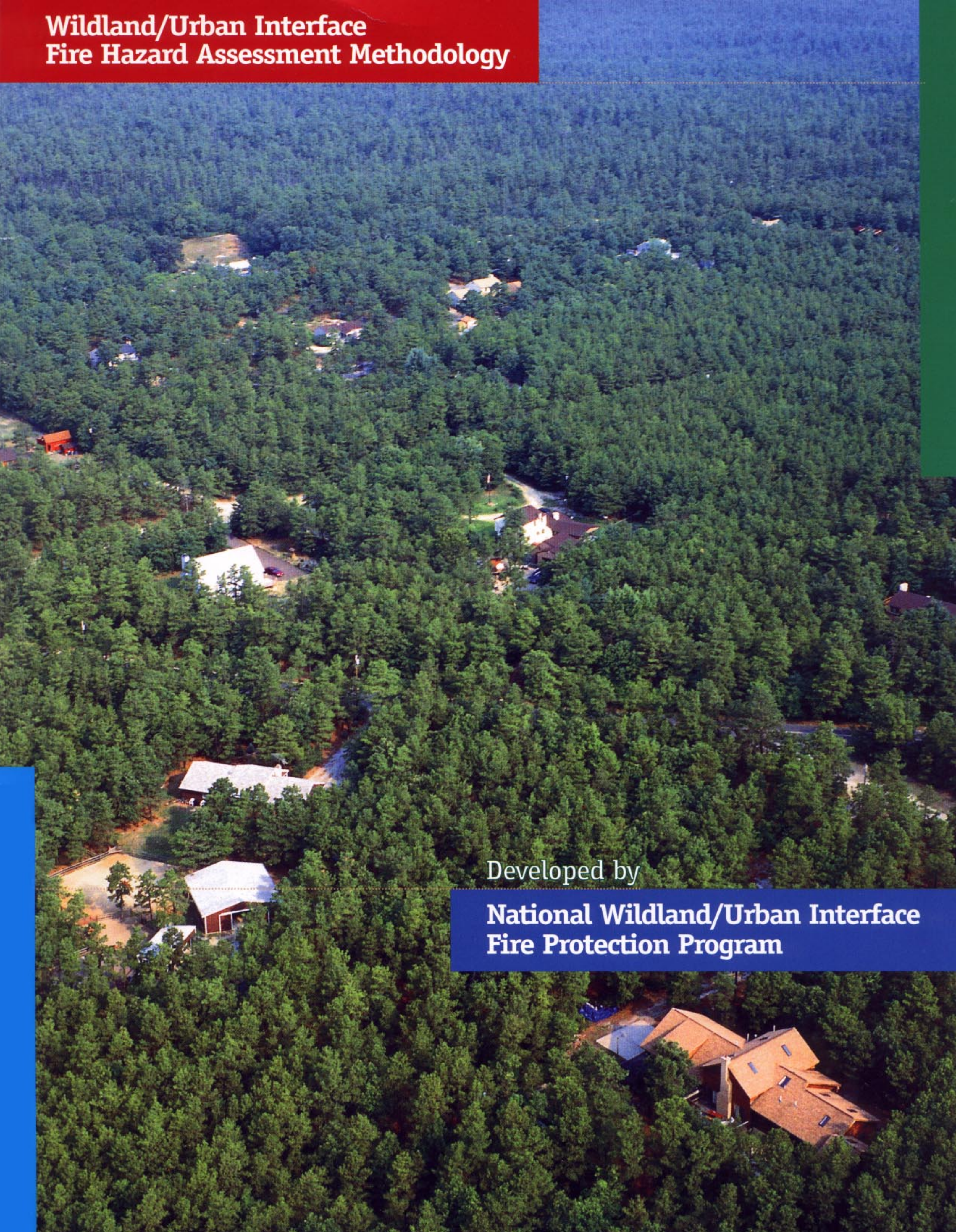
Wildland/Urban Interface Fire Hazard Assessment Methodology



Developed by

National Wildland/Urban Interface Fire Protection Program

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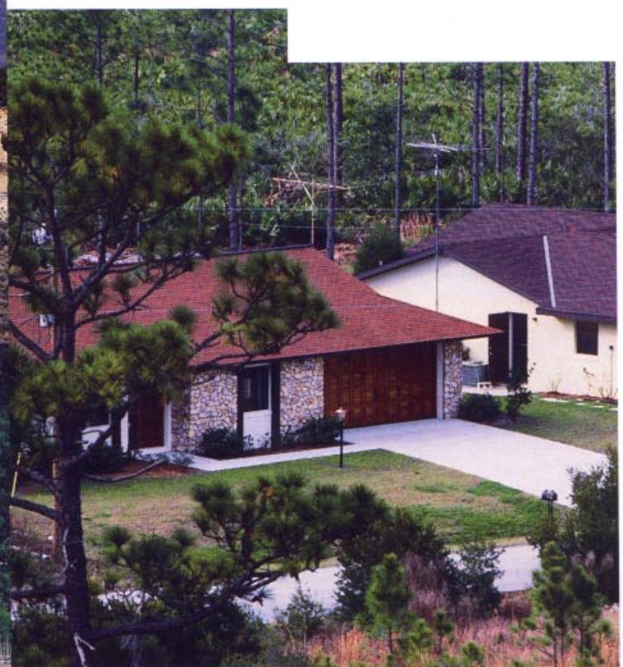
INTRODUCTION


Wildland/urban interface located in (clockwise from upper left): Nevada, Florida and Colorado

Throughout the United States it is more and more common to see homes and other types of structures being built in wildland environments. This trend is creating an expansion of wildland/urban interface areas where structures are located next to large amounts of vegetation. Because of their location, these structures are extremely vulnerable to fire should a forest or wildland fire occur in the surrounding area.

There are many actions that can be taken to reduce the potential of fire in existing housing developments as well as planned new developments. This guide will help users assess the potential of a structure located in a wildland environment to withstand an approaching forest fire *without the intervention of fire fighting personnel and equipment.* This document focuses exclusively on proactive, pre-fire preventative actions rather than reactive fire suppression plans.

This guide first provides a description and understanding of the three ignition sources of concern to a structure located in an wildland environment:

- radiation,
- convection and
- firebrands.

Next, it offers a five-step method for assessing the hazards of a wildland/urban interface area. Several potential hazards are discussed in depth. In addition, this guide provides suggestions for reducing the fire potential using the following approaches:

- building a structure or altering an existing structure to reduce its chance of ignition and,
- completing mitigation measures on the surrounding wildland area.

STRUCTURE IGNITION SOURCES

Structures exposed to wildland or forest fires can ignite by radiation, convection or firebrands. An explanation of each type of ignition source follows.

Radiation

Wildland fires can cause ignition by radiating heat to a structure. Radiation exposure depends on the intensity and the duration of the flame front.

The radiant heat exposure to a structure (and the chance of ignition) will increase under the following conditions:

- An increase in the size of the flames
- An increase in the structure surface area exposed to the flames
- An increase in the duration of the exposure
- A decrease in the distance between the flames and the structure

Convection

Ignition of a structure by convective heat transfer requires the flame to come in direct contact with the structure. Contact with the convection column also can cause ignition but the temperature of the column is generally not hot enough to ignite a structure.

When attempting to reduce the chance of ignition by convection, the duration of the exposure to the flame is more critical than the size of the flame. Thus, clearing to prevent flame contact with the structure must include any materials capable of producing even small flames (for example, cured grasses, low ground cover, leaves, pine needles and trash). Wind and steep slopes will tilt the flame and the convection column uphill increasing the chance of igniting a structure. Structures extending out over a slope have the greatest likelihood of ignition from convection.

Firebrands

Firebrands are pieces of burning materials that detach from a fire due to the strong convection drafts in the burning zone. Firebrands can be carried a long distance (one mile or more) by fire drafts and winds. Severe wildland/urban interface fires can produce heavy firebrand showers. The chance of these firebrands igniting a structure will depend on the size of the firebrand, how long it burns after contact, and the materials, design, and construction of the structure.

This fire generates radiative and convective heat. The radiative heat is generated horizontally to the adjacent trees. The convective heat rises vertically in the smoke plume.

• *Roof*

Roofs are less vulnerable to radiation and convection because of their slope but are more susceptible to ignition by firebrands. Roofs should be covered with nonflammable materials and should be inspected for gaps which could expose ignitable subroofing or roof supports. A major cause of home loss in wildland areas is flammable woodshake roofs.

• *Walls*

Walls are most susceptible to ignition by radiation and convection. The edges of flammable wall materials, such as trim materials on casings and facing, will ignite before flat surfaces. The walls should be constructed of fire resistant materials compatible with the surrounding fuels. Wall materials which resist heat and flames include cement, plaster, stucco and concrete masonry such as stone, brick or block. Though some materials will not burn, such as vinyl, they may lose their integrity when exposed to high temperature and fall away or melt, exposing interior materials.

• *Windows*

Exposure to heat can cause windows to fracture and collapse leaving an opening for flames or firebrands to enter and ignite the interior of a structure. Using glass products that can withstand the potential convective and radiant heat will reduce this risk. Tempered glass will withstand much higher temperatures than plate glass and should be used for large windows—particularly windows overlooking slopes or vegetation. Double pane glass is slightly more resistant to heat than single pane glass.

• *Eaves and Overhangs*

Eaves and overhanging features—room pushouts, bay windows, and extensions over slopes—are very vulnerable to convective exposures and have a design that can sustain ignition. Fuels should be eliminated from contact with eaves and overhangs. Eaves and overhangs should be boxed or enclosed with nonflammable materials to reduce the surface area and eliminate the edges that can trap firebrands.

• *Vents*

Vents are a necessary feature of a structure for preventing condensation and subsequent wood decay. However, openings should be screened to prevent firebrands from entering the structure. The screens should prevent passage of objects larger than 1/4 inch (6.0mm). Both vents and screens should be constructed of materials that will not burn or melt when exposed to heat or firebrands.

• *Attachments*

Attachments include any structures connected to the residence such as decks, porches and fences. When assessing the ignition potential of a structure, attachments are considered part of the structure. For example, if the ignition potential of the attachment is high, the ignition potential of the entire structure is considered high.

Vegetative Fuel Hazards

Vegetative fuels include living and dead vegetation materials. The amount of heat energy released during a wildland fire is defined by the amount, arrangement and rate of combustion of the vegetative fuels. Vegetative fuel flame lengths can exceed 100 feet and the radiated heat can ignite combustible materials from distances of 100 feet or more. Winds can carry live firebrands for several miles.

Fuels *within the immediate vicinity* can have a significant impact on the potential of a structure to ignite. The size of the "immediate vicinity" will vary depending on the vegetation and characteristics of the land. Fuels within the immediate vicinity of the structure should be fire resistant and maintained in fire resistant condition.

Fuels *beyond the immediate vicinity* are those that surround the structure but are not immediately adjacent to it. The concern with these fuels is primarily their ability to produce firebrands, which can indirectly cause ignition of the structure, and their ability to produce long flame lengths and intense radiant energy. Fuels beyond the immediate vicinity of the structure should consist of fire resistant ground cover and trees that are thinned and pruned to prevent ground fires from igniting the crowns, or tops of trees.

Miscellaneous Hazards

Structure Density

The density of structures is determined by lot size, structure arrangement and number of structures per lot. This density affects the overall exposure, spread and intensity of wildfires.

Slope

Slope is defined as the upward or downward incline or slant of the terrain. All other variables being equal, a fire traveling up a slope will move faster and have longer flames than a fire traveling on flat terrain—a fire on a 30 percent slope can produce flames twice the length and travel as much as one and one half times as fast, as a fire on flat ground.

$$\% \text{ slope} = \frac{\text{(Y) vertical distance (rise or fall)}}{\text{(X) horizontal distance}} \times 100$$

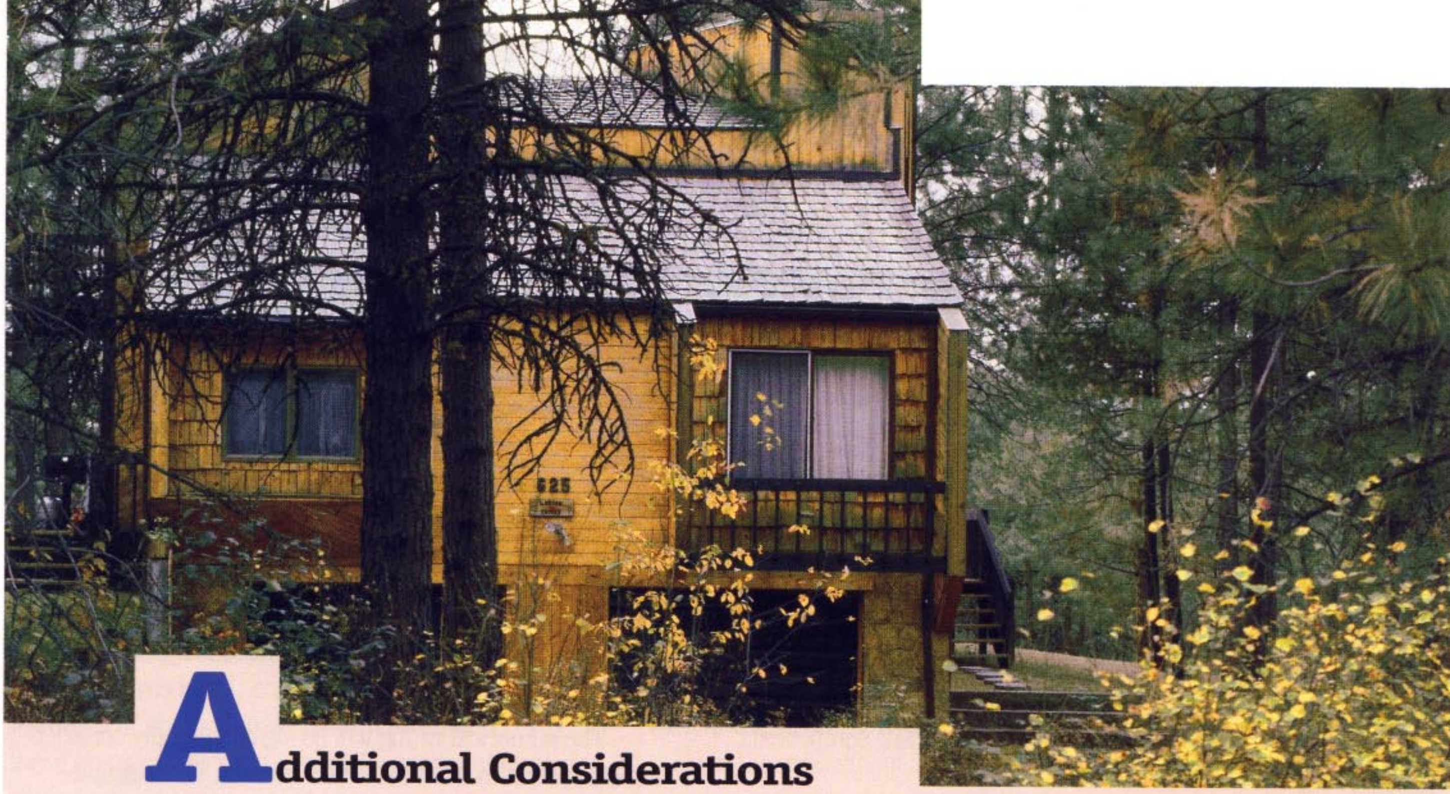
Weather

All aspects of weather can affect the fire assessment. Temperature, humidity and winds will affect the probability of ignition and the ability to control and extinguish the fire. Weather patterns such as long and short-term droughts need to be considered.

Fire Occurrence

The history of wildfires can provide a valuable dimension for the assessment. There will be an increase in the probability of a fire occurring in environments where they have occurred in the past. The severity and frequency of fires enable authorities to determine the resources required.

See Additional Considerations on page 9.



Additional Considerations

Additional considerations may need to be studied depending on the local situations. A list of additional hazards are given in Table 1.

Table 1 — Additional Considerations

Fire Suppression	Slope	Fuel	Weather	Environmental
Access/Egress	Aspect	Building Construction	Drought Factor/Index	Endangered Species
Bridges	Dangerous Terrain	Defensible Space	Historic Climatological Data	Endangered Plants
Building Construction	Position by Slope	Fuel Breaks	National Fire Danger Rating System	Environmental Impact
Density and Spacing	Percent Slope	Fuel Continuity		Visual Impact
Preattack Plan		Fuel Loading		
Resources		Fuel Type/Models		
Response Times				
Utilities				
Water Supply				

Step 3: Rank the Hazard Components

Develop or use an existing system to define the significance of each hazard component. The system, though subjective in nature, should be specific and consistent. Page 15 of this document references several hazard assessment systems that are currently being used by wildfire experts throughout the United States.

One system used by the Virginia Department of Forestry uses a system that ranks the *risk, hazards* and *values* at risk in each area of the assessment using a low (**L**), medium (**M**) and high (**H**) rating scale. The *risk* is defined as the likelihood of a wildfire ignition. The *hazards* included are fuels and topography. The *values* are the loss potentials should a wildfire occur. Each delineated area in the assessment will have three rankings. For example, a **LMH** ranking would designate the area as having a low potential for ignition; a medium level of hazards such as moderate slopes and/or moderate amounts of vegetation; and a high value such as a residential area. Areas with a **HHH** ranking would be the most severe fire risks receiving the most immediate attention. Areas with a **LLL** ranking would be the least fire risks and would be a lower priority.

Alternatively, the component may be assigned a numerical value to indicate its significance. For example, *NFPA 299 Standard for the Protection of Life and Property, 1997 Edition,* uses a numerical rating system to define the relative contributions of several components. A summary of the NFPA 299 system is given in Table 2. To obtain an overall rating for the interface, the NFPA 299 system requires simply adding the points from the individual components.

Table 2 **NFPA 299 Wildfire Hazard Severity Checklist**

Component (Number of items)	Criteria	Points per item
Subdivision Design (6)	Road widths, dead ends, lot sizes, street signs	1 - 5
Vegetation (2)	Fuel models, defensible space	1 - 10
Topography (1)	Slope	1 - 10
Additional Factors (3)	Topography, weather conditions	2 - 4
Roofing Material (1)	Materials used for roofing	1 - 10
Building Construction (1)	Materials used for siding, decks	1 - 10
Fire Protection (2)	Water sources and supply	1 - 10
Utilities–Gas and Electric (1)	Utility placement	1 - 5

Table 3 **Virginia Department of Forestry Component Rating System**

Component	Criteria	Points
Fuel	Low hazard fuels	1
	Medium hazard fuels	2 - 3
	High hazard fuels	4 - 5
Slope	Mild (0-5%)	1
	Moderate (6-15%)	2
	Steep (16-25%)	3
	Extreme (greater than 25%)	4
Structure	Roof and siding material	1 - 10
Safety Zone	Percentage of homes with defensible space	3 - 10
Emergency Access	Road width, dead ends, turnaround and bridges	2 - 3
Other Factors	Marked addresses, street signage, water sources, power lines and special circumstances	1 - 5

Figure 1

_______ (Fuel Hazard Rating
x _______ Slope Hazard Rating)

= _______
+ _______ Structure Hazard Rating
+ _______ Safety Zone Rating
+ _______ Emergency Access Rating
+ _______ Other Factors Rating

= _______ **Fire Hazard Rating**

Similarly, another Virginia Department of Forestry system assigns numerical values to each component as defined in Table 3 (*Everyone's Responsibility: Fire Protection in the Wildland/Urban Interface*). The Virginia system uses the formula as shown in Figure 1 to determine an overall interface hazard rating.

The numerical rating will be significant only considering the system from which it was derived. For example, under NFPA 299, 69 to 83 points indicates a high hazard property. In contrast, a high hazard property in the Virginia rating system is defined as 40 to 60 points.

Step 4: Compile the Hazard Rankings in a Useable Format

Compile the component hazard rankings in a format that will reveal the relationships between the individual hazards and categories of hazards. Three methods are often used to analyze the data collected.

1. A geographic information system (GIS) can define the hazards components on a map of the assessment area. Displaying each hazard on clear overlays, rather than on a single map, allows you to study various combinations of data.

2. A grid index system references specific points of interest on a map. The coordinates of the grid define the hazard rating of a specific property or area.

3. A matrix system describes the severity of each hazard for each area within the assessment.

Any or all of these data analysis methods can be used to understand the relationships between the various hazard components and can also help to develop an overall hazard ranking of each area within the assessment. On pages 11 and 12 examples of each of these data analysis methods are given.

Methods for Analyzing Hazard Ranking Data

Geographic Information System (GIS)

Consider either manual or computer graphic techniques to illustrate hazards according to their location on a map. This technique can show the frequency of particular hazards to a specific geographic area—identifying problem areas. Called "pattern recognition maps," these maps can be used to visually analyze the relationship of hazard components to land use, fire management, economic development and so forth.

Figures 2, 3, and 4 demonstrate this technique by defining the roof material of the structures; the vegetation density; and the percent slope in each area of the assessment. From the maps, it is easy to identify the high risk areas of each hazard. Figure 5 demonstrates how the three maps are combined to determine the relationship between each hazard component.

Grid Index System

A grid index system can be used to reference specific points of interest on a map. Each grid can represent a square mile or fraction of a square mile. A grid index is used to display each hazard component included in the assessment. Table 4 displays a grid index system where the structure density is rated for each square mile of the assessment area. This example identifies G-5 as an area having a high structure density.

Descriptive Matrix System

A descriptive matrix system simply describes the severity of each hazard component for a given area. Table 5 shows how a descriptive matrix system is used to rate the vegetation, structures, slope and history of each lot in the assessment area.

Table 4 Example of Grid Index System

	A	B	C	D	E	F	G	H
1	L	L	L	M	L	L	L	M
2	L	L	L	L	L	M	L	L
3	L	M	L	L	L	L	L	L
4	L	L	L	L	L	M	M	M
5	L	L	L	L	L	M	H	M
6	L	L	L	L	L	M	M	M

Structure Density

Low = <10 structures per square mile.
Medium = 10-30 structures per square mile.
High = >30 structures per square mile.

Table 5 Example of Descriptive Matrix System

Area	Vegetation	Structures	Slope	History
Melville Heights	heavy hardwood trees and brush	large homes on about one half acre lots, primarily wood sided with wood roofs	moderate	two small wildland fires in the last two years—suspected cause is children with matches
Melville Slopes	small trees and medium-size shrubs with grass undercover	small homes primarily with wood roofs and stucco siding	moderate	four wildland fires last year caused by trash burning

Example of Geographic Information System (GIS)

Roof Material

Figure 2

- Composite or Asphalt
- Metal or Tile
- Untreated Shake
- Treated Shake

Vegetation Density

Figure 3

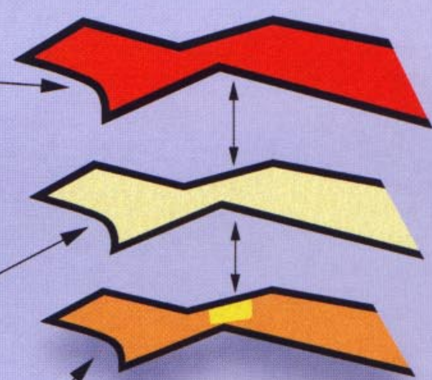
- Thinned Conifers
- Sagebrush/Willow
- Mod. Dense Trees
- Grass
- Grass with Aspen

Percent Slope

Figure 4

- Less than 8%
- Between 8% and 20%
- Between 20% and 30%
- Greater than 30%

Figure 5



Sample Property

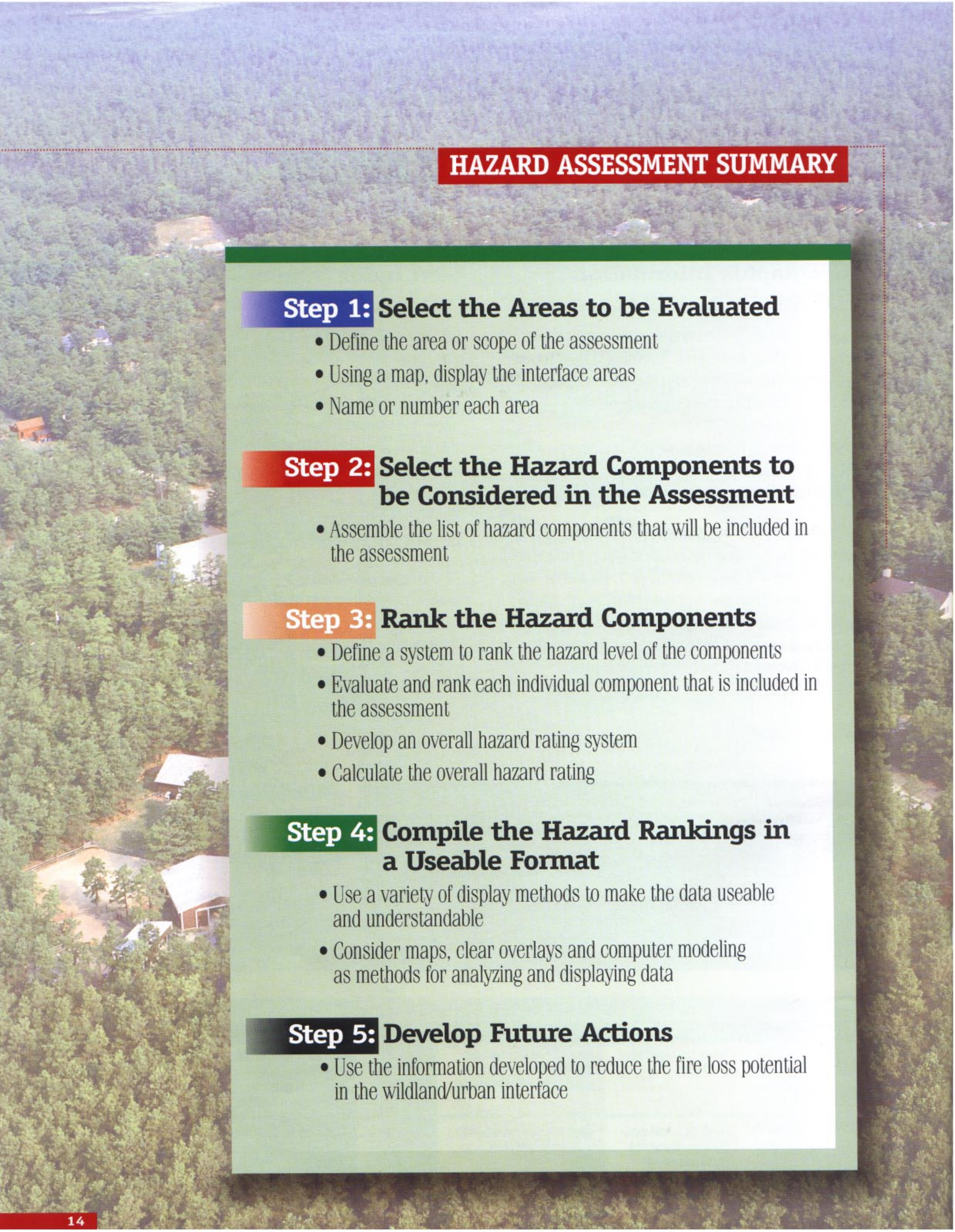
Results of Assessment

Roof material assessment is high (**H**) for untreated shake, vegetation assessment is medium (**M**) for thinned conifers and slope assessment is high (**H**) for a greater than 30% slope. The overall rating is **HMH** for this sample property.

Step 5: Develop Future Actions

The information developed from the assessment can be used to develop strategies to reduce fire hazards in the wildland/urban interface. Suggestions on how to use the information follows:

- Develop mitigation strategies
- Develop fire response/evacuation plans
- Provide reference tools for planners, insurers, bankers and local code adoption
- Develop region-wide cooperative fire protection agreements
- Use as a basic fire protection evaluation tool in conjunction with the Insurance Service Office (ISO) fire suppression rating schedule
- Distribute along with public fire safety education information
- Improve fire fighter and public safety
- Perform cost/benefit analyses
- Implement or evaluate existing programs
- Adopt a more sophisticated fire modeling program
- Strategically focus fuel reduction projects
- Educate property owners, local and state governments and fire-service agencies



HAZARD ASSESSMENT SUMMARY

Step 1: Select the Areas to be Evaluated

- Define the area or scope of the assessment
- Using a map, display the interface areas
- Name or number each area

Step 2: Select the Hazard Components to be Considered in the Assessment

- Assemble the list of hazard components that will be included in the assessment

Step 3: Rank the Hazard Components

- Define a system to rank the hazard level of the components
- Evaluate and rank each individual component that is included in the assessment
- Develop an overall hazard rating system
- Calculate the overall hazard rating

Step 4: Compile the Hazard Rankings in a Useable Format

- Use a variety of display methods to make the data useable and understandable
- Consider maps, clear overlays and computer modeling as methods for analyzing and displaying data

Step 5: Develop Future Actions

- Use the information developed to reduce the fire loss potential in the wildland/urban interface

Hazard Assessment Systems

The following references are the basis for the hazard components and the methodology outlined in this publication. These publications give details on a variety of hazard rating systems and can be used as additional information.

1. ***California's I-Zone—Wildland/Urban Fire Prevention and Mitigation.* Rodney Slaughter, Editor. Governor's Office of Emergency Services. 1996.**
   This book was made possible by hazard mitigation grant funding from the Federal Emergency Management Agency and involved several agencies. It is a reference manual that addresses: model codes, hazard zoning and enforcement; building standards and technology; domestic and wildland fuels; and community programs. It is available from CFESTES Bookstore, 7171 Bowling Drive, Sacramento, CA 95823-2034.
2. ***California Fire Plan: A Framework for Minimizing Costs and Losses from Wildland Fires.* California State Board of Forestry. 1996.**
   This document gives a detailed framework for evaluating and prioritizing wildfire hazards including structures, watersheds, timber, range land, air quality, recreation potential, sensitive habitats and cultural resources. It includes a process for developing assessments that involve multiple jurisdictions and interested parties.
3. ***Colorado Wildland Interface Pre-plan Initiative.* Colorado State Forest Service (CSFS). 1997.**
   This system is being taught through classroom and field sessions. It provides a simple method to rate homes within the wildland/urban interface on their ability to withstand wildfire. This system uses the *Wildland Home Fire Risk Meter*, a rating sheet developed jointly by CSFS and the Fire Protection Districts and the *Fire Hazard Severity Form* as shown in the *1997 Urban/Wildland Interface Code.*
4. ***Development Strategies in the Wildland/Urban Interface.* International Association of Fire Chiefs and Western Fire Chiefs Association. 1996.**
   This handbook was designed to be an educational tool for the fire service and academic and development professionals protecting or developing wildland or forested areas. It provides strategies for land use decisions, risk assessment, vegetation management, public education and fire operations.
5. ***Everyone's Responsibility: Fire Protection in Wildland/Urban Interface.* NFPA, 1994.**
   This is a combination videotape/book program discussing how three communities dealt with the interface problem, each using different methods but all focusing on cooperation and improved safety. The Virginia Forestry's Woodland Home Fire Hazard Rating Form is included.
6. ***Fire Risk Rating for Existing and Planned Wildland Residential Interface Development.* Montana Department of Natural Resources and Conservation, Missoula, MT, March, 1993.**
   This rating system allows prevention planners to assess interface areas for risks and hazards, rank them according to their risk score, and then set priorities for prevention resources and actions. It organizes physical site information, such as road access, topography, fuels, construction and water sources, so that the fire managers can easily review all the information at once.
7. ***Fire Safety Considerations for Residential Development in Forested Areas—A Guide for Fire Agencies, Planning Boards and Subdivision or Housing Developers.* New Hampshire Rural Fire Protection Task Force. February, 1997.**
   This guide lists minimum fire safety considerations for woodland development, guidelines for a sample subdivision rating, and a wildfire hazard rating form for subdivisions.
8. ***Incline Village/Crystal Bay Defensible Space Handbooks: A Volunteer's Guide to Reducing the Wildfire Threat.* University of Nevada Cooperative Extension Service, 1991.**
   This handbook, designed as a reference guide for neighborhood leaders, provides guidance in understanding the threat of wildfire, implementing defensible space and developing the role of leadership in neighborhood efforts.
9. ***IFCI Urban/Wildland Interface Code.* International Fire Code Institute, 1996.**
   This wildland interface code provides specifications for water supplies, defensible space and access in wildland interface areas. It includes a table to rate the severity of the hazard based on vegetation, slope, fire and weather frequency, and fuel models.
10. ***NFPA 299 Protection of Life and Property from Wildfire.* National Fire Protection Association, 1991.**
    This document, developed by the NFPA Forest and Rural Fire Protection Committee, provides criteria for fire agencies, land use planners, architects, developers and local governments to use in the development of areas that may be threatened by wildfire.
11. ***North Whitefish Fire Risk Ration GIS Project.* Fire and Aviation Management Office, Montana Department of Natural Resources and Conservation, Missoula, MT, 1995.**
    This project applies geographic information systems (GIS) to Montana's Fire Risk Rating System (FRA). Twenty-eight key variables are assigned a weighted score and the scores are added to achieve a composite score. This publication is useful for agencies wishing to automate all or part of an existing fire hazard rating system.
12. ***Protecting Life and Property from Wildfire: An Introduction to Designing Zoning & Building Standards for Local Officials.* Great Lakes Forest Fire Compact, 1996.**
    This document focuses on planning needs and considerations for assessing the urban interface and includes recommendations for firewise landscapes, access, water supplies, and structural design. The appendix provides ideas for risk assessment and a sample risk rating system for a subdivision or development.
13. ***Wildfire Hazard Evaluation—Field Notes.* Colorado State Forest Service, 1992.**

This hazard-rating field form, developed for subdivision level use, considers many of the key elements defined in the NWCG document. It is simple in function and design using low, moderate and high fire risks based on numeric scores.

14. *Wildfire Hazard Identification & Mitigation System (WHIMS)*, Boulder, Colorado. 1992.
Through the involvement of multiple local, state, and federal government inter-agencies, wildfire components have been tied together to identify hazardous areas. The fire protection district can foresee these high-hazard areas, passing along mitigation tips to the individual residents, homeowners and homeowner associations and showing them the importance of mitigation around their homes. www.boco.co.gov/gislu/whims.html.

15. *Wildfire Prevention Analysis and Planning.* Department of the Interior. 1992.
This procedure was developed to determine the locations and levels of fire risks, hazards (fuels and topography of an area), and values (areas where loss of destruction by fire would be unacceptable) in fire-prone forests or wildland developments. Ratings of low, medium and high are determined for risks, hazards and values (delineated on a map), as well as a ranking system for planned activities in specific areas.

16. *Wildfire Risk Analysis.* Virginia Department of Forestry. 1997.
This statewide project uses the *Wildfire Prevention Analysis and Planning* procedure. Field personnel determine the level of risk, hazard and value in each county, based on local knowledge of an area and historical fire occurrence. The result will be a series of GIS-based maps to be used to identify and prioritize planned specific actions to reduce fires in problem areas. The Virginia Department of Forestry also conducts woodland home and development forest fire hazard ratings, and a five-year woodland home survey.

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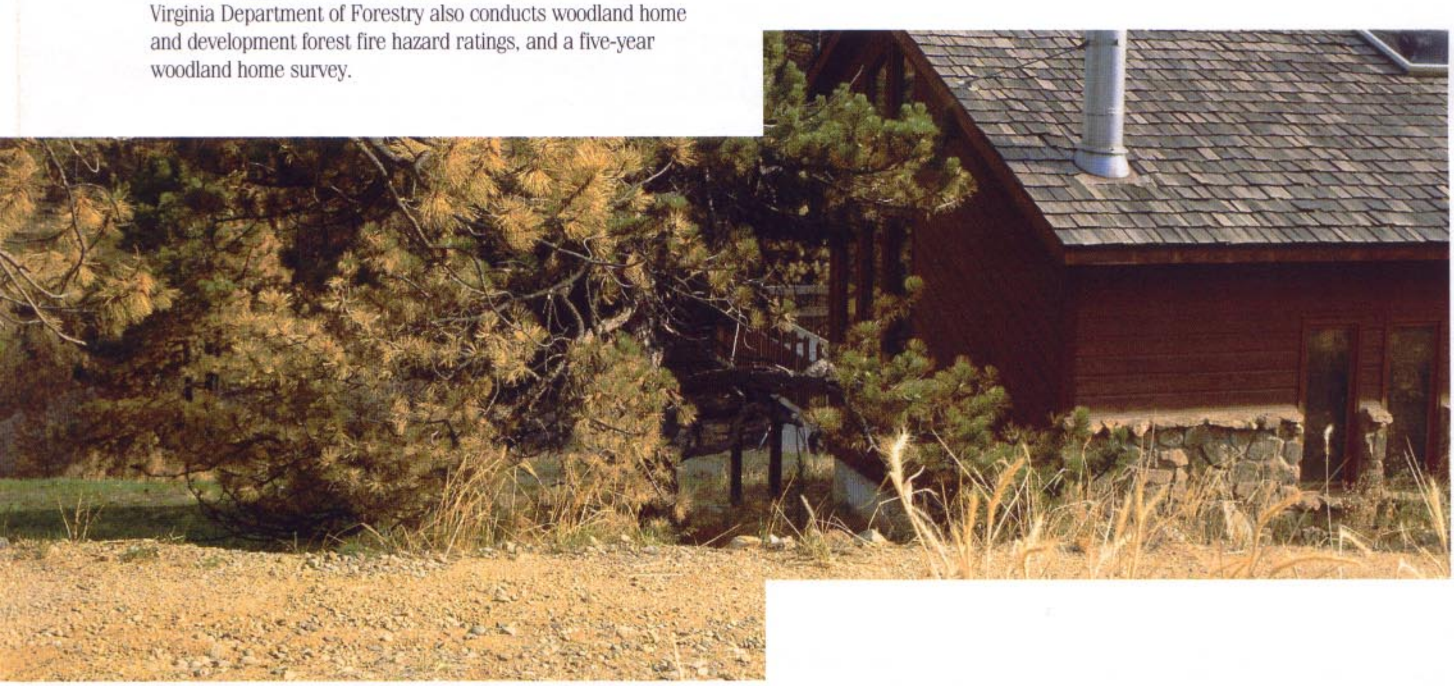

Future Hazard Assessment System

Structure Ignition Assessment Model (SIAM)

SIAM is a computer program being developed that can rate the potential for ignition of a structure located in a wildland/urban interface. The purpose of the program is to enable home-owners and developers to incorporate features into a structure and the structure's surroundings that will improve its chances of surviving a wildland fire. The program can also be used to identify problem areas of existing structures and/or developments.

SIAM uses an analytical approach to establish relationships between the structure design and the resulting fire exposure. SIAM requires the user to input a general description of the structure, the topography at the building site, and the potential fire characteristics. Because actual conditions of a potential fire are unknown, the worst-case scenarios are assumed. SIAM rates only the potential for structure ignition and does not predict ignition.

The computer model completes five principal processing steps.

1. The program requires the fire professional to provide an estimate of the flame length and the rate of fire spread—based on the weather, topography and the fuels.
2. Based on the input information, the program calculates the flame size, flame angle, burning residence time and the structure's exposure to the radiant and convective heat.
3. The firebrand exposure is estimated from the type of fuels and the fire intensity.
4. The ignition potential is estimated based on the firebrand exposure, the structure design, and the heat transfer model.
5. The final risk rating is calculated by combining the heat transfer and firebrand exposure.

The SIAM program is being designed to be used by:

- **local regulators** to establish minimum fire safety requirements
- **home owners** to integrate a structure's design and landscaping to meet fire safety requirements
- **developers** to plan a new development to meet fire safety requirements
- **fire agencies** to assess wildland/urban interface fire risks for pre-suppression and suppression planning

The SIAM computer model is expected to be available in late 1998. For more information on SIAM contact:

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