WILDLAND/URBAN INTERFACE FIRE RESEARCH AT THE USDA FOREST SERVICE, FOREST PRODUCTS LABORATORY: PAST, PRESENT, AND FUTURE[1]

ROBERT H. WHITE, Supervisory Wood Scientist
Wood Preservation and Fire Research
USDA Forest Service, Forest Products Laboratory
Madison, WI

INTRODUCTION

Because more homes are being built in the forests and other wildlands, the safety of these homes during forest fires has become a major issue. Although not noted for loss of life, fires in the wildland/urban interface (WUI) are responsible for extremely large property losses. Approaches to this problem include improved management of the forests to reduce fuel loadings, improved fire service response, improved community design, and improved home designs. Unlike the normal house fire, the forest fire represents an exterior fire exposure. As such, the components of a home that can immediately be affected by exposure to the flames and burning debris of a forest fire includes ornamental plants near the home, wood decks of preservative-treated or naturally durable wood species, exterior siding, and wood shingle roofs.

The USDA Forest Service is the federal agency responsible for our National Forests. In cooperation with other federal land management agencies and state governments, the Forest Service has a major role in the prevention and control of forest fires. At the USDA Forest Service, Forest Products Laboratory (FPL), in Madison, WI, our fire research program is oriented toward the fire behavior of wood products and wood structures. One component of our program is to develop information and methods geared toward helping homeowners in the WUI improve the fire survival capabilities of their own homes.

In this paper, we review past, present, and possible future research at FPL that has application to this problem. The research is discussed in terms of the various components of the home that can contribute to the loss of the structure to a forest fire.

WOOD SHINGLES

With their large horizontal surfaces. roof coverings represent a major exposure to the flames and burning debris of an adjacent forest fire. FPL has conducted research on fire-retardant treatments (FRT) for wood shingles and methods for evaluating their performance. Early research was involved an accelerated method for weathering treated wood shingles prior to fire testing and a companion study of 10 years of actual outdoor exposure prior to fire testing. Various exterior FRTs were evaluated in the 10-year study and earlier studies. In more recent years, we evaluated possible combined treatments that would improve resistance of the wood shingles to both tire and decay. This overview is limited to FPL research, but LeVan (1984) reviewed the overall literature on FRTs.

Accelerated Weathering

For efficient research, product development, and marketing of new leach-resistant FRTs for wood shingles and other exterior fire-retardant-treated wood products, it is critical that the durability of the

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treatment to outdoor weathering can be quickly evaluated. In an adaptation of a method prescribed by the city of Los Angeles in 1964, FPL designed and constructed the FPL weathering chamber (Holmes 1971) that uses the exposure that became Method B of ASTM D 2898 (ASTM 1994). Ultraviolet sunlamps are used. FPL cooperated with the ASTM Subcommittee on Fire Performance in the 1970s to evaluate the existing two methods for accelerated weathering (Holmes 1973). The methods were the 12-week "rain test" method of Underwriters' Laboratories (Method A of ASTM D 2898) and the 1,000-hour accelerated weathering chamber used by FPL (Method B). The characteristics of these two methods are listed in Table 1.

A leach-resistant and a nonleach-resistant fire-retardant treatment were used in the comparison of the methods. In both methods, the water picked up by the specimens during the wet cycles caused about a 22% gain in weight compared with their initial weights. In the drying cycles, Method A specimens lost all the water gained in the wet cycles and some of their initial moisture content while the Method B specimens retained a 7% gain over their initial weights at the end of the drying cycles. Both Method A and B were considered equivalent in their leaching effect as evidenced by the ASTM E 84 tests (ASTM 1998a) and tests in the FPL 8-ft (2.4-m) tunnel apparatus [FPL no longer has this apparatus, and it has been withdrawn as an ASTM standard].

In early work on FRTs for wood shingles, a 28-day outdoor exposure was used. The natural rain exposure was supplemented with daily water spray so total water exposure was 30 in. (0.8 m) of water for the 28 days. While it is not comparable to Method B (LeVan and Holmes 1986), it was successfully used to eliminate less durable treatments and to adjust chemical retentions.

The rain test (Method A) is what has been used to weather fire-retardant-treated wood shingles prior to the fire tests specified by ASTM E 108 (ASTM 1996). UBC 15-2 standard on roof covering (International Conference of Building Officials 1997) requires the rain test and that the FRT shingles be fire-tested after 1, 2, 3, 5, and 10 years of actual outdoor exposure. UBC-15 also provides for an alternative rain test (Table 1). The FR wood roofing products are listed or certified by an independent third-party agency if the tire tests conducted after the rain test exposures are successful. This certification or listing is rescinded in later years if fire testing after actual outdoor weathering results in failures. Apparently because of concerns about such occurrences, ICBO Evaluation Services currently requires in its acceptance criteria for fire-retardant-treated wood roof systems (AC 107) (ICBO Evaluation Service. inc. 1997) either fire tests after three years of outdoor exposure or fire tests after a new accelerated weathering procedure. As can be seen in Table 1, the characteristics of Method A and B of ASTM D 2898 were combined and modified in such a manner that this new procedure provides a substantially more severe weathering exposure.

In recent years, FPL has used simple leaching procedures in combination with fire testing in heat release calorimeters to evaluate potential new FRTs (Sweet and others 1996). In one recent case, ten days of leaching in a bucket and shaker (water changed at 1 and 4 days) reduced the performance of a treated product to that close to untreated wood. The samples were evaluated using the cone calorimeter (ASTM E 1354) (ASTM 1997b). In the cone calorimeter, the heat release rate is obtained as a specimen is exposed to a constant heat flux. In the tests of the treated shingles in the cone calorimeter at 50-kW/m^2 exposure, the initial peak heat release rate increased from 100 to 170 kW/m^2 with leaching. Also, leaching of the samples increased the effective heat of combustion From 9 to 12 MJ/kg. The relationships between these leaching tests and the accelerated weathering procedures are not known.

FPL has considered new studies to evaluate the different methods for accelerated weathering prior to fire testing of exterior FRT wood, The lack of documentation of the effect of different aspects of the new ICBO procedure has prevented its approval by the ASTM Subcommittee on Fire Performance of Wood Products as an addition to ASTM D 2898. A critical component of the new procedure and Method B of

D2898 is the UV exposure. While FPL research has supported the need for UV exposure in an accelerated weathering method, the exact impact on the durability of FRT needs further study. It is believed that treatment chemicals are lost as the UV exposure degrades the wood and the degraded wood is washed away. Other types of lamps are used in weathering apparatuses that are intended for other applications.

Environmental concerns raise questions about the amount of water used. This concern was somewhat addressed when the ICBO modified its procedure to allow partial recirculation of the water for all cycles except the first three and last three cycles. It is possible that for an equivalent amount of rainfall, more leaching of chemical treatments from wood occurs with a low-level water spray than with a high flow rate spray (Lebow 1996). One of the difficulties is the size of the specimens needed for the fire tests specified in ASTM E 108. The acceptance of alternative fire test methods such as the cone calorimeter for the post-weathering evaluation could allow other weathering techniques to be considered. Currently, the durability and leaching of wood treated with preservatives is a major research activity for FPL.

Outdoor Exposure

As part of an evaluation of potential exterior FRTs (Holmes 1971), various FRT wood shingles were subjected to outdoor weathering prior to fire testing. As noted earlier, a simple 28-day weathering procedure was used for initial screening of a number of fire-retardant coatings and pressure-impregnated treatments (Holmes 1971). Selected treatments were further evaluated with fire testing after Method B weathering. Because FPL does not have the test apparatuses for the ASTM E 108 fire tests, fire testing was done with an FPL-modified Class C burning brand test and an FPL-modified Schlyter flame spread test (Holmes 1971). Five impregnated treatments and one coating were selected for further evaluation. In addition, an untreated and a commercial product (NCX) were tested. (NCX is no longer marketed in the United States) The shingles were fire tested after 2, 5 (Holmes and Knispel 1981), and 10 years (LeVan and Holmes 1986). The results are shown in Figure 1 for those treatments and retention levels that were fire tested after Method B weathering and after the 2, 5, and 10 years of outdoor weathering.

Table 1. Comparison of different accelerated weathering methods.

		D2898 Method A	D2898 Method B	UBC 15-2 Alternative to D 2898 Method A	ICBO AC107
Cycles	Number	12	42	7	252
	Cycle duration, h	168	24	336	8
	Total duration, h	2,016	1,000	2,328	2,016
Water exposure	Duration, h/cycle	96	4+4	168	4
	Flow rate, L/min/m^2	0.30	12.2	0.30	12.2
	Recirculation	No	Some	No	Some
	Temperature, °C	2-16	<32	2-16	2-32
	Total duration, h	1,152	336	1,152	1008
Drying cycle	Duration, h	72	4+4	120	4
	Temperature, °C	57-60	60-66	60	60-66
	UV exposure	No	Yes	No	Yes
	Total duration, h	864	336	840	1008
Rest cycle	Duration, h/cycle	None	8	48	None
	Total duration, h	-	328	336	-

The treatments are dicyandiamide-phosphoric acid-formaldehyde (DPF), dicyandiamide-phosphoric acid (DF), an epoxy fire-retardant paint, and the commercial NCX treatment. The solid symbols in Figure 1 are the flame spread results after accelerated weathering and indicate their correspondence with results after outdoor exposure. These results support the ICBO decision to require fire test results after 3 years outdoor exposure or after their new alternative accelerated weathering procedure. The reduced impact of years 5 to 10 on fire performance supports the prepossession that 10 years of data are sufficient to evaluate the durability of the FRT wood shingles.

Combined Treatment

Most wood shingles have been western redcedar. The different FRT treatments evaluated in the 10-year weathering study (Holmes 1971, LeVan and Holmes 1986) were applied to western redcedar shingles. With the natural decay resistance of western redcedar, a treatment limited to improving fire performance has traditionally been sufficient. As with most wood products, there is a need to use different species to make wood shingles (Govett and others 1991). Since the alternative species are often nondurable, preservative treatment is needed (DeGroot and Nesenson 1995). Preservative-treated southern pine wood shingles are currently being marketed. Preservative treatments are also used to produce more durable western redcedar shingles.

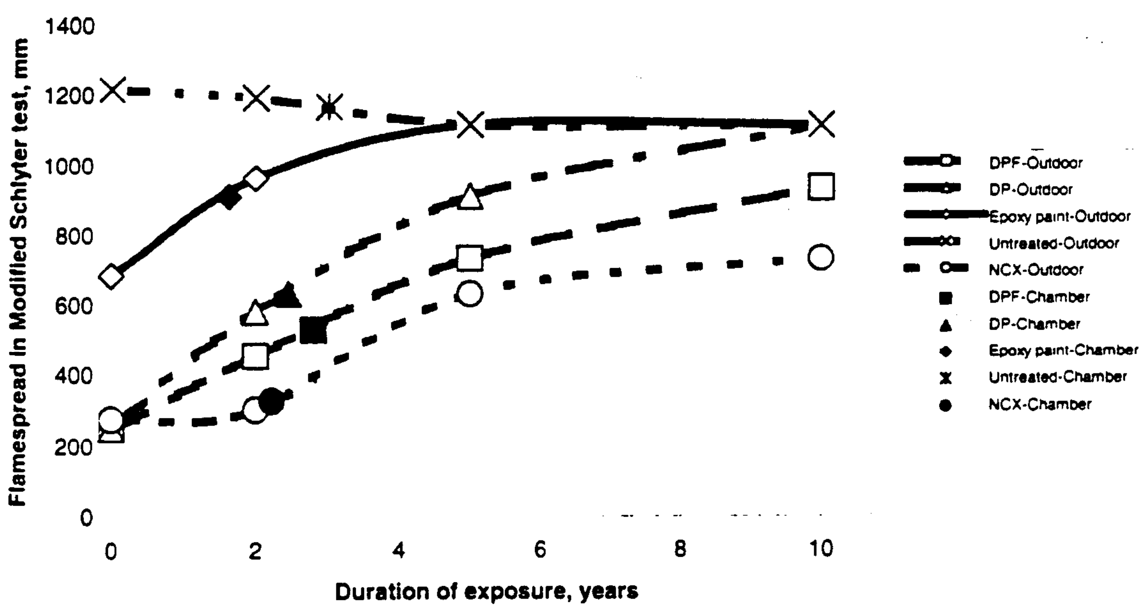

Figure 1. Flame spread of various FRT wood shingles after years of outdoor exposure and after 1,000 hours in the FPL weathering chamber (ASTM D2898 Method B).

In response to the desire of Northwest lumber manufacturers to make roof shingles and shakes out of western hemlock, Pacific silver fir, and western white pine, FPL conducted a study of potential one-step combined preservative and FRTs. The initial step was to determine the chemical compatibility of 19 preservative systems and 12 fire-retardant systems. Combinations that generated chemical reactions (gases generated or color change), phase changes, or precipitates when mixed in water were eliminated. The compatibility screening tests resulted in three fire retardants and six preservatives being selected for fire-tube tests (ASTM 1995). The fire-tube test results for 15 of the 18 possible combinations were not sufficiently different to result in an ideal candidate. Based on decay resistance and other factors, the combination of a polymerized organic phosphate resin tire retardant [UDPF (urea, dicyandiamide, phosphoric acid, and formaldehyde) or MDPF (melamine, dicyandiamide, phosphoric acid formaldehyde)] with a quaternary ammonium chloride preservative [DDAC (didecyl dimethyl ammonium chloride) or the proprietary NP-1 (DDAC with 3-iodo-2-propynyl butyl carbamate)] was selected. There was a synergistic effect between the two compounds in resisting brown-rot decay fungi. The proposed one-step combined fire-retardant/preservative treatment was patented (LeVan and DeGroot 1993), and fire tests were conducted (Sweet and others 1996).

EXTERIOR SIDING

Research on the fire growth properties of wood has been a major component of the FPL fire research program in recent years. Such properties include ignition, heat release rate, flame spread, and optical smoke density. Much of that research has been done with heat release rate calorimeters. Early work at FPL was done with a FPL calorimeter, which was later replaced with an O.S.U. calorimeter (ASTM E906) (ASTM 1997c). More recently, FPL replaced the O.S.U. calorimeter with a cone calorimeter (ASTM 1997b). In O.S.U. or cone calorimeter tests, the specimen is subjected to a constant heat flux and normally the test includes piloted ignition. As part of an effort to develop a home assessment model known as structure ignition assessment model (SIAM), this fire growth research was applied to development of a model for the ignition of exterior siding.

As explained by Tran and others (1992), ignition criteria have included three approaches. These approaches are 1) a critical total heat flux-time product, 2) a critical temperature, or 3) a critical mass flux of pyrolysis volatiles. The flux-time product approach was used to develop the initial model for ignition of exterior sidings exposed to the flames and heat of a forest fire. The model assumes the linear relationship of Janssens (1991) for thermally thick material. In this model, the reciprocal of the ignition time raised to the 0.547 power is taken as a linear function of the radiant heat flux. The regression equation is

$$(t_{ig})^{-0.547} = a\dot{q}_e'' + b$$

For Douglas-fir plywood, Tran found a = 0.006006 and b = -0.0789. This equation results in a critical heat flux $\dot{q}_c''$ of 13.1 kW/m^2 (time equals infinity). For a transient heat flux, the model derived from above is

$$\int (\dot{q}_e'' - \dot{q}_{cr}'')^{1.828} dt \geq a^{-1.828}$$

The model was included in SIAM (Cohen and others 1991, Cohen 1994).

As part of FPL's continuing efforts to improve ignition models, research included tests with our lateral ignition and flame spread test (LIFT) apparatus (ASTM 1997a). Various siding materials were tested (Dietenberger 1994). In the process, it was determined that the different convective heat transfer coefficients in the different apparatuses (O.S.U., cone, and LIFT) affected the results and that critical irradiance was not a viable ignition criterion (Dietenberger 1994). A new analysis and test protocol was developed for ignition tests in the LIFT apparatus (Dietenberger 1995a, 1995b) and the cone apparatus (Dietenberger 1996). With a thermal diffusion equation used as part of the analysis, the protocol can be used to determine the thermophysical properties of thermal conductivity and thermal diffusivity in addition to the surface ignition temperature. In the future, we expect this work to continue with modeling of flame spread as well as ignition.

VEGETATION

Homeowners are often given the advice to minimize or eliminate the use of highly flammable vegetation when landscaping their home. FPL and the USDA Forest Service, Forest Fire Laboratory in Riverside, CA, cooperated with a Menifee Valley, CA, nursery, Plants for Dry Places, to investigate the flammability of native and ornamental plants for homes in WUI. The objective of this project is to improve the reliability and scope of information on the relative flammability of native and ornamental plants that could be used to landscape a home. Initial results were presented at the 21st International Conference on Fire Safety (White and others 1996), and a paper on the related topic of flammability of Christmas trees was presented at the 24th Conference (White and others 1997). The final report is in preparation. Since heat release rate is a critical factor in flammability, we used the cone calorimeter (ASTM 1354) to determine the heat release characteristics of 10 different plants.

Branch samples from the 10 plants were collected four times during a one-year period. The 10 plants included chamise, aloe, saltbush, wild lilac, crimson-spot rockrose, sageleaf rockrose, toyon, prostrate myoporum, olive, and *Rhagodia spinescens.* Samples were tested both as received (i.e., green) and after being ovendried. The amount of material was usually a single layer of foliage with the entire exposed surface area of the sample holder not covered.

Cone calorimeter results for the 10 species showed distinct differences in effective heat of combustion between some of the species. Chamise and olive had distinctly higher effective heats of combustion and peak heat release rates. The average effective heats of combustion (25 kW/m^2 external heat flux) for the green samples of olive and chamise were 9.5 MJ/kg. Myoporum and aloe had distinctly lower average effective heat of combustion (1.44 MJ/kg and less). The average effective heat of combustion for the other plants ranged from 3.3 to 7.1 MJ/kg. Some of these differences in effective heat of combustion are due to differences in moisture contents and resulting different moisture, i.e., mass loss in the tests. The general rankings of the plants were consistent with available data in the literature.

DECKS AND OTHER EXTERIOR WOOD STRUCTURES

Other significant items that can be exposed to external fires are the wood decks, fences, and other similar structures around the home. Such structures are generally constructed of natural durable species, such as cedar and redwood, or preservative-treated wood. The fire performance of such materials may influence the involvement of a home in a WUI fire. Both preservative-treated wood and the naturally durable species are considered to have lower than average flame spread properties compared with other wood products.

Except for an early study involving nine wood preservatives impregnated in oak lumber and plywood (Bruce 1956), the fire performance of preservative-treated wood has not been researched at FPL beyond some limited internal testing. While not the subject of a specific study, cedar and redwood have been included in various studies. Decayed wood is susceptible to smoldering ignition from burning debris. We are currently conducting a study on tire behavior of decayed wood.

Preservative-Treated Wood

In a study for the Navy, Bruce (1956) found that inorganic waterborne preservative salts improved ignition times and reduced flammability. The improvements were not as great as with FRTs. Tests conducted included the ASTM E 69 fire-tube test (ASTM 1995) and the modified Schlyter test. Tests showed that the copper and chromium treatments tended to increase the glowing combustion of the charred wood. Flame spread of oilborne preservatives was increased if there were residual flammable oils remaining after treatment. Flame spreads of wood treated with waterborne preservatives were somewhat reduced compared with untreated wood. The retention levels ranged from 0.4 to 1.9 lb/ft^3 (6 to 30 kg/m^3) for the waterborne preservatives.

In 1986, we conducted limited exploratory and unpublished tests on ¾-in.-thick (19-mm) CCA-C treated plywood (0.60 lb/ft^3 (9.6 kg/m^3) retention) and on ¾-in. (19-mm) untreated C-D interior plywood with exterior glue. The specimens were not matched samples and had been purchased from a local lumberyard. In FPL-modified Schlyter tests (severe version) (Forest Products Laboratory 1965), the average flame spread and maximum flame spread were less and the time for maximum flame spread was longer for the CCA-treated plywood than for the untreated plywood. The maximum flame spread was 36 in. (0.914 m) at 2.9 min. with treated plywood compared with 46 in. (1.168 m) at 1.25 min. for the untreated plywood. In the three ASTM E 648 critical radiant panel tests (ASTM 1984) of each panel type, the critical radiant fluxes were 3.6 to 7.4 kW/m^2 (5.2 kW/m^2 average) for the treated plywood and 5.0 to 5.4 kW/m^2 for the untreated plywood. In fire penetration tests using the ASTM E 119 time-temperature curve (ASTM 1998b) and our small vertical furnace, average burn through times for the ¾-in. (19-mm) panels were 16.2 min with the CCA-treated plywood and 18.2 min with the untreated plywood. Three replicates were tested. As noted before, the specimens were not matched samples; thus differences observed could be due to other factors other than the preservative treatment.

As with the tests by Bruce, the one negative fire performance is the tendency for afterglow with CCA-treated wood. In FPL-modified Class C burning brand tests, the treated plywood did not go out by itself but rather continued to glow with eventual penetration of the plywood. With the untreated plywood, the glowing stopped 4 min after the brand was consumed and there was no penetration. Prolonged glowing of the CCA-treated plywood was also observed in the ASTM E 648 critical radiant panel tests. In one test, afterglow continued overnight beneath the charred surface of an extinguished specimen.

In more recent exploratory tests, untreated southern pine samples and samples treated with chromated copper arsenate type C (CCA-C), ammoniacal copper quat type D (ACQ-D), and ammoniacal copper citrate (CC) were tested in the cone calorimeter (ASTM E1354; ASTM 1997b). The retention levels were approximately 0.5 lb/ft^3 (8 kg/m^3). The ¾- and 1½-in.- (19- and 38-mm-) thick specimens were tested with the retainer frame but without the grid. Heat flux was 50 kW/m^2. No significant differences were found in the peak heat release rate, average hear release rate, effective heat of combustion, and the times for sustained ignition.

The behavior of treated materials depends on the retention levels of the treatments. In the tests of Bruce (1956) in which differences in tire performance were observed, the retention levels were higher than the retention levels of the samples in the more recent exploratory tests. In the use of fire-retardant chemicals, the retention levels necessary are substantially higher than the retention levels used in preservative treatments. We expect to conduct additional research on the fire performance of preservative-treated wood.

Naturally Durable Species

While no study specific to the fire performance of naturally durable species has been conducted by FPL, both cedar and redwood have been tested in various studies. Western redcedar and redwood are considered Class II materials with ASTM E 84 flame spread indexes (FSI) of 75 or less (Forest Products Laboratory 1999). Most domestic species are Class III, or FSI of 76 to 200. Both western redcedar and redwood were tested in a study of the charring rate of wood species exposed to ASTM E 119. (White and Nordheim 1992). While their low densities resulted in relatively fast charring rate, they both benefited from relatively thick char layers. The relatively high lignin contents of cedar and redwood are probably the reason for this reduced contraction of the char layer from its original wood thickness. Redwood was also tested in a study of burning rate of wood in a heat release rate calorimeter (Tran and White 1992). Redwood has also been included in studies pertaining to fire growth in compartments (Tran 1992) and the exterior siding study (Dietenberger 1994). We expect to conduct further research on the fire performance of these naturally durable species.

HOME ASSESSMENT

Home assessment tools are used to implement the knowledge and research results on the relative fire safety of structures in the WUI. Home assessment methods can help ensure that the various aspects are considered in the proper manner. Such home assessment tools range from simple checklists to computer programs that provide some analysis and quantitative assessment of the overall safety of the structure and its environment. Quantitative assessments provide the means to evaluate alternative designs and materials to optimize fire safety while controlling costs and other benefits or desires. Such assessments need to include the evaluation of nonwood materials as well as wood products. These include alternate materials for roofing, decking, and exterior siding.

Initial FPL effort in this area was a proposed multiattribute utility assessment system for obtaining a fire hazard rating for a specific building site or structure (LeVan and others 1990). After evaluating this proposed method, it was decided to change to a method based more on physical models. FPL participated in the early development of such a model, the structure ignition assessment model (SIAM) (Cohen and others 1991). As noted earlier, our research on the ignition of exterior siding materials was conducted as part of the SIAM project (Tran and others 1992).

Initial Efforts

A home assessment includes the structure itself and the environment surrounding the structure in terms of the hazards that it represents. Environmental factors that need to be considered include the wildland fuels, the landscape, and the topography. Structure factors include such items as the composition and construction of the roof, the type of exterior siding, and the type and size of windows. Other factors include the distance between fuels and the structure and mitigation factors. Mitigation factors include water supply, roads, and fire fighting resources. The initial proposed fire hazard assessment model assumed a linear, additive relationship of the different elements (LeVan and others 1990). Thus, the hazard, *H,* was

$$H = w_1F + w_2S + w_3L + w_4T + w_5D + w_6M$$

where w_i is the weight of each element and *F, S, L, T, D*, and *M* are the hazards of forest fuel, structure, landscape, topography, clearance distance, and mitigation, respectively. The elements were to be calculated from values for their attributes such as roofing materials, surface integrity, and number of openings in the structure. Surveys of experts were used to decide the attributes and the weighing factors. *In* the evaluation of this proposal, including a survey of 10 fire manager experts, it was concluded that the likely nonlinear interdependence of the attributes, the use of subjective expert opinions, and the inclusion of mitigation factors made successful completion of the project unlikely. It was decided to abandon this approach, and an alternative approach was developed.

Structure Ignition Assessment Model

The fundamental changes in the approach were adding modules that were based on physical models to the extent possible and deleting mitigation factors. Mitigation factors were deleted by considering the ignition of the structure as the failure criterion. The model became known as the structure ignition assessment model (SIAM). Initial development was a USDA Forest Service research cooperative project involving Susan LeVan of the Forest Products Laboratory, Richard Chase of the Riverside Forest Fire Laboratory, and Jack Cohen of the Southern Forest Fire Laboratory in Macon, Georgia (Cohen and others 1991). As the result of reassignments, retirement, and downsizing of the FPL fire research program and the closure of the Southern Forest Fire Laboratory, SIAM is now the domain of the Forest Service Intermountain Fire Sciences Laboratory in Missoula, MT (National Wildland/Urban Interface Fire Protection Program, year unknown; Cohen 1999).

SIAM attempts to evaluate the potential for ignition of the structures (Cohen 1994). Potential ignition scenarios include ignition as a result of radiation and convection heating from the flames of adjacent fuel sources including vegetation and other structures such as neighboring residences and ignition as result of firebrands. Required inputs include information on the structure, the potential sources of fire exposure including flame height and duration, topography, and fire weather severity. As discussed previously, an analytical model is used to determine the potential ignition of the exterior siding (Tran and others 1992). A less rigorous approach is used to evaluate the potential ignition from firebrands. Reseach at the Southern Forest Fire Laboratory on the project included a series of window breakage and wall ignition tests (Cohen 1994). The SIAM model has provided insights into the wildland fire threat to homes (Cohen 1999)

CONCLUDING REMARKS

Thirty years of FPL research on fire hazards in the wildland/urban interface include research on fire-retardant-treated wood roof coverings, ignition of exterior wood sidings, relative flammability of ornamental vegetation, fire behavior of natural durable and preservative-treated wood, and assessment of the fire safety of a home. Consistent with its mission, FPL research has concentrated on defining and improving the fire performance of wood products used in WUI structures. Since passive fire protection of the structure is critical to the survivability of homes in the wildland/urban interface, we expect to continue such research. In the short-term, we expect to continue studies on flame spread behavior of wood products and the overall fire performance of preservative-treated wood.

This paper has been limited to structures in the WUI. In-the related area of vegetation management, FPL is very active in improving the markets for small-diameter and thinning materials (Forest Products Laboratory 1998). The large amounts of such materials in our National Forests have adversely affected the health of our forests and increased the risk and severity of forest fires. By improving the economics involved in removing such excess materials, FPL also contributes to the well being of communities in the WUI.

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