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Analysis of the Utility of Wildfire Home Protection Strategies in Central Florida

A Final Report Submitted to the Interagency Fire Science Team

Jeff L. De Witt[1]

Abstract

A qualitative analysis of the effectiveness of wildfire home protection strategies utilized by homeowners in the wildland-urban interface is presented. Several factors were statistically significant in protecting homes from structural damage: metal soffit vents, block homes, the amount of tree and brush clearance surrounding a home, a lack of debris around a residence, and defensible actions. Logistic regression analysis was utilized to analyze the effect of each factor on three structural damage levels. Eight factors were identified by the model as significant at the 0.05 level. The model correctly predicted the observed damage levels in 79 percent of the samples. The results of this study indicate that there are several strategies homeowners can utilize to protect their homes from wildfires.

[1] Johnson Controls World Services, Inc., USGS-BRD, National Wetlands Research Center, Lafayette, LA 70506.

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Introduction

During the summer of 1998, Florida was besieged with a series of wildland fires of considerable strength and intensity. Statewide, these fires burned almost 500,000 acres and damaged or destroyed over 350 homes and businesses (Greenlee et al. 1998). The wildfires were preceded by an unusually severe drought caused by the El Nino weather phenomenon that created conditions favorable for a wildfire outbreak.

Several counties in central Florida were particularly hard hit, including the highly populated counties of Flagler, Volusia, and Brevard where the wildfires burned into numerous urban areas causing significant property damage. These residential communities, built adjacent to wildlands , are referred to as wildland-urban interfaces (Foote et al. 1991). Building homes in the wildland-urban interface is a growing trend in Florida and throughout the country as many homeowners are moving away from the congestion and pollution of metropolitan areas.

By living in the wildland-urban interface, many of these homeowners are unknowingly subjecting themselves to the danger of wildfires. The native vegetation typically found in and around the wildland-urban interface in Florida is highly susceptible to burning and is dependent upon periodic fires. When fire is excluded and vegetation accumulates, the risk of a severe wildfire outbreak can significantly increase (Greenlee et al. 1998). The vegetation in Central Florida is diverse but typically includes an understory of dense brush such as saw-palmetto (*Serenoa repens*), gallberry (*Ilex glabra*), *fetterbush* (*Lyonia lucida*), and wax myrtle (*Myrica cerifera*) generally ranging from 4 to 8 feet in height under an overstory of southern pine (*Pinus elliottii* [varieties *elliottii and densa*], *P palustris, or P. taeda*) (Myers and Ewel 1990). Fire has historically kept the accumulation of wildland fuels in check, reducing the likelihood of catastrophic fire.. By intentionally reintroducing fire back into the natural landscape in a controlled manner (called prescribed fire), these fuels can be managed in such a way that the intensity of future wildfires is substantially reduced.

In addition to the use of prescribed fire, several state and federal agencies have developed numerous recommendations in an effort to help homeowners better protect their homes from wildfires. These strategies include establishing a buffer zone around a residence, maintaining the proper crown clearance between yard trees and the home, and using fire retardant building materials in home construction (FEMA 1993, Florida Division of Forestry 1996, Brenner 1998). The recommendations stem in part from the results of a Florida Division of Forestry study of a 1985 wildfire that burned into the Palm Coast community in Flagler County. Abt et al. (1987) indicated that fire intensity, the amount of brush clearance around a home, and the type of soffit vent were major factors determining fire damage to a residence.

This paper will assess the effectiveness of these recommendations to determine how well they protected homes in the wildland-urban interface from the 1998 wildfires. The home protection strategies specifically chosen for evaluated include:

- the establishment of a buffer zone of at least 30 feet around the home by keeping flammable materials and vegetation away from a residence;
- the creation of a 15 foot crown clearance between trees and the roof of a home; and
- the utilization of fire-resistant materials in the construction of homes located in wildland-urban interface areas.

Data gained from this study can be used to identify factors that affect structural damage levels under similar fire conditions. One factor not assessed in this study was the possibility of ignition of interior furnishings due to radiant heat exposure through picture windows.

Data Collection

Study sites were chosen based on the presence of homes structurally damaged by the 1998 wildfires. These areas included four subdivisions of the Palm Coast Development in southern Flagler County, the Bear Creek and National Gardens subdivisions in northern Volusia County, and the community of Mims in northern Brevard County. Seventy-five homes were chosen and classified as destroyed, damaged, or undamaged (25 in each classification). Destroyed and damaged samples were randomly selected using damage assessment reports compiled by property appraisers in Brevard, Flagler, and Volusia counties. Undamaged homes were chosen based upon their proximity to sampled homes that were destroyed or damaged. The nearest undamaged residence to a randomly chosen destroyed or damaged home in any direction was sampled.

Data for each sample was collected through personal on-site observations and interviews with affected homeowners. Data from owners of destroyed homes was gathered from phone conversations with homeowners as well as examinations of home remains. Data collected included descriptions of home construction, vegetation clearances, defensible actions taken, and awareness of protection measures (see interview form in appendix A). Tree clearances were measured as the distance between the crowns of yard trees and the roof of the home. Brush clearances were determined using the decision criteria utilized by Foote et al. (1991) that measured vegetation clearances based upon a tree or shrub’s form, spacing, and flammability. The fire-resistance of vegetation was assessed using the recommendations listed in the Flagler County Extension publication by Lippi and Kuypers (1998). Fire and weather data was obtained from firefighters, Florida Division of Forestry personnel, and county agents. Based on this data, wildfires in each study area were assumed to be high intensity crown fires that generally advanced from the west and northwest. Comprehensive fire data for each individual residence was not available.

Data Analysis

Logistic regression was utilized to determine which characteristics jointly provided the best estimate of the probability for each structural damage level. The logit model is based on the cumulative logistic probability function which estimates the probability of an event given certain conditions (Pindyck et al. 1981). In this study, the model is estimating the odds of a home sustaining a certain level of structure damage (destroyed, damaged, or undamaged). All variables included in the model were assumed to be independent.

The stepwise logistic regression procedure of Statistical Analysis System (SAS 1996) was used to select the independent variables that best explained the three levels of structure damage. Variables were included in the model if they met the chosen significance level criteria (0.25 to enter and 0.25 to stay in the model) and their combined influence was significant in predicting structural damage. The resulting significant variables indicated their effect on the probability of a home sustaining each level of structural damage.

All independent variables in the data set were binary, where 0 indicated a "yes" response and 1 indicated a "no" response. Brush clearances were partitioned into 10-foot groups up to 80 feet and greater while tree clearances were grouped into 5-footranges with a maximum range of 30 feet and above.

Results

Using the variables that were kept in the model, the logit model (which included data from all 75 samples) predicted the structural damage levels of residences affected by the wildfires (Tables 1 and 2). The parameters listed were significant at the 0.05 level. A negative coefficient indicates that a parameter response of "yes" is more likely with destroyed or damaged homes rather than undamaged homes. Similarly, a positive coefficient signifies that a "no" response is more probable with sampled residences that have been damaged or destroyed rather than undamaged. The odds ratio for each parameter indicates the probability of a home being either destroyed or damaged versus not being significantly affected by the wildfires.

The positive coefficient for metal soffit vents indicates that residences which did not have metal soffits (they instead had plastic, vinyl, or metal screens in wood eaves) were more likely to be damaged or destroyed rather than undamaged. Furthermore, the odds ratio indicates that homes without metal soffit vents were 34 times more likely to be affected than not affected (Table 1). Similar results were found with the "yard clear of debris" variable. The positive coefficient signifies that homes which had debris (dead grass, trash, pine needles, etc.) around them were approximately 98 times more likely to sustain structural damage than to escape undamaged.

Although wildfires can be driven by winds from any direction, it is not surprising that the vegetation clearances from 10-19 feet to the west and north were significant as the prevailing winds on the east coast of Florida during the '98 fires were from a westerly direction and from a northerly direction after frontal passages. The negative coefficients for these variables in Table 1 indicate that these homes were more likely to sustain structural damage. The combined odds ratios of homes having a 10-19 foot clearance to the north and west shows that they were almost 100 times more likely to be affected by wildfire. The north and west tree clearance parameters of 0-4 feet were also significant, being almost 90 times more likely to sustain structural damage.

According to Table 1, homes with wood-frames were much more likely to sustain damage than block homes. Almost 64 percent of sampled wood-frame homes were destroyed, with no wood-frame homes remaining undamaged. A significant finding in this study was that residences in which no defensible actions occurred (roof watering, lawn watering, fire department intervention, or combinations of fire department and homeowner action) were 50 times more likely to be destroyed or damaged rather than undamaged (Table 1). Defensible actions taken by homeowners (roof watering, lawn watering, etc.) had no effect (p=.08) on the level of structural damage in this study.

The results further indicate that clearances to the south and east were significant in determining structural damage levels (Table 1), which is the prevailing wind direction (east-southeast) during a typical year and were likely related to sea breezes in 1998. It is not clear why the 0-9 foot brush clearance category to the north and west were not significant, although the relatively small sample size may explain this anomaly. Table 2 Includes parameters in the final output of the logit model that were significant at the 0.12 level.

Table 3 indicates how well the logit model predicted the observed structural damage levels. This table indicates that the model correctly predicted the three damage levels 79 percent of the time. Of the 23 homes that it predicted to be destroyed, 21 actually were destroyed for a false positive rate of 8 percent. Of the 27 homes it predicted would be damaged, 18 actually were damaged. And of the 25 homes it predicted would be undamaged, 20 homes actually were undamaged for a false negative rate of 20 percent.

Figures 1-5 represent the frequency distributions for each of the significant variables included in the logit model. In Figure 1a, note that of the 14 homes sampled with fire-resistant metal soffit vents, over 64 percent of the structures were undamaged. Contrastingly, Figure 1b indicates that of the 11 sampled homes with wooden-frames, all were either damaged or destroyed.

The significance of both brush and tree clearance is also clearly seen in Figures 2a through 3b. In the case of brush clearance north of 10-19 feet, approximately 94 percent of the sampled homes with this amount of clearance were damaged or destroyed. Similarly, almost 67 percent of sampled residences having 10-19 feet of brush clearance to the west were either damaged or destroyed. As indicated in Figures 3a and 3b, tree clearance to the north and west was also significant. Sampled homes having a tree clearance of 0-4 feet to the north and west were affected 75 and 73 percent of the time respectively.

Figure 4 shows that sampled structures where the yard was not clear of debris were affected 83 percent of the time. The variable indicating whether or not defensible actions were taken was also significant in predicting the level of structural damage. As indicated in Figure 5, 85 percent of the homes were either damaged or destroyed when no action to protect the home was taken.

Conclusion

This study provides strong evidence that several factors are effective in protecting homes in the wildland-urban interface from wildfire damage.

Home Construction
The utilization of fire-resistant materials in building construction was an important factor in wildfire home protection. The use of metal soffit vents in home construction proved to be effective in protecting homes from wildfire structural damage and homes built with wooden-frames were not as fire-resistant as block homes. Homes built with tile roofs also provided an additional degree of protection from wildfires, although its significance was less than that of using metal soffit vents or block home construction. No significant relationship was found with the number of stories a residence had, or whether the home was a mobile home or single family home.

Vegetation Clearance
The importance of recommended brush and tree clearances was supported statistically. A brush clearance of 10-19 feet to the north and west was best correlated with homes sustaining structural damage while a tree clearance of 0-4 feet to the north and west resulted in a greater probability of structural damage. These findings indicate that the recommended 30-foot brush clearance and the 15-foot tree clearance were effective in protecting homes as these suggested vegetation clearance distances were not correlated with homes sustaining wildfire damage.
These findings are not to imply that homeowners should maintain a brush and tree clearance less than the recommended distances. Homeowners should abide by these recommendations in order to provide the best degree of wildfire protection for their homes. The results of this study only indicate the amount of clearance that proved to be the most significant for the 75 sampled residences.

Yard and Roof Debris
Other factors also played a significant role in amount of structure damage a home sustained. Yards that were maintained and clear of debris proved to better protect homes from wildfire damage than homes that were surrounded by debris. Debris left on the roof of a home also contributed to the probability of a residence sustaining structural damage, although at a slightly higher significance level than yard debris.

Defensible Actions
The data also indicates that instances where no defensible actions were taken were significant in determining whether or not a home sustained wildfire damage. It is not clear, however, what type of defensible action: fire department intervention, roof or lawn watering, or combinations of

each, would be the most effective in protecting homes from wildfire damage. It is logical that fire department action played a substantial role in the incidence of structural damage and should be considered highly effective in protecting homes from wildfires.

Although these findings revealed the effectiveness of wildfire protection strategies, it appeared that these measures were rarely implemented by homeowners. Of the 75 homeowners surveyed, only 12, or 16 percent, were aware of the ways they could protect their home from wildfires. Furthermore, of these 12, fewer than half actually implemented one or more wildfire protection measures. Clearly, more effort is needed to educate homeowners on the benefits of these recommendations. Flagler County, for example, recently passed a wildfire hazard mitigation regulation (ordinance number 98-14), to help alleviate this problem. The ordinance requires all property owners to maintain the condition of their undeveloped lots so that their land does not pose a significant fire hazard to surrounding homeowners. Property owners must either perform certain mitigation measures or pay for the mitigation work to reduce the risk of fires on their property. Additional ordinances are likely in adjacent counties as a response to the 1998 wildfires.

Additional Observation

Although not statistically supported, several other factors played an important role in determining whether or not a home sustained structural damage from the wildfires. A relatively small sample size for each of the following factors likely resulted in their exclusion from the model.

Prescribed Fire

Despite the substantial administrative costs associated with contacting every property owner in neighborhoods where used and the resistance of some residents to this hazard reduction treatment, the use of prescribed fire at the wildland-urban interface was shown to be very effective in protecting homes from wildfire damage. Of the 32 homes located in areas where prescribed fire was used during the winter preceding the 1998 wildfires, only one home was damaged. Unfortunately, the significant increase in the cost of prescribed fire within a subdivision limit its use. As a result, alternative fuel reduction methods such as use a bush-hog to control understory vegetation have been proposed

Privacy Fences

Not surprisingly, wooden privacy fences contributed to the incidence of fire damage. Particularly destructive were privacy fences that were attached to the residence. These fences, located directly underneath soffit vents, provided a means for flames to enter a residence through these vents. Several instances were documented where the fence ignited and burned into the residence causing significant structural damage or destruction. In these cases, it was clear that privacy fences were a fire hazard. However, these fences may have also provided some degree of wildfire protection. On a few occasions, the privacy fences acted to deflect the heat of an advancing wildfire long enough for the flame front to move past the home without causing any significant structural damage. In one instance, a burning fence drew nearby firefighters to a home they did not know was there in time to save it from being damaged. Additional investigation is needed to determine if these fences really are a fire hazard or a means of fire protection.

Roof Type, Slope, and Vents

Roofing materials clearly played an important role in protecting homes in the wildland-urban interface from wildfire damage. Although not significant at the 0.05 level, tile roofs provided a greater degree of protection than asphalt shingles. Several instances were observed where tiles or fire-resistant shingles helped to protect a residence from significant structural damage.

Data was also collected on roof slope. This data was omitted from the model, however, as roof slope was not measured in quantitative terms, but was subjectively measured and recorded as either a flat, shallow, or steep pitch. As a result, the data was subject to significant variability due to the imprecise measurement procedure. It would be beneficial in future studies to use more quantitative measurements to determine if roof slope has any effect on fire incidence.

A similar conclusion can be made regarding roof vents. The logit model indicated that roof vents were not significant in predicting structural damage levels. Ridge vents were the most prevalent type of vent and were almost evenly distributed among each damage level. Subsequent research may help to better explain the effect roof vents have on the incidence of wildfire damage.

Exterior Building Materials

The vast majority or residences sampled had an exterior consisting primarily of stucco, especially in the Palm Coast community. The results indicated that this type of exterior had no significant relationship with the three structural damage levels. A similar outcome was observed with homes with brick exteriors. These findings coincide with the study by Abt et al. (1987) which also concluded that exterior building materials were not correlated with the incidence of fire damage to wildland-urban residences. As with the 1985 Palm Coast wildfire, the majority of structural damage from the 1998 wildfires likely stemmed from fire entering through soffit vents.

Branch Removal

Another recommended wildfire home protection strategy suggests that homeowners prune the branches of their yard trees to 15 feet above the ground. This tactic was designed to prevent ground fires from reaching into the crowns of yard trees where the fires can more readily spread. In this study, data was collected on the average amount of branch clearance of all yard trees. As each of the wildfires investigated was primarily high intensity crown fire, this data was not significant in predicting the levels of structural damage. This type of information may be useful in future studies investigating the relationship ground fires may have to the incidence of wildfire damage.

Proximity of Neighbors

The distance and direction of the nearest residence to a sampled home was collected to determine the effect that the closest residence may have had on the amount of structural damage sustained by the sampled home. This data was collected to account for homes that may have been damaged or destroyed as a result of a fire from a nearby home. Due to the high variability of the distance and direction measurements, along with the relatively small sample size, this data proved not to be significantly related with the amount of structural damage.

Summary

This study supports earlier findings by Abt et al. (1987) and Greenlee et al. (1998) which indicated that the type of soffit vent and the amount of vegetation clearance were directly related to the incidence of fire in homes located in the wildland-urban interface. The current analysis indicates that the recommendations developed to reduce the incidence of wildfire damage were effective when implemented. Additionally, the importance of defensible actions was a contributing factor in the results. Unfortunately, budget constraints limited the number of samples that could be collected. Additional funding would have allowed for a larger sample size to further substantiate the findings of this study.

Subsequent studies are needed to better understand the role that prescribed burning or some other fuel reduction measure may have in protecting homes in the wildland-urban interface from wildfires. This type of ongoing fire research is essential to the development of effective wildfire home protection strategies for residences in the wildland-urban interface.

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Table 1. Logistic Regression Model Results (0.05 significance)[1]

Parameter	Coefficient	Chi-Square Statistic	Standard Error	Probability Odds
Intercept 1	17.4662	0.0096	6.7430	-
Intercept 2	21.8397	0.0023	7.1609	-
Metal Soffit Vent	3.5291	0.0056	1.2739	34.09
Frame Home	-8.4953	0.0003	2.3401	4891.72
Brush Clearance North 10-19 feet	-4.3685	0.0011	1.3417	76.92
Brush Clearance West 10-19 feet	-3.0963	0.0053	1.1103	22.22
Brush Clearance East 50-59 feet	-7.2294	0.0308	3.3479	1379.39
Brush Clearance South 0-9 feet	-7.7262	0.0001	1.9792	2266.97
Tree Clearance North 0-4 feet	-2.9971	0.0144	1.2246	20.00
Tree Clearance West 0-4 feet	-4.1850	0.0010	1.2766	66.67
Tree Clearance East 30 or more feet	-2.4588	0.0176	1.0362	11.69
Yard Clear of Debris	4.5882	0.0019	1.4778	98.32

Parameter	Coefficient	Chi-Square Statistic	Standard Error	Probability Odds
No Defensible Actions	-3.9074	0.0002	1.0450	50.00

[1] Degrees of freedom = 1 for all parameters.

Table 2. Logistic Regression Model Results (0.12 significance)[1]

Parameter	Coefficient	Chi-Square Statistic	Standard Error	Probability Odds
Roof Clear of Debris	2.5177	0.0671	1.3750	12.40
Homeowner Defensible Actions	-2.8560	0.0741	1.5988	17.39
Tile Roof	-2.5040	0.0869	1.4624	12.23
Tree Clearance East 20-24 feet	-2.2266	0.1164	1.4183	9.27

[1] Degrees of freedom = 1 for all parameters.

Table 3. Classification Table of Estimated Logistic Regression

		Predicted			
		Destroyed	**Damaged**	**Undamaged**	**Total**
Observed	**Destroyed**	21	4	0	**25**
	Damaged	2	18	5	**25**
	Undamaged	0	5	20	**25**
	Total	**23**	**27**	**25**	**75**

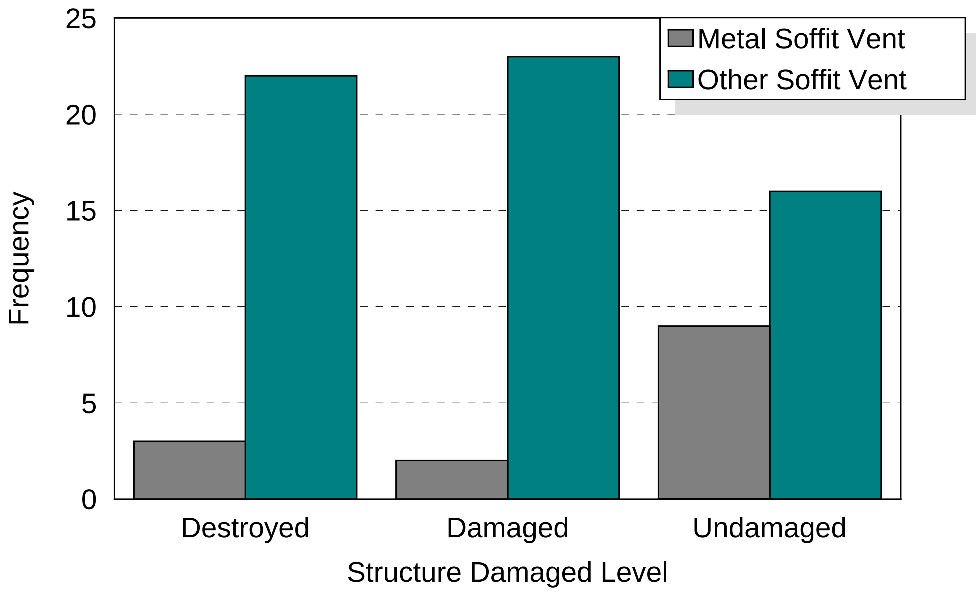

Figure 1a. Distribution of metal soffit vents for each structure damage level.

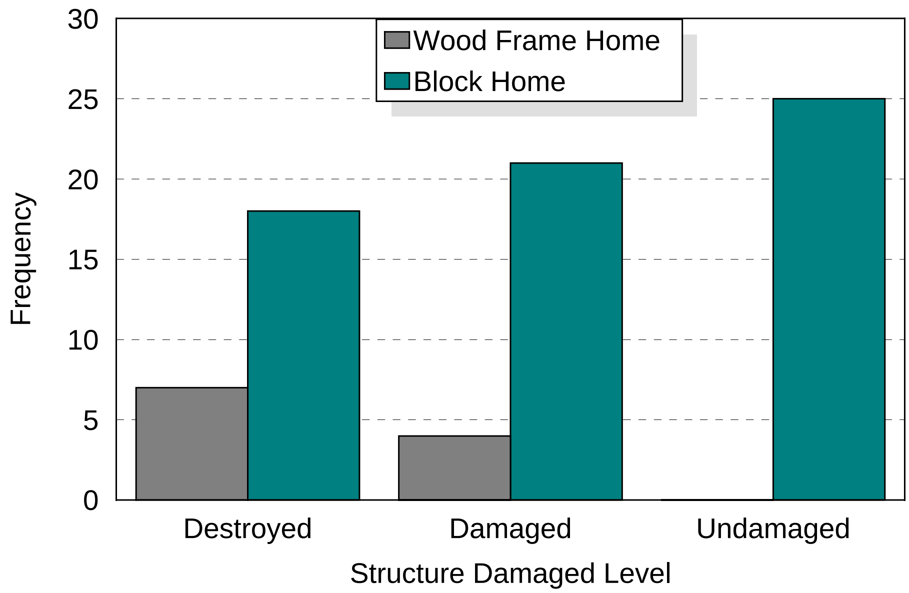

Figure 1b. Distribution of wooden frame homes for each structure damage level.

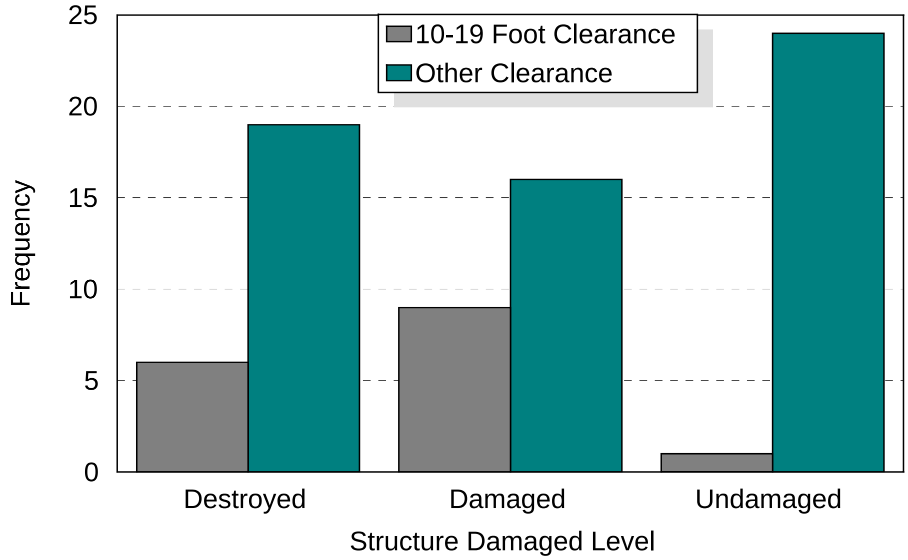

Figure 2a. Distribution of brush clearance north, 10-19 feet, for each structure damage level.

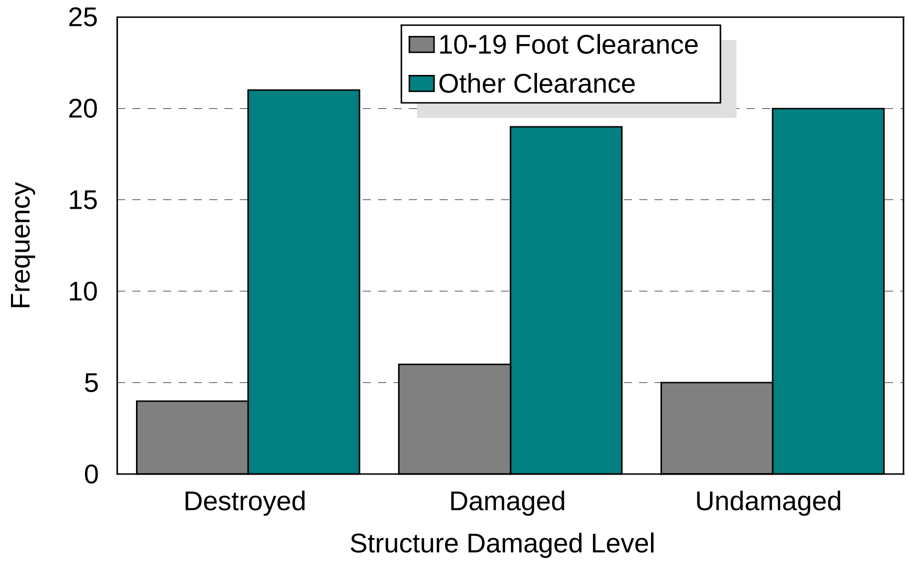

Figure 2b. Distribution of brush clearance west, 10-19 feet, for each structure damage level.

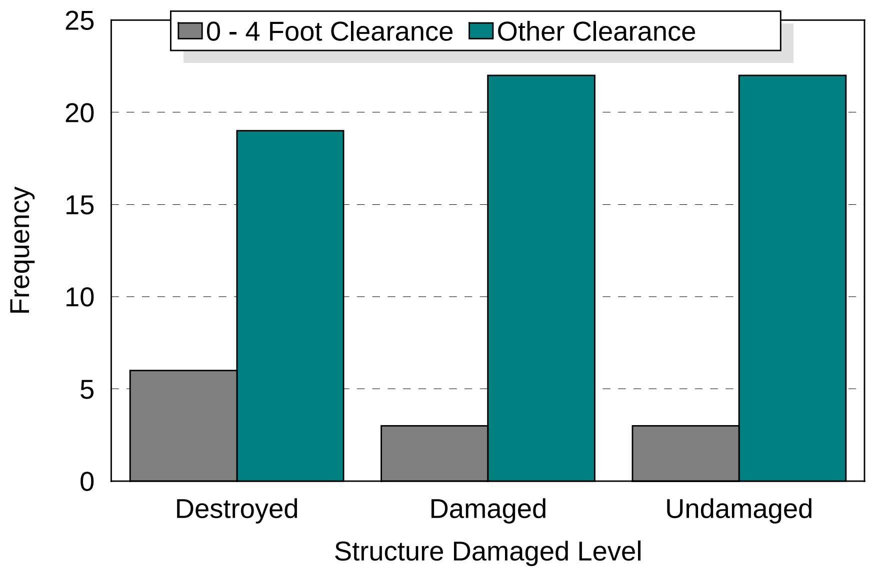

Figure 3a. Distribution of tree clearance north, 0-4 feet, for each structure damage level.

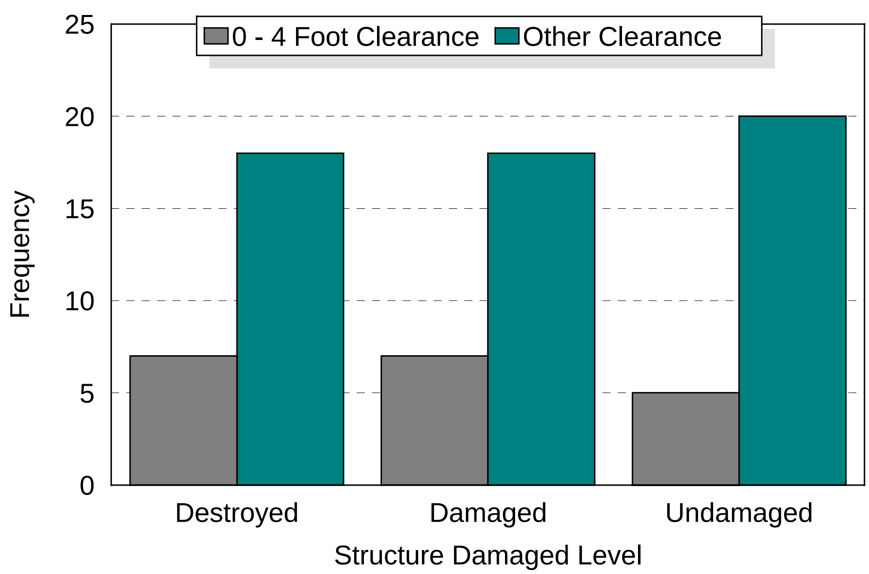

Figure 3b. Distribution of tree clearance west, 0-4 feet, for each structure damage level.

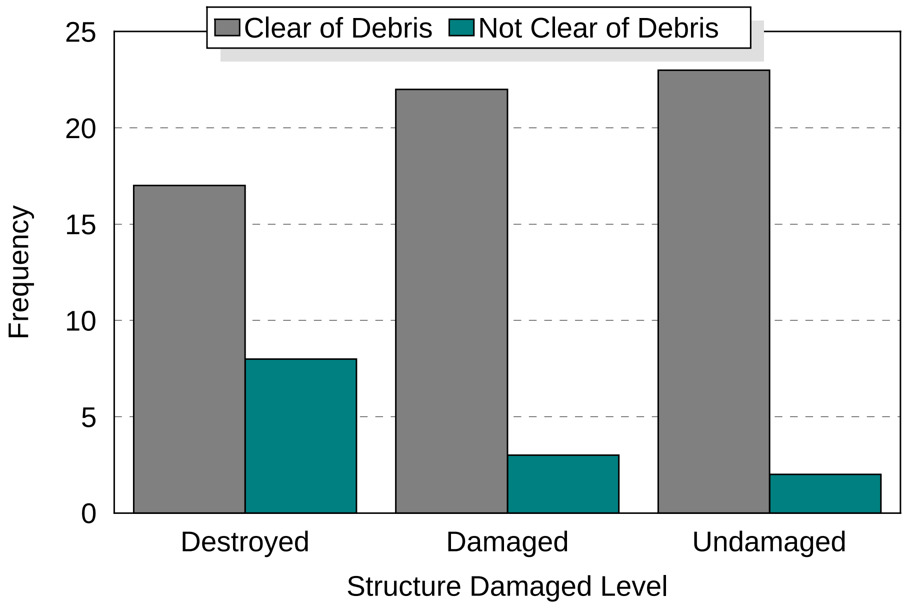

Figure 4. Distribution of homes with yards clear of debris for each structure damage level.

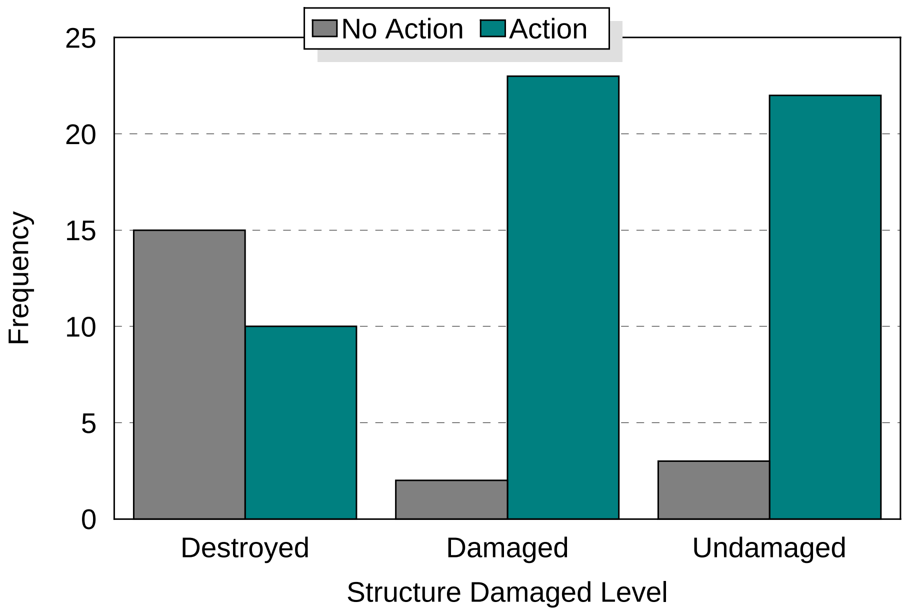

Figure 5. Distribution of homes where no defensible action occurred for each structure damage level.

Appendix A

Home Protection Survey Summary

Exterior Structure Type	Number of Homes
STUCCO	42
WOOD	11
BRICK	4
STONE	0
METAL	3
CONCRETE SHEETING	1
VINYL	13
TAR PAPER	1
Total	75

Soffit Vent Type	Number of Homes
FIBERGLASS	0
METAL SCREEN	10
PLASTIC WITH VENT	8
METAL WITH VENT	13
VINYL WITH VENT	32
WOOD WITH SCREEN	2
NONE	10
Total	75

Roof Pitch	Number of Homes
FLAT	0
SHALLOW	65
STEEP	10
Total	75

Overall Structure	Number of Homes
SINGLE FRAME	55
MOBILE HOME	20
Total	75

Frame Structure Single Frames	Number of Homes
BLOCK	44
FRAME	11

Total	55

Frame Levels	Number of Homes
ONE-STORY	70
TWO-STORY	5
Total	75

Roof Type	Number of Homes
TILE	6
ASPHALT	63
METAL	4
FIBERGLASS	2
Total	75

Yard Fence - North	Number of Homes
YES	4
NO	71
Total	75

Yard Fence - East	Number of Homes
YES	3
NO	72
Total	75

Yard Fence - South	Number of Homes
YES	6
NO	69
Total	75

Yard Fence - West	Number of Homes
YES	2
NO	73
Total	75

Roof Vent	Number of Homes
YES	69

NO	6
Total	75

Roof Vent Type	Number of Homes
RIDGE	46
FLAT	20
METAL	1
TURBINES	2
Total	69

Brush Clearance	Average Distance (Feet)
NORTH	27.63
EAST	25.13
SOUTH	21.79
WEST	25.43

Overstory Canopy Distribution*	Average Overstory Cover (Feet)
NORTH	14.25
EAST	13.35
SOUTH	11.0
WEST	10.6
*only houses with trees present in yard considered.	

Fuel Reduction Measures	Number of Homes
PRESCRIBED FIRE	3
NONE	72
Total	75

Debris on Roof	Number of Homes
YES	30
NO	45
Total	75

Yard Clearance – Pine Straw	Number of Homes
YES	62
NO	13
Total	75

Damage Class	Number of Homes
DESTROYED	25
DAMAGED	25
UNDAMAGED	25
Total	75

Primary Defensible Action	Number of Homes
ROOF WATERING	5
LAWN WATERING	1
FIRE LINES	1
FIRE DEPARTMENT ACTIONS	41
OTHER	2
NONE	25
Total	75