

Oregon Department of Forestry



TECHNICAL BULLETIN

Wildfire Prevention and Control in Areas of Residential Forest Land Development: An Analysis of Fire Data

PREPARED BY THE
OREGON DEPARTMENT OF FORESTRY
WITH THE ASSISTANCE OF THE
OREGON DEPARTMENT OF LAND CONSERVATION
AND DEVELOPMENT

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Homes burned by wildfire attract intense public and news media attention. Wildland fire protection agencies have long held that residential development on forest lands increases the risks of wildfire incidence and the hazards of wildfire suppression. Many have also suggested that the presence of residential dwellings can also restrict or redirect fire fighting efforts normally used to extinguish wildland fires, which results in increased loss of forest resources and increased fire fighting costs.

Despite these perceptions, little effort has been made to document the risks and hazards of wildfire posed by residential development on forest lands (the urban/forest interface) and to test these hypotheses.

This study analyzes fire report and other data and provides a spatial analysis of digitized map information, such as the location and types of fires over a 5-year period, dwelling densities and land use zones.

The results support the hypothesis that residential development in the urban/forest interface significantly increases the risk of wildfire. The results also show that large fires that threaten residential developments cost significantly more to extinguish than similar fires in unpopulated areas. Findings related to fire hazard were not conclusive.

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To more fully test the questions and perceptions described previously, additional analysis is needed to properly isolate factors that influence wildfire hazard. The development of databases and digitized map layers through this study will enhance further analysis efforts.

WILDFIRE AND FIRE PROTECTION IN OREGON FORESTS

Lightning caused many forest fires in Oregon before the arrival of European settlers. Native Americans also started many fires for various reasons — such as clearing land and driving game. Some of these fires burned for long periods, occasionally with furious intensity. Overall, forest fires occurred frequently.

European settlers used fire for clearing agricultural land, and fires commonly escaped control. The large-scale logging of low-elevation old-growth timber in the late 1890s and early 1900s created large amounts of burnable woody debris — a precursor for later wildfire disasters.

The Tillamook Burn Fires of 1933, 1939 and 1945 — all of which were caused by human activity — had a major effect on the development of Oregon's fire prevention program. In 1953, Oregon State Law (ORS Chapter 477) was strengthened to give the state forester authority to prevent forest fires and to recover suppression costs from those who caused the fires. The state forester also regulates public, landowner and forest operator activities that are perceived as wildfire risks and hazards.

The Oregon Department of Forestry (ODF) and USDA Forest Service (USFS) provide the majority of fire protection to forest land in Oregon — 15.9 million and 16 million acres, respectively. A third agency, the USDI Bureau of Land Management (BLM), provides fire protection to approximately 13.1 million acres of wildland, much of which is rangeland in eastern Oregon (Table 1). Two additional federal agencies, the USDI Bureau of Indian Affairs (BIA) and USDI National Park Service (NPS), provide fire protection to relatively small areas of forest land in Oregon. However, these agencies are important cooperators in fire protection efforts.

**Table 1. Wildland Protection Base
(Approximate Acres)**

Agency	Forest	Nonforest	Total
ODF	12,962,400	2,914,400	15,876,800
USFS	16,104,700	0	16,104,700
BLM	987,000	12,183,000	13,170,000
BIA	105,000	560,000	665,000
Totals	30,159,100	15,657,400	45,816,500

For many years, the Oregon Department of Forestry and the USFS focused their fire prevention programs on preventing forest fires caused by lumber production, logging, slash burning and land clearing. Public fire prevention efforts included education programs such as Smokey Bear and Keep Oregon Green.

In the 1960s, a growing number of human-caused wildfires unrelated to the logging industry resulted in an increase in wildfire suppression costs and resource losses. The Oregon Department of Forestry responded by developing more sophisticated fire prevention programs that addressed specific causes.

Each forest protection district developed targeted fire prevention programs, first implemented in 1972, that were largely successful. For example, railroad-related activities caused more than 110 fires in 1970. Fire prevention efforts targeted railroad-related causes — improving engineering and maintenance of spark arresters, managing vegetation in rights-of-way, and adding suppression equipment and facilities — which, along with rail line abandonment and reduced use of railroads in forested areas, resulted in a reduction of railroad-caused fires to an average of around 13 annually.

Also in the early 1970s, the urban/forest interface first became an important issue in Oregon. Additional prevention efforts focused on children-caused fires, debris-burning fires and other specific problems unique to or associated with dwellings in the forest. Since many residential developments in the forest represent areas of joint fire protection responsibility or shared concern, fire protection agencies implemented a cooperative fire prevention strategy directed at the rural forest resident that proved both efficient and effective. This joint effort involved the Oregon Department of Forestry, USFS, BLM, rural fire protection districts, and fire protection agencies that shared fire protection responsibilities in the urban/forest interface.

Air quality regulations implemented in the 1970s also influenced the number of wildfires caused by open burning, including slash burning and agricultural field burning, particularly in western Oregon. Regulation of open burning drastically reduced the number of days that burning could take place, and had both positive and negative effects on fire prevention.

Despite the absence of documentation of the role of rural development on fire ignition and suppression, the empirical evidence has been compelling enough for the Oregon legislature, the Land Conservation and Development Commission (LCDC) and the Oregon Board of Forestry each to take recent actions affecting the urban/forest interface.

Following Oregon's disastrous 1987 fire season, the Wildfire Planning Task Force was formed to address the problem of fires in Oregon's urban/forest interface. The LCDC, following the recommendations of the task

force, adopted a new Forest Land Goal and administrative rules on January 25, 1990. Among the provisions are wildfire safety considerations for the siting of structures on forest land (Goal 4 lands).

Similarly, the 1989 Legislature clarified the Department of Forestry's "mission" regarding forest fire protection because of the increased number of priority decisions — homes versus natural resources — being made by fire control managers. The statute now affirms that "the need for a complete and coordinated forest protection system is acknowledged and the primary mission of the Department in such a system is protecting forest resources second only to saving lives. Structural protection, though indirect, shall not inhibit protection of forest resources" (Oregon Revised Statutes 477.005, *emphasis added*).

The Board of Forestry, as part of its 1990 *Forestry Program for Oregon*, also took an active stance on the wildfire problem in the urban/forest interface. The program calls upon the Department of Forestry to:

- Create awareness in Oregonians of the possible consequences of wildfire to dwellings;
- Promote adoption of land use and building codes to prevent and minimize fire-related effects;
- Ensure that fire protection efforts in the interface are fully coordinated with other responsible agencies; and
- Encourage development of improved rural fire defense, specifically fire protection for rural structures.

These actions prompted public questions regarding the scope of Oregon's urban/forest interface wildfire problem — its costs and the effects on neighboring forest resources — as well as the need for further wildfire safety measures. No comprehensive resource was available to answer these questions.

Therefore, this analysis attempts to fill a portion of that information gap. The goal is to identify and quantify the impact, if any, that residential development may create for wildfire protection on forest lands.

METHODOLOGY

The methodology for analyzing the data was designed to address four specific questions:

1. Does residential development on forest lands (the urban/forest interface) increase the risks (the probability of a fire starting) of wildfire?
2. Does residential development on forest lands increase the wildfire hazard (the difficulty of fire control due to factors such as fuel, topography, level of initial attack and detection, and weather)?
3. Does residential development result in greater loss to forest land and increased fire-fighting costs?

4. What, if any, are the other effects of residential development on fire protection?

Information to analyze all four questions was gathered from state-wide Oregon Department of Forestry and USFS fire data.

Oregon Department of Forestry, USFS and other agency fire report records contain data that were used to establish trends related to urban/forest fire causes, fire losses and fire suppression costs.

Oregon Department of Forestry fire data were available for the period from 1956-90. USFS fire data were available for the period of 1970-90. The accessibility and comprehensive nature of Oregon Department of Forestry fire data enabled a significantly more detailed analysis with the Oregon Department of Forestry data base.

Fire data from the four Oregon Department of Forestry protection units were examined to see if a statistical correlation exists between the presence of dwellings and the occurrence of fires. Using digitized map data for the four Oregon Department of Forestry units over a five-year period, the location and types of fire starts were spatially correlated with dwelling densities and zoning. The locational data covered the period 1986-90.

Changes in forest fuels were analyzed using historical information from the BLM, USFS and state agencies. Some of the work was done by comparing historical photographs and historical drawings with current photographs. This analysis was strictly subjective.

One method used in analyzing the question of forest resource loss and increased fire fighting costs was to compare incidence of "escaped" fires — fires that escaped initial attack — for sites in the urban/forest interface and non-interface sites. Since 1971, the Federal Emergency Management Agency (FEMA) has administered a program offering disaster assistance to states for fires that become or threaten to become a major disaster because of a large number of dwellings. Therefore, fires declared by FEMA to constitute a major disaster were compared with similar-sized non-FEMA-eligible fires to determine whether the costs for fighting large fires in areas of residential development were greater than the cost of fighting similar-size fires in unpopulated areas. The 1990 Awbrey Hall fire near Bend is an example of a FEMA fire.

Other fire protection-related effects of residential development in forest lands were analyzed through review of state-wide Oregon Department of Forestry fire data and analysis of fire data from other agencies, mainly the Office of the Oregon State Fire Marshal. Additional information about the urban/forest interface fire problem was gathered through a survey conducted as part of the LCDC's Farm and Forest Land Study. One component of the study included a survey to explore the frequency and severity of conflict be-

tween forest land operators and nearby residents, including direct and measurable effects of human-caused fire.

Because of the prevention efforts and air quality programs implemented in the 1970s, the 20-year period from 1971-90 was most commonly analyzed. Other factors considered when analyzing fire data were weather and climate variability, improved technology and improved forest access. Weather and climate are obviously significant factors in the number of fires and acres burned. Much of the variability observed in the fire data can be explained by variations in these factors. Less obvious are the effects of technology and access. In many ways, these two factors work together. Improved access has resulted in greater opportunity to apply improved fire-fighting technology, and thus have resulted in quicker initial attack response times and enhanced fire detection.

GENERAL SUMMARY OF FIRE REPORT DATA

Wildfire is common on Oregon's forest lands. On land protected by the Oregon Department of forestry and USFS from 1970-90, a total of 50,504 forest fires burned 915,918 acres. An average of 2,405 forest fires and 43,615 acres burned per year. The annual number of fires ranged from a low of 1,461 fires (1983) to a high of 3,940 fires (1970). The annual acres burned ranged from a low of 4,212 acres (1975) to a high of 245,352 acres (1987) (See Fig. 1).

From 1970-90, both number of fires and acres burned are larger on USFS-protected lands. During that period a total of 26,716 fires (1,272 fires per year) burned 625,015 acres (29,762 acres per year) on USFS-protected land. In comparison, during the same period, a total of 23,788 fires (1,133 fires per year) burned 290,903 acres (13,852 acres per year) on Oregon Department of Forestry-protected land. However, on an annual basis comparison shows considerable variation on whether the Oregon Department of forestry or USFS lands had the larger number of fires and acres burned (Figs. 2 and 3).

Looking longer-term, data available for Oregon Department of Forestry-protected lands show that a total of 36,483 fire burned 565,019 acres during the period 1956-90.

The primary cause of wildfire differs between federally and state-protected lands. On USFS-protected lands lightning caused most fires, with 17,318 fires (64 percent of the total) burning 526,982 acres (84 percent of the total) (Fig. 4). Humans caused most fires on Oregon Department of Forestry-protected lands, having started 16,661 fires (70 percent) burning 149,876 acres (52 percent) (Fig. 5).

The number of fires and acres burned varies widely from year to year. For example, on Oregon Department of Forestry-protected lands from 1956-90, the number of fires averaged 1,057, with a low of 582 fires in 1959 and a high of 1,678 in 1970 (Fig. 6). Acres burned averaged 16,143, with a low of 2,296 acres in 1984 and a high of 91,441 in 1987. The variation in acres burned is highly related to weather and climate, as measured by burning index (BI). The number of fires is inversely related to BI. The success of fire prevention programs directed at human-risk activities is apparent at high to extreme BIs. Average fire size increases in direct relationship to increases in BI (Table 2). Due to drought and other weather factors, the most recent five-year period saw a substantial increase in the number of acres burned.

TABLE 2: Acres Burned, Number of Fires, and Average Fire Size by Burning Index (BI) ODF Protection (1956 - 1990)

	No BI#	0-29	30-59	60-79	80+
Acres	16,726	39,0461	15,706	180,566	212,973
Number of Fires	3,252	7,021	13,489	8,453	4,104
Avg. Size (Acres)	5.14	5.56	8.58	21.36	51.89

#No BI means fire occurred outside of fire season. Generally, these fires occur during periods of "low" fire danger; i.e. 0-29 BI.

Large, disastrous fires are not infrequent in Oregon. During the 21-year period of 1970-90 on USFS-protected lands, there were six years during which more than 20,000 acres (over 30 square miles) were burned. Of these six years, the most recent five years, 1986-90, saw in excess of 50,000 acres burned in each year.

During the 35-year period of 1956-90, there were eight years (22.85 percent) during which more than 20,000 acres burned on Oregon Department of Forestry-protected lands. Among those years, three saw more than 50,000 acres burned.

Historically, much larger fires, in terms of acres, have occurred both in areas east and west of the Cascade Range, but the most notorious were western Oregon fires, including the three Tillamook fires, The Bandon Fire of 1936 and the 700,000-acre Yaquina Fire of the 1850s.

QUESTION 1:

DOES RESIDENTIAL DEVELOPMENT ON FOREST LANDS INCREASE THE RISKS OF WILDFIRE?

Note: "Risk," as used in this report, refers to the probability of wildfire occurring. An increased risk in areas of residential development on forest land would indicate that wildfire would be more likely to occur and would occur more frequently in areas of development than in unpopulated regions.

FIGURE 1: TOTAL NUMBER OF FIRES AND ACRES BURNED IN OREGON (1970 - 1990)

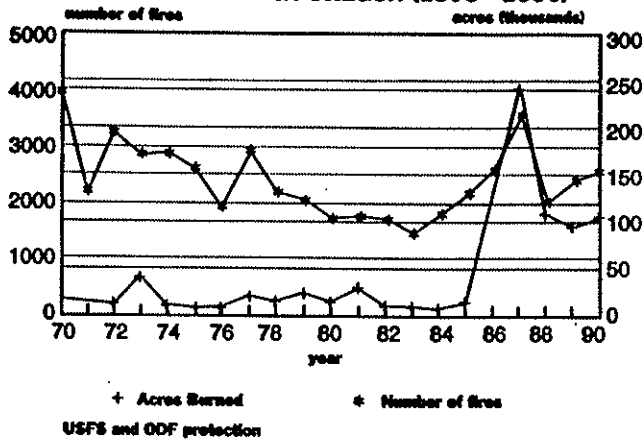


FIGURE 4: NUMBER OF FIRES (1970-90) USFS PROTECTION

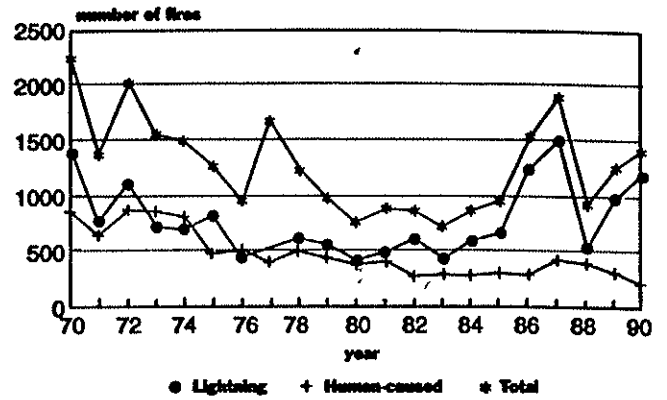


FIGURE 2: NUMBER OF FIRES (1970-90) USFS AND ODF PROTECTION

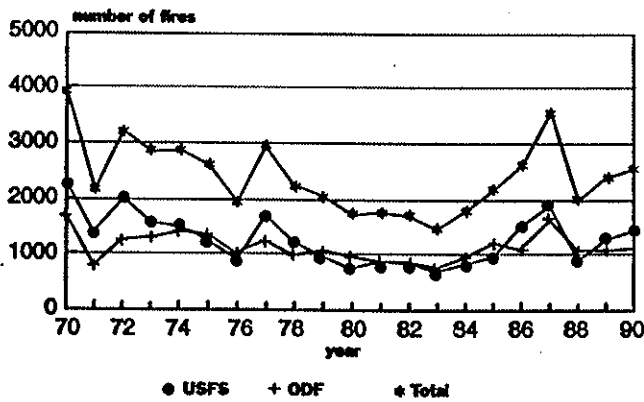


FIGURE 5: NUMBER OF FIRES BY CAUSE ODF PROTECTION (1970-90)

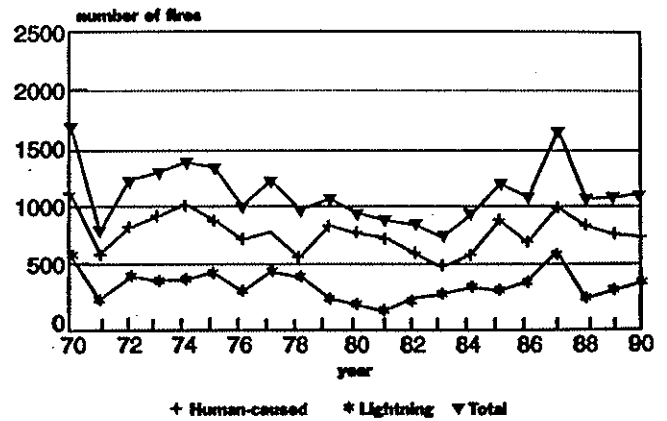


FIGURE 3: ACRES BURNED (1970-90) USFS AND ODF PROTECTION

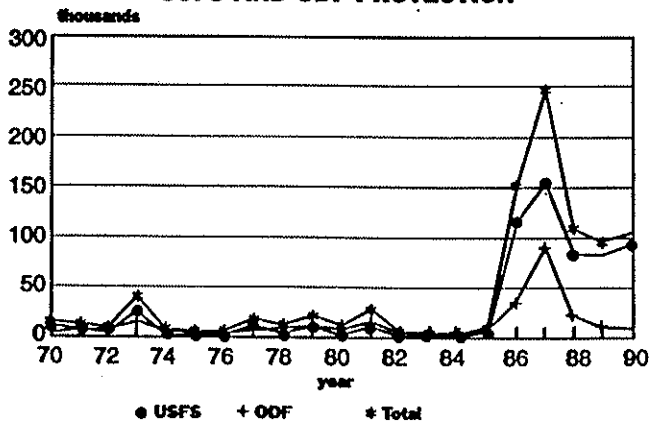
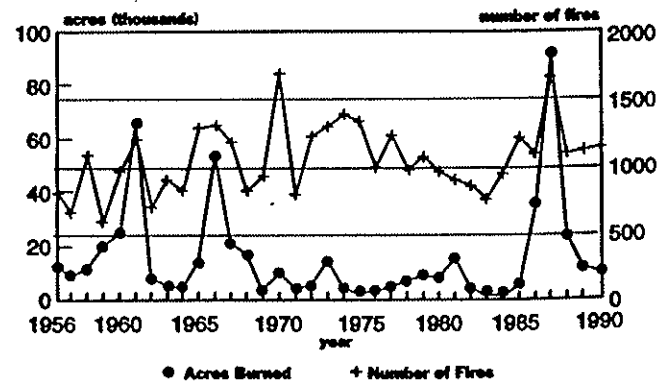


FIGURE 6: ACRES BURNED AND NUMBER OF FIRES ODF PROTECTED LANDS (1956-90)



FINDINGS

People caused most of the fires on lands protected by the Oregon Department of Forestry. Of the 36,983 fires that occurred on Oregon Department of Forestry-protected land during the 35-year period starting in 1956, more than 67 percent were human-caused. During the most recent ten-year period (1981-90), human-caused fires accounted for 70 percent of the total number of fires.

Lightning was the origin for 64 percent of all fires occurring on USFS-protected lands. During the 1970-90 period studied, lightning caused 17,138 fires out of the total of 26,716.

Data for Oregon Department of Forestry-protected lands from 1956-90 reveal an increasing trend in the number of human-caused fires overall (Fig. 7). However, data appears to indicate the positive effects of the prevention program implemented in the early 1970s, when a temporary downward trend began. The downward trend in human-caused fires persisted until the early 1980s, when the trend appears to reverse itself. Lightning fires on Oregon Department of Forestry lands have been randomly distributed, showing no obvious trend. During the 1970-90 period, the number of human-caused fires on USFS-protected lands steadily decreased (Fig. 8).

On Oregon Department of Forestry-protected lands, three general cause categories — logging, debris burning and miscellaneous — showed increasing trends in the number of fires caused over the past 20-year period (Fig. 9). During the same period, the remaining five general cause categories — railroad, camper, smoker, arson and children — showed decreasing trends (Fig. 10).

For Oregon Department of Forestry-protected land, debris burning and miscellaneous categories also show an increasing trend between 1956-90. The debris-burning fire problem is increasing despite a significant reduction in opportunity to burn. Both debris burning and miscellaneous categories are generally related to rural residents.

Many of the human-caused fires on Oregon Department of Forestry-protected lands are related to rural forest dwellers (ruralists). In the 1956-90 period, ruralists caused 17.3 percent of the total number of fires and 25.6 percent of the human-caused fires. During the most recent ten-year period, ruralists accounted for 18.7 percent of the total number of fires and 26.7 percent of the human-caused fires, indicating a moderately upward trend in ruralist-caused fires for the 1956-90 period (Fig. 11).

Structures and power lines associated with residential development create risk to forest land. From 1956-90 on Oregon Department of Forestry-protected land, there were 650 (an average of 18.6 per year.) fires caused by burning dwellings and 49 fires caused by

chimney sparks. During the same period, power lines caused 854 (an average of 24.4 per year) fires. Both burning building and power line fires show increasing trends on Oregon Department of Forestry-protected lands; the trend in power line fires is increasing substantially (Fig. 12).

On Oregon Department of Forestry-protected lands, the number of human-caused fires is strongly correlated with dwelling density in each of the four protection units analyzed. A statistically significant relationship was found between the number of dwellings in a section (640 acres) and the number of fires that had occurred in that section during the period 1986-90. In each of the protection units examined, the number of human-caused fires within a section showed an exceedingly strong correlation with the number of dwellings (significance level = .0000).

Second, dwelling densities were plotted in six different density ranges: no dwellings, 1 to 5 dwellings, 6 to 10 dwellings, 11 to 20 dwellings, 21 to 40 dwellings and 40 or more dwellings per section. The number of sections within each protection unit was compared by dwelling density range to the number of total fires occurring within these sections. This produced an average number of fires per section in each density range. For each protection unit, the average number of fires in a section increased in a direct proportion to the increase in dwelling density (Figs. 13-16).

Due to the a high number of dwellings as well as a high number of fires on the Department of Forestry's Sisters Protection Unit, it was possible to use a Logistic Regression analysis to assess the change in the likelihood that a fire would start in a section with a given number of dwellings present. When compared to sections without dwellings, the presence of 1 to 5 dwellings increased the odds of a section having a human-caused fire 2.6 times. Similarly, the odds of having a fire in sections with 6 to 10 dwellings increased 4.7 times, 21 to 40 dwellings increased the likelihood of a fire 21.3 times, and sections with more than 40 dwellings were 71.4 times more likely to have a human-caused fire when compared to sections without dwellings. (The change in odds of fire starts for the 11 to 20 dwelling category was not statistically significant due to a small sample size.)

On Oregon Department of Forestry-protected lands, the combined fire prevention effort directed at human-caused fires appears to be effectively reducing some types of human-caused fires, especially railroad fires and children-caused fires. Similarly, but with somewhat more success, USFS prevention efforts appear to be reducing human-caused fires on their lands. The specific reduction being made on USFS-protected lands could not be determined with the data. Identifying the affected causes would be useful. However, despite vigorous coordinated prevention efforts and direct regulation of open burning, the total number of some human-caused fires on Oregon Department of Forestry-

FIGURE 7: NUMBER OF HUMAN-CAUSED FIRES ODF PROTECTION (1956-90)

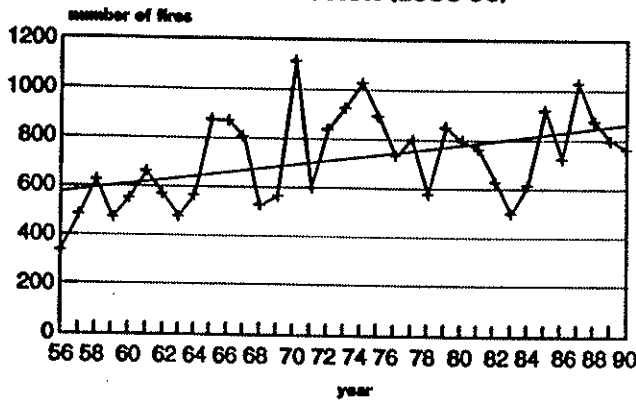


FIGURE 8: HUMAN-CAUSED FIRE TRENDS USFS (1970-90)

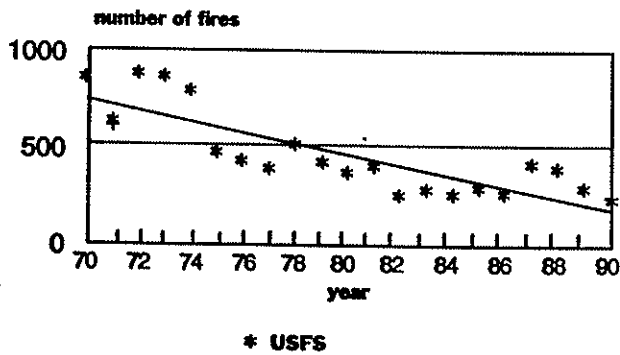


FIGURE 10: NUMBER OF FIRES BY CAUSE DECREASING TRENDS, ODF PROTECTION

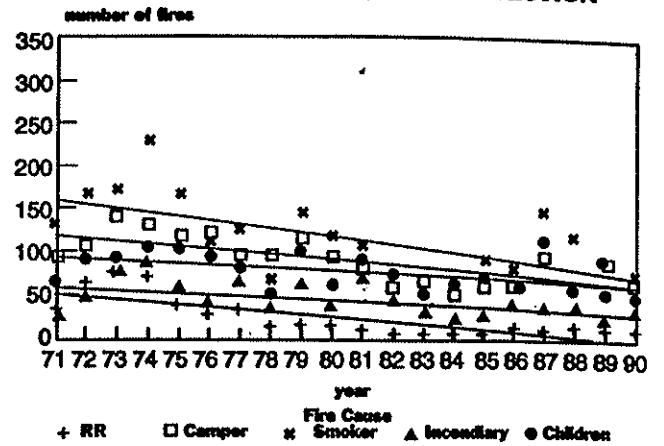


FIGURE 11: NUMBER OF RURALIST FIRES ODF PROTECTION (1956-90)

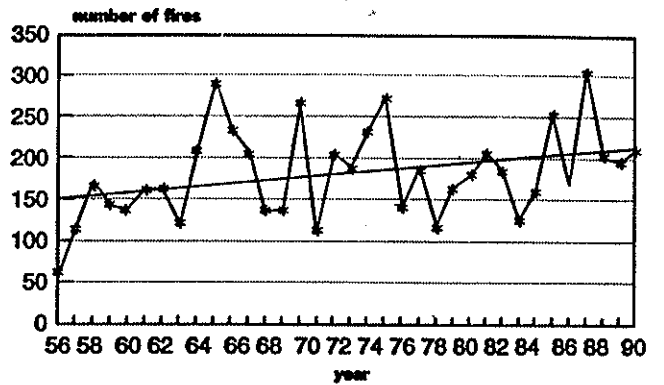


FIGURE 9: NUMBER OF FIRES BY CAUSE INCREASING TRENDS ODF PROTECTION

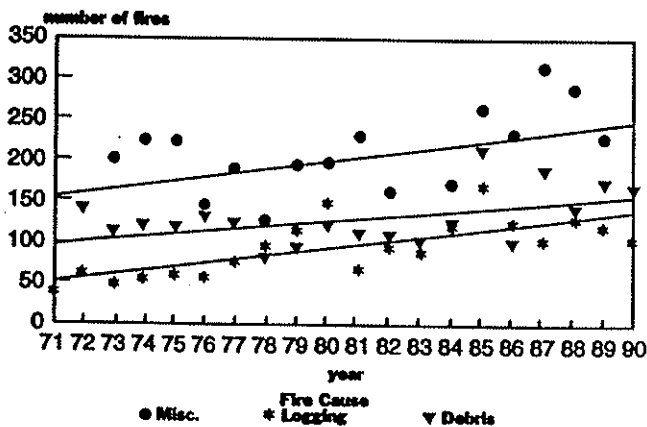
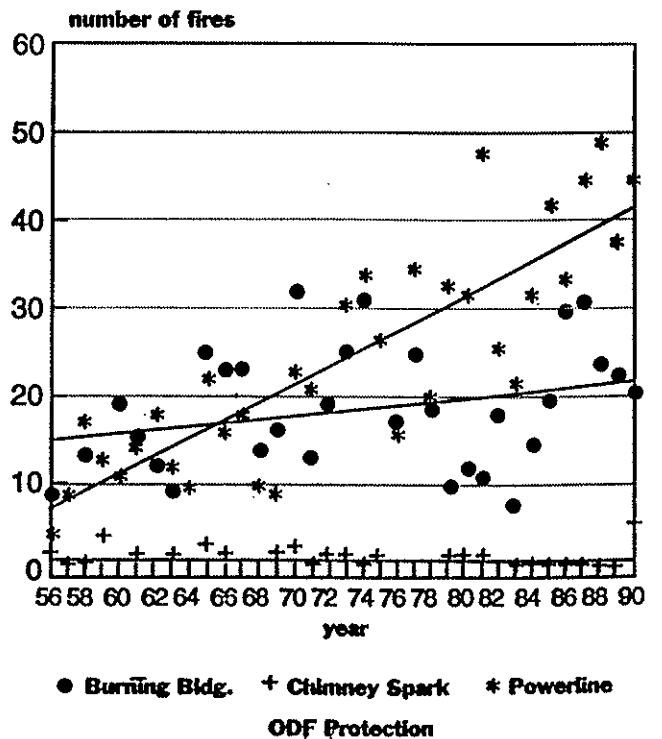
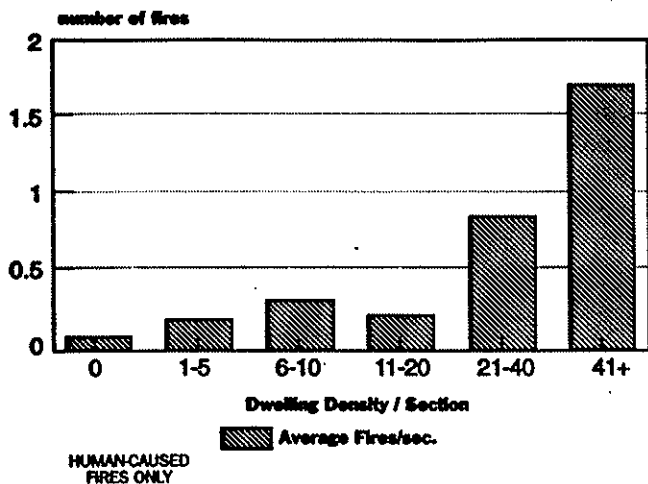


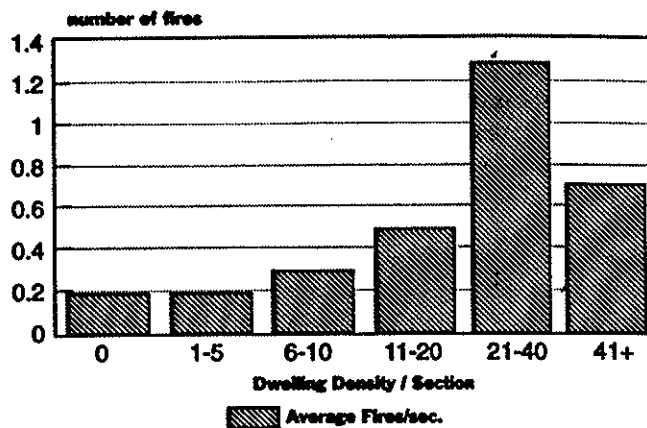
FIGURE 12: BURNING BLDG., CHIMNEY AND POWERLINE FIRES (1956-90)



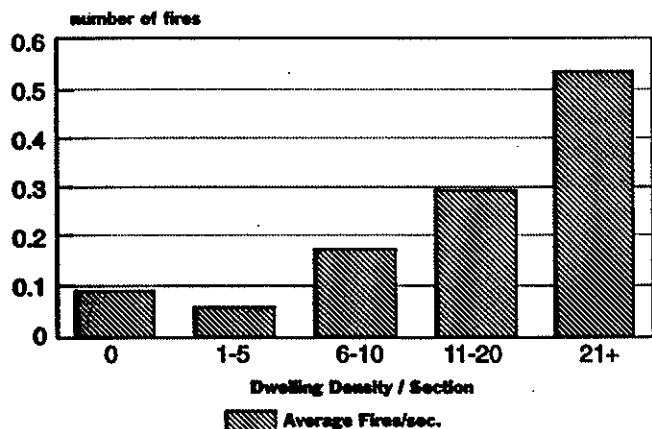
**FIGURE 13: AVE. FIRES/SECTION
Sisters Unit (1986 - 1990)**



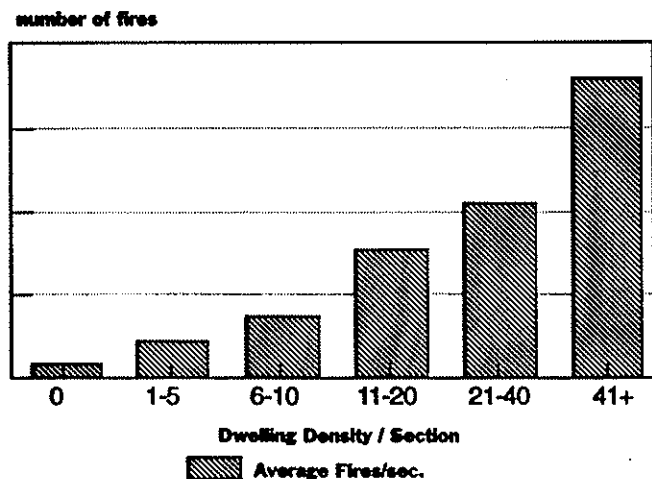
**FIGURE 16: AVE. FIRES/SECTION
(The Dallas Unit 1986-1990)**



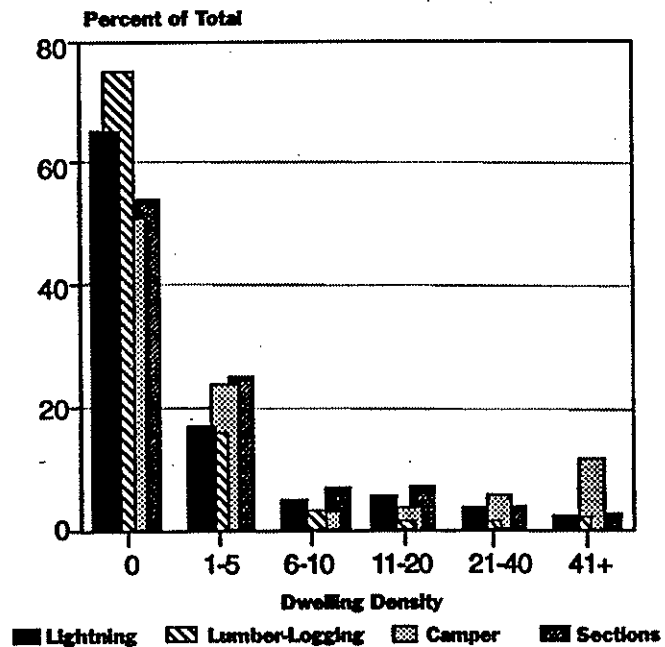
**FIGURE 14: AVE. FIRES/SECTION
(Dallas Unit 1986-1990)**



**FIGURE 15: AVE. FIRES/SECTION
Medford Unit (1986-1990)**



**FIGURE 17: PERCENT OF FIRES BY
CAUSE BY DWELLING DENSITY**



Percent of the total number of fires for each general cause and percent of total sections

FIGURE 18: PERCENT OF FIRES BY CAUSE BY DWELLING DENSITY

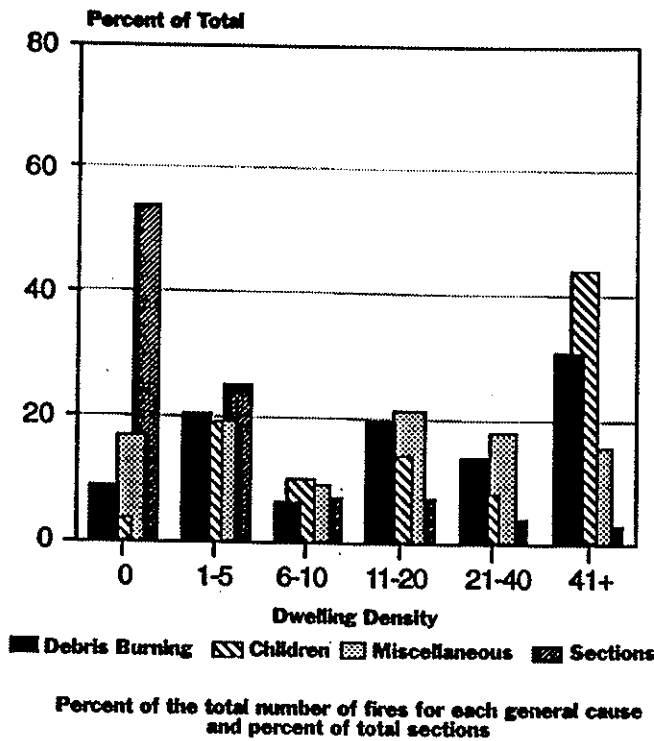
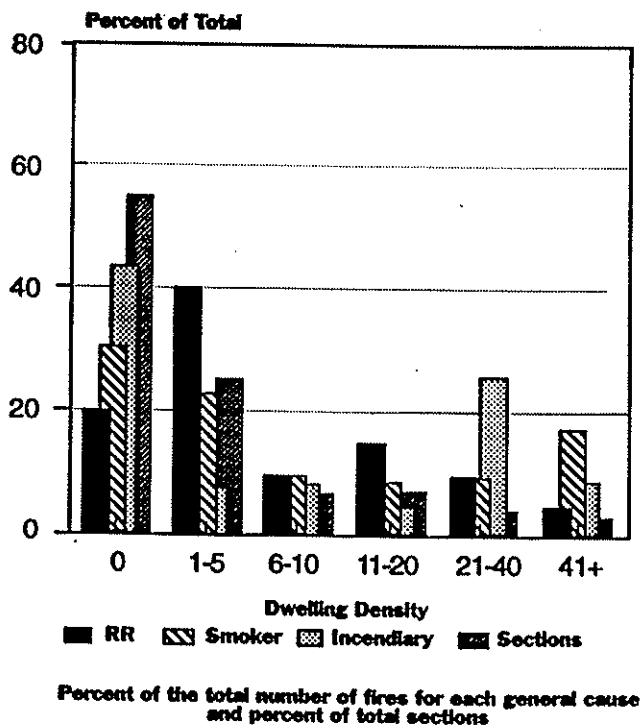


FIGURE 19: PERCENT OF FIRES BY CAUSE BY DWELLING DENSITY



protected lands is increasing, particularly debris-burn- ing fires and miscellaneous-cause fires.

Some general causes appear to be more strongly related to increased residential development than others. For the four Oregon Department of Forestry protec- tion units analyzed, the total number of fires were plotted by general cause and dwelling density. We then compared fire cause by section to dwelling density (Figs. 17-19).

Based upon the total number of all fires occurring by density range, for sections with no dwellings, the leading fire cause was lightning (53 percent of the total number of all fires that occurred within this density level), followed by miscellaneous (12 percent), logging (10 percent), camper (9 percent) and smoker. For sections with densities of 1 to 5 dwellings, the leading causes were miscellaneous (27 percent), lightning (26 percent), smoker (12 percent) and debris burning (12 percent). For sections with dwelling densities of 6 to 10 dwellings, the leading causes were miscellaneous (36 percent), lightning (20 percent), smoker (14 percent), debris burning (10 percent) and children (10 percent). For the 11 to 20 dwelling per section density, the leading causes were miscellaneous (46 percent), debris burning (18 percent) and lightning (15 percent). For sections with densities of 21 to 40 dwellings, the leading causes were miscellaneous (48 percent), debris burning (15 percent) and lightning (11 percent). For sections with more than 40 dwellings, the leading causes of fire were miscellaneous (30 percent), debris burning (24 percent), children (21 percent) and smoker (12 percent). For all sections within the four protection units, the causes by percent of total were lightning (29 percent), miscellaneous (28 percent), debris burning (11 percent), smoker (10 percent), children (7 percent), camper (6 percent), logging (5 percent), arson (2 per- cent) and railroad (2 percent).

A relationship between incendiary or arson fires and residential development appears to exist based upon Oregon Department of Forestry data (Fig. 19).

The LCDC Farm and Forest Land Study survey found that forest operators who had conducted commercial harvest activities such as commercial thinning, salvage and especially clearcutting experienced a significantly higher level of fires caused by the general public (non- ruralists).

CONCLUSIONS

Residential development on forest land significantly increases the risk of wildfire. USFS lands generally are free of residential development, and lands protected by the USFS have many fewer human-caused fires than Oregon Department of Forestry-protected lands, even though the acreage protected by each agency is more or less the same. This is true despite the high level of recreational use that occurs on USFS lands.

The Oregon Department of Forestry protects the lands in the urban/forest interface where the majority of residential development exists. Humans cause most of the fires on Oregon Department of Forestry-protected lands, and rural residents contribute significantly to the number of human-caused fires.

Statistical analysis of the available data confirms that an increased density of residential development will increase the number of human-caused fires.

Fire prevention efforts can be effective in mitigating some of the increased risk posed by siting residential dwellings on forest land. Certain causes — in particular, children, arson, debris burning and miscellaneous causes — appear to be strongly related to residential development. Continued prevention efforts in the urban/forest interface targeted at these causes may be very beneficial in preventing disastrous fires.

Additional efforts, such as siting and road access standards or building codes directed at mitigating the added risks in areas zoned "rural-residential" and those areas within urban growth boundaries may be necessary. Administrative Rules do not currently require consideration of wildland fire risks when granting permits or when siting developments.

Additionally, it appears that special attention should be directed at preventing the rapidly increasing number of power line fires. The October, 1991, fires in eastern Washington, where strong winds produced many power line fires with severe consequences, should be especially worrisome when placed in the context of the growing trend in Oregon. One possible mitigation would be to locate power lines underground in forested subdivisions.

QUESTION 2:

DOES RESIDENTIAL DEVELOPMENT ON FOREST LANDS INCREASE THE WILDFIRE HAZARD?

Note: "Hazard," as used in this report, means the difficulty of fire control, once a fire has started, due to factors such as fuel, topography, level of initial attack, detection, and weather.

If the established hypothesis related to wildfire hazard is correct, everything else being equal, increased fire hazard would result in:

- More rapid rates of spread and higher fire intensities, thus larger fire sizes, higher costs, and more fires that escape initial attack, and
- Over time, a gradual overall increase in fire size.

FINDINGS

Interpretation of various photo pairs and other data from throughout Oregon shows that vegetation changes

are occurring on forest land. These changes may increase the forests' susceptibility to disastrous fire. The data do not suggest, however, that changes in vegetation are occurring any differently on residential forest land than on general forest land, although many dwellings, especially in central Oregon, are being sited in areas that have experienced significant vegetation changes.

Fire is a significant historical event in all of Oregon. BLM data show that the north Coast Range has been the location of several large stand-replacement fires since 1850; however, fire occurrence tends to be more frequent in other areas of the state.

State-wide, on Oregon Department of Forestry-protected lands from 1956-90, the overall trend in average fire size is decreasing. This decrease is due to a smaller average fire size in western Oregon. In eastern Oregon, the trend in average fire size has been constant during the 35-year period examined.

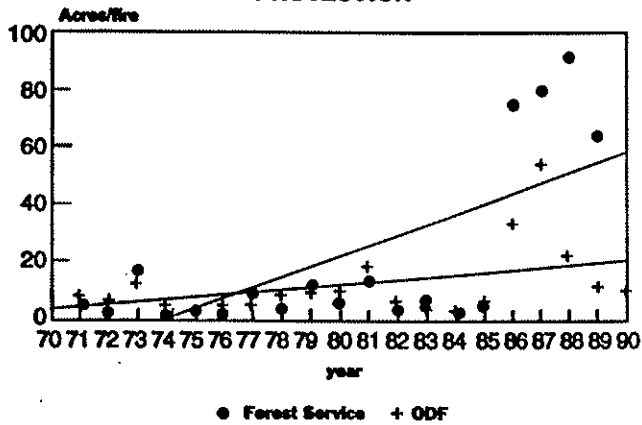
From 1970-90, on both Oregon Department of Forestry and USFS lands, the trend in average fire size is increasing, with the trend on USFS land increasing at the highest rate (Fig. 20). Over this period, the average USFS fire was 21.89 acres, and the average Oregon Department of Forestry fire was 11.3 acres. The Oregon Department of Forestry, however, had the greatest average fire size in 11 of the 21 years. The high number of fires during the period 1986-90 is a major factor in the increasing trends.

In each of the four Oregon Department of Forestry protection units analyzed, the majority of human-caused fires occurred on lands that are also within rural fire protection districts (RFPDs), while the large majority of lightning fires occurred outside of RFPDs (with the exception of the Dallas Unit, which experienced only two lightning fires during the analysis period, one inside RFPD boundaries and one outside). On the Sisters Unit, 82 percent of all human-caused fires occurred within an RFPD; Medford Unit, 55 percent; Dallas Unit, 61 percent; and The Dalles Unit, 52 percent. The percentage of lightning fires occurring outside RFPDs were Sisters, 80 percent; Medford, 83 percent; Dallas, 50 percent; and The Dalles, 94 percent.

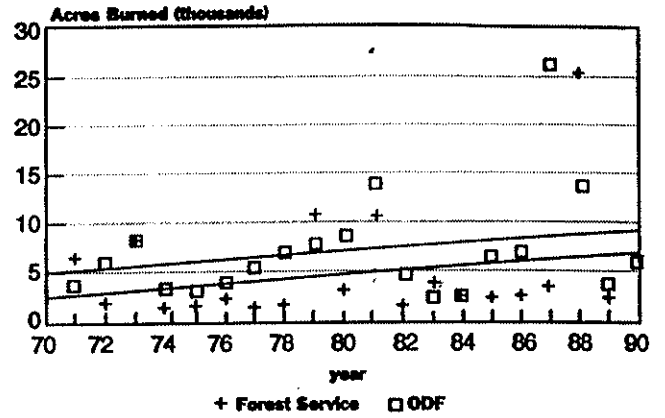
Since 1971, when the FEMA program began, only 8.5 percent of large fires (over 300 acres) in Oregon have threatened enough dwellings or other improvements to constitute a threat of adequate proportions to receive a FEMA disaster declaration.

On Oregon Department of Forestry-protected lands over the 35-year period analyzed, the trend for total acres burned by all causes is fairly constant (Fig. 21). The overall trend for acres burned by human-caused fires is down, while the trend for acres burned by lightning-caused fires is up. With the peak fire years of 1986 and 1987 removed, the trend in human-caused and total fires is down, while the trend in lightning fires remains fairly constant. In general, more acres are

**FIGURE 20: AVE. FIRE SIZE
FOREST SERVICE AND ODF
PROTECTION**



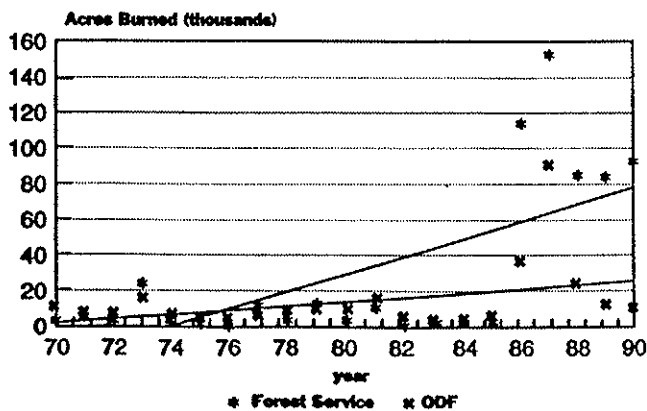
**FIGURE 23: HUMAN-CAUSED ACRES BURNED
FOREST SERVICE AND ODF (1970-90)**



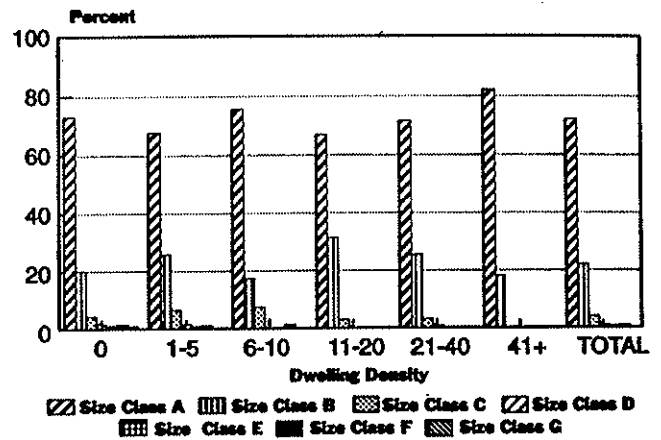
**FIGURE 21: ACRES BURNED
ODF PROTECTION (1956-90)**



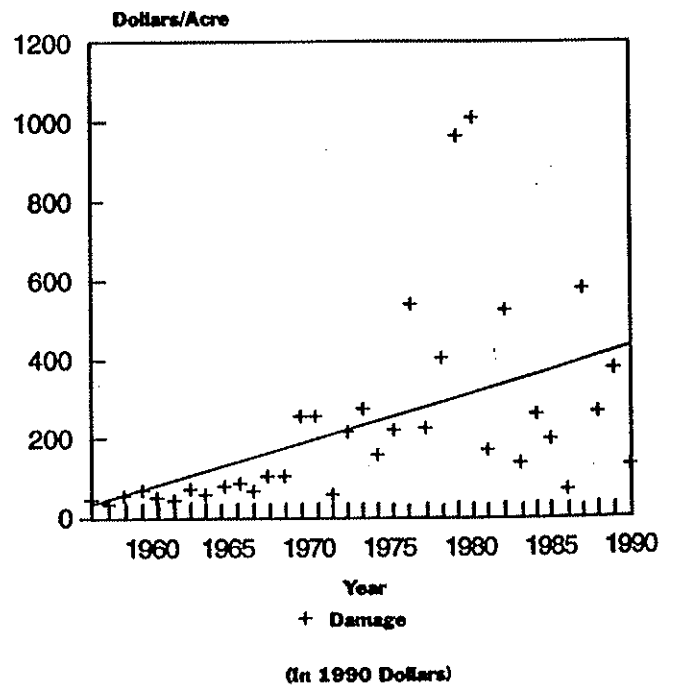
**FIGURE 22: TOTAL ACRES BURNED
FOREST SERVICE AND ODF (1970-90)**



**FIGURE 24: PERCENT OF TOTAL FIRES
BY SIZE CLASS BY DWELLING DENSITY**



**FIGURE 25: FIRE DAMAGE
PER ACRE TREND, ODF PROTECTION**



burned annually by human-caused fires, than by lightning-caused fires.

Over the 1970-90 period for which data are available for both Oregon Department of Forestry and USFS protection, the trend in acres burned for all causes for both agencies is increasing, with the USFS acres burned trend increasing significantly (Fig. 22). Over the same period the trend for human-caused fires is increasing on both USFS and Oregon Department of Forestry-protected lands at about the same rate (Fig. 23).

As measured by cumulative annual burning index (BI) for selected weather stations, the trend in fire danger was downward between 1956-90. Though no statistical analysis was done, the trends and variability of cumulative BI appear similar to those of human-caused fires.

State-wide, on Oregon Department of Forestry-protected lands, for the period of 1981-90, fires associated with residential development (including debris-burning, children- and miscellaneous-caused fires) were slightly smaller than the average fire. For all fires, 93.6 percent were less than 10 acres, while 95.7 percent of debris burning fires were less than 10 acres, 97.1 percent of children-caused fires were less than 10 acres and 95.5 percent of miscellaneous cause fires were less than 10 acres. Lightning-caused fires were most likely to be larger than 5,000 acres and were generally the result of dry lightning igniting several areas at once. The majority (73.3 percent) of fires that exceed 5,000 acres were lightning fires; miscellaneous fires comprise 12.9 percent and smoker and logging each comprise 9 percent of all fires larger than 5,000 acres.

Based upon analysis of fire data from the four Oregon Department of Forestry protection units, it appears that larger fires may be slightly less likely to start in sections with higher dwelling densities than would be expected, based on the distribution of fires by size for the total sample of sections (Fig. 24).

CONCLUSIONS

Over the last 21 years, average fire size has been increasing substantially on both Oregon Department of Forestry and USFS-protected lands. Over the total 35 years studied, however, average fire size showed a decreasing trend on Oregon Department of Forestry lands.

It is clear that improved levels of initial attack (including initial attack by RFPDs), increased fire prevention effort, improved access, early detection, improved fire fighting technology, weather and climate may all have served to affect the overall fire hazard. Apparently these and other factors have partially compensated for vegetative changes, if any, that may have occurred on general forest land, as well as forest lands with residential development. Any mitigation gained by these factors appears to be offset by other factors,

resulting in much higher average fire sizes and total acreage burned over the most recent period of time.

Residential development does not appear to directly increase fire hazard — the difficulty of fire control. The evidence suggests that hazard associated with rural residential causes (debris burning, miscellaneous and children) is somewhat less than the hazard for other causes of fires. This appears to be more the nature of the fire type than any direct positive benefits of residential development. One would expect, for example, that logging-related fires would be more hazardous due to the circumstances under which they occur (abundant dead and down fuel on steep slopes) than debris-burning fires. Without additional analysis, it is impossible to separate the contribution each potential factor makes to the hazards associated with various human-caused fires. Without knowing the degree of contribution for each factor, making predictions is unwise because changing the levels or types of fire prevention and protection resources would have unknown effects.

Without a doubt, vegetation is changing on forest land as a result of forest fire prevention and suppression efforts. The relationship of this change to wildfire hazard associated with dwellings is unclear. The presence of RFPDs may be a major factor in mitigating any increases in fuel hazard occurring in residential areas. Therefore, planning residential development with RFPD fire protection would be sound policy.

Additional analysis is needed to begin to properly model and separate the various factors, including residential development, initial attack response level and time, weather, climate, slope and fuels that influence wildfire hazard. Now that data bases and digitized map layers have been developed, additional analysis may be greatly facilitated.

QUESTION 3:

DOES RESIDENTIAL DEVELOPMENT RESULT IN GREATER LOSS TO FOREST LAND AND INCREASED FIRE-FIGHTING COSTS?

FINDINGS

Even in terms of constant dollars, on Oregon Department of Forestry-protected lands, cost per acre of fire suppression and damage per acre both show significant increases over time (Figs. 25 and 26). In addition to this overall trend, the rate at which fire costs rise annually is also increasing. It should be noted that the increase in fire suppression cost per acre is similar to the rate of increase in pre-suppression costs for Oregon Department of Forestry protection. On Oregon Department of Forestry-protected lands, average cost (in 1990 dollars) per fire has also been increasing (Fig. 27). The rate of increase in fire suppression costs is greater than the rate of rate of increase in acres burned.

FIGURE 26: FIRE SUPPRESSION COST PER ACRE TREND, ODF PROTECTION

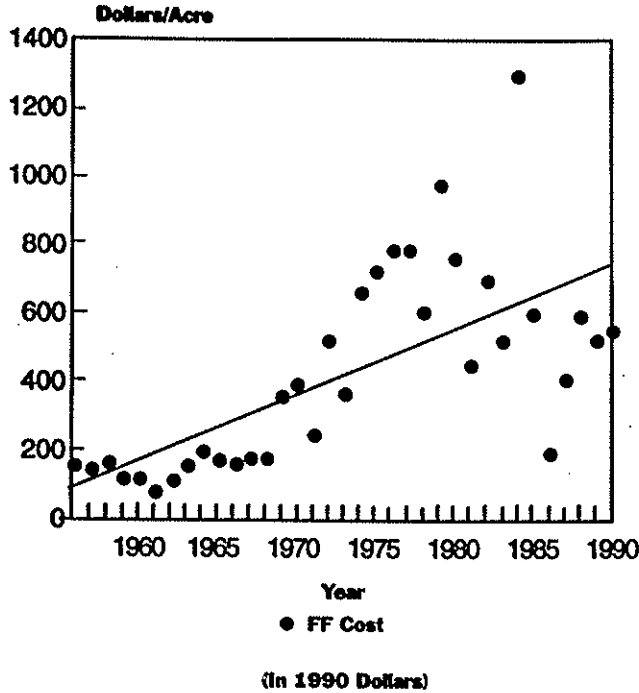


FIGURE 28: NON-STATISTICAL FIRES, ODF PROTECTION (1966-89)

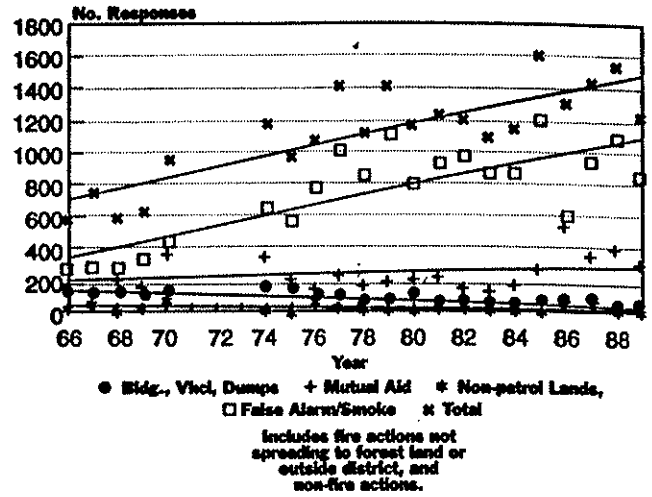


FIGURE 29: NON-STAT FIRE COSTS ODF PROTECTION (\$1990)

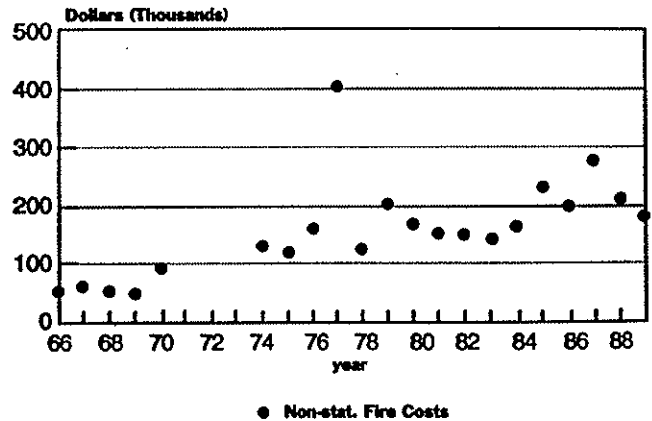
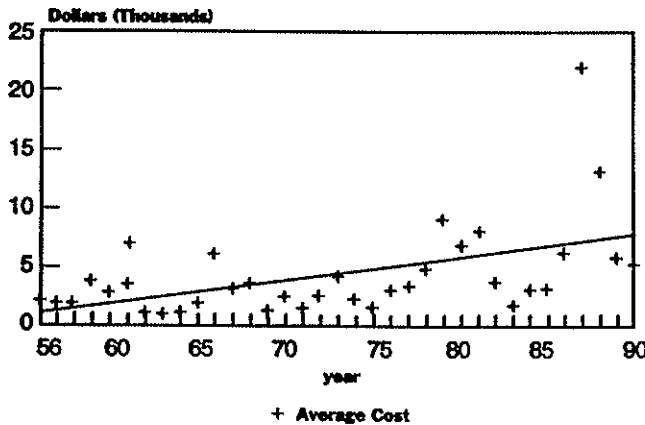


FIGURE 27: AVERAGE COST PER FIRE ODF PROTECTION 1956-1990



For fires that have escaped initial attack on Oregon Department of Forestry-protected lands (those fires larger than 300 acres), the comparison of fire size and suppression cost between FEMA fires and non-FEMA fires shows that FEMA fires are substantially larger than non-FEMA fires and that they are also significantly more costly per acre to suppress. This is significant, because cost per acre is usually inversely proportional to fire size; that is, as fire size increases, cost per acre decreases. Costs for suppressing these large fires were examined using regression analysis. After adjusting for fire size and whether the fire occurred in eastern or western Oregon, the model predicted FEMA fires to be 48.3 percent more expensive to suppress (Table 3).

CONCLUSIONS

Large fires that threaten residential development have significant effects on the cost of suppressing large fires ($P=0.0062$). Overall, total fire fighting costs are going up on Oregon Department of Forestry-protected lands. Some of these increased costs may reflect additional effort being applied to initial attack at the urban/forest interface.

While damage per acre has substantially increased, additional analysis is needed to determine whether this increase is statistically related to residential development.

TABLE 3: Fire Size and Cost Comparisons (1990 Dollars), FEMA and Non-FEMA Fires Greater Than (>) 300 Acres, Eastern and Western Oregon (1971-90)

EASTERN OREGON						
	NO. FIRES > 300 AC.	ACRES BURNED	AVG. ACRES/FIRE	F.F. COST 1990 DOLLARS	AVG. COST/FIRE	AVG. COST/ACRE
FEMA	4	11,674	2,919	4,858,072	1,214,518	416
NON-FEMA	72	92,869	1,290	16,407,320	227,879	177
TOTAL	76	104,543	1,535	21,265,392	279,808	203
WESTERN OREGON						
	NO. FIRES > 300 AC.	ACRES BURNED	AVG. ACRES/FIRE	F.F. COST 1990 DOLLARS	AVG. COST/FIRE	AVG. COST/ACRE
FEMA	8	46,487	5,811	18,270,649	2,283,831	393
NON-FEMA	58	66,993	1,155	19,198,944	331,016	287
TOTAL	66	113,480	1,719	37,469,593	567,721	330

QUESTION 4:

WHAT, IF ANY, ARE THE OTHER EFFECTS OF RESIDENTIAL DEVELOPMENT ON FIRE PROTECTION?

FINDINGS

The number of RFPDs and the number of square miles protected by RFPDs has substantially increased in Oregon. In 1970, there were 209 RFPDs. By 1990, the number had increased by 26.3 percent to 264 districts. Area protected has also expanded, from 7,296 square miles in 1975 to 11,900 square miles in 1990, an increase of 63.1 percent.

RFPDs probably enhance initial attack of many wildland fires in the urban/forest interface, as the majority of all fires on Oregon Department of Forestry-protected lands occur within RFPDs.

The trend for Oregon Department of Forestry non-statistical fires — those for which the Oregon Department of Forestry does not have direct protection responsibility or that do not require a control action — is increasing (Fig. 28). Non-statistical fires include false alarms and smoke chases; responses by the department to aid other fire control agencies; fire control actions on building, vehicle and dump fires that did not threaten to spread to forest land; and fire control actions on non-paying lands inside or outside forest fire protection districts which did not threaten forest land. Nearly all of the growth in this trend is due to an increase in the number of false alarms and smoke chases. There appears to be a very slight increase in mutual aid responses. Building, vehicle, and dump fires not threatening forest land are on a slightly downward trend.

Of more significance, the trend in costs (in constant dollars) related to non-statistical fires is increasing substantially (Fig. 29). Non-statistical fire suppression costs over the 1980 to 1989 period averaged \$170,058 annually. Most of these costs have been related to mutual assistance provided to RFPDs for wildland fires outside of forest protection districts, in particular in central Oregon.

CONCLUSIONS

Protection provided by RFPDs appears to be expanding with residential development on forest land. The Oregon Department of Forestry should continue to foster RFPDs as an essential part of its fire protection efforts. Given the increased need for department resources in suppressing wildland fires outside forest protection districts, the department should review its policy on wildland fires occurring outside district boundaries.

SUMMARY & RECOMMENDATIONS

Residential development on forest land significantly increases the risk of wildfire and the cost of fire control. Additional analysis is needed to determine whether residential development is related to amount of damage or wildland fire hazard.

The Oregon Department of Forestry's mission, as clarified by the 1989 Oregon Legislature, affirms both the need for a complete and coordinated forest protection system and that the department's primary responsibility is protecting forest resources second only to saving lives. Given this directive, the finding that residential development on forest lands increases the risk of wildfire and suppression costs should further support fire prevention programs, and the development of fire prevention regulations in the urban/forest interface.

Fire prevention programs have been effective in mitigating increased risks in the interface, and continued efforts targeted at specific, high-risk causes may be beneficial in preventing future fires. Regulations for home siting, road access and building codes should be developed with the goal of reducing fire risk. Locating power lines underground could also provide valuable protection.

Cooperation among fire prevention agencies, including the Oregon Department of Forestry and RFPDs, and a policy for protection of forest resources within the urban/forest interface, should be an essential part of the department's fire prevention strategy.

Data are available to continue to develop methodology that would build on this work. Methodology and analysis to separate the efforts of residential development from other factors affecting fire risk and hazard — such as weather, topography and fuel type — are needed.