Effects of Prescribed Fire in Ponderosa Pine on Key Wildlife Habitat Components: Preliminary Results and a Method for Monitoring[1]

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Abstract
We monitored the effects of prescribed fire in ponderosa pine forest on snags, down logs, oaks, and old ponderosa pine trees. Five prescribed burns were monitored over a total of 47.7 ha (118 acres). The prescribed fires consumed more than 50 percent of the 342 down logs and approximately 20 percent of the 138 snags monitored. The fires created few snags or down logs. Our methodology evolved from a variable plot method to a grid method through a series of sites. The final method—using a grid, aluminum tags, and sketch mapping—resulted in almost a 50 percent time saving at the end of the first post-burn reading.

Introduction

The reintroduction of fire into the current forests has the potential to greatly change the frequency and distribution of key wildlife habitat components, such as snags, down logs, old trees, and large oaks *(Quercus gambeli).* Snags are an important habitat component and need to be present at appropriate densities in forested ecosystems for cavity nesting birds (Cunningham and others 1980, Horton and Mannan 1988, Newton 1994). Down logs are important to small mammals and need to be well distributed across the landscape to provide for wildlife habitat (Goodwin and Hungerford 1979). Oaks provide key habitat for wildlife in the Southwest, including birds, bats, ungulates and small mammals. Oaks are one of the most important factors affecting bird distribution (Rosenstock 1998) in northern Arizona ponderosa pine *(Pinus ponderosa)* forests. Old-growth ponderosa pine trees are used by 80 species of wildlife on the Coconino National Forest for nesting, feeding, foraging, and roosting sites.

Forest managers in the Southwest use prescribed fire to restore the health of ponderosa pine ecosystems and reduce the threat of catastrophic wildfire. Prescribed fire has become more important recently because of increased emphasis on forest restoration, urban interface fire prevention, and fire as a vegetation management tool.

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Little published information is available, however, on the effects of prescribed fire on snags, logs, oaks, and old-growth ponderosa pine trees.

Since 1995, we have been monitoring prescribed fire on two national forests and a national monument to determine effects on selected wildlife habitat components. These data are intended to give resource managers better information about gains and losses of key wildlife habitat components following prescribed fire in northern Arizona. This paper presents data from five burns. Our study is ongoing and eventually will include 10 sites. The data we have collected to date provides needed information on the effect of prescribed fire on key wildlife habitat components in ponderosa pine forests.

The prescribed burns we have studied are the first use of prescribed fire on each site. The results represent effects of the first entry with prescribed fire, which may cause the most change to wildlife habitat depending on the frequency of reentry burns.

Study Area and Methods

We monitored pre and post-burn habitat components on five sites totaling 47.7 ha (118 acres). The sites are located near Flagstaff in north central Arizona. The five sites include three ranger districts on the Coconino National Forest, one ranger district on the Kaibab National Forest, and Walnut Canyon National Monument. The sites are named Walnut, Unknown, Stoneman, Twin Springs and Howard.

All the sites are in the ponderosa pine vegetation type *(table 1).* Some of the sites also include varying proportions of Gambel oak and alligator juniper *(Juniperus deppeana).*

Table 1—*Pre-burn habitat component data by site.*

	Number of components/ha (components/acre)					
Site	**Snags**	**Logs**	**Oaks**	**Old-growth trees**	**Ha monitored**	**Habitat type**
Walnut	6.1 (2.5)	6.1 (2.5)	>1	19.8 (8.0)	8.9 (22)	Ponderosa pine
Unknown	1.5 (.6)	3.7 (1.5)	>1	26.7 (10.8)	14.2 (35)	Ponderosa pine
Stoneman	1.9 (.77)	7.9 (3.2)	8.4 (3.4)	5.4 (2.18)	8.9 (22)	Ponderosa pine/Gambel oak
Twin Springs	3.2 (1.3)	9.4 (3.8)	6.8 (2.8)	11.3 (4.6)	9.7 (24)	Ponderosa pine/Gambel oak
Howard	6.6 (2.7)	13 (5.3)	22 (8.9)	3 (1.2)	6.0 (15)	Ponderosa pine/Gambel oak

All the monitoring sites on the national forests have similar histories, with logging beginning in the late 1800s and continuing until the present decade. Recent logging includes both pre-commercial thinning of trees less than 5 inches (12.7 cm) dbh, and varying levels of overstory removal. Wildfire suppression began in the early 1900s.

The Walnut Canyon National Monument site is strikingly different because it has never been logged, although wildfire suppression history is similar. The Walnut site has a substantial old-growth ponderosa pine component and is structurally diverse.

The sites are approximately 6 to 14 ha (15 to 35 acres) in size depending on the density of habitat components. On each site, we attempted to monitor an area large enough to include at least 50 individuals of each component studied. This number was selected to try to balance biological significance and data collection practicability. In practice, some sites did not achieve the desired number of all habitat components. Snags proved to be the most rare component, and none of the sites burned so far contained 50 snags. In each instance, we truncated the sites to keep their size manageable or to remain within the prescribed fire area. One site (Howard) also failed to meet the desired number of old ponderosa pine.

Prescribed Fire

Sites are located within prescribed burns planned in the normal course of forest management. The burn prescriptions followed normal agency practice. Sites selected are in areas where agency personnel had planned prescribed burning. We made an effort to find burns carried out by a variety of crews in order to assess variability caused by crews as well as sites.

All five burns monitored occurred in the fall. Prescribed fire burning plans were similar for all burns conducted *(table 2)*. Fuel moisture in the 1,000-hour fuels ranged from 13 to 16 percent. Firing techniques and devices were the same for all burns. Planned weather conditions and general topography of all sites were similar.

Table 2—*Prescribed fire data and monitoring dates.*

Site	1,000-hour fuel moisture percent	Firing techniques	Humidity percent	Temperature (degrees F)	Month/ year burned	Post-burn data	Post-burn year 3	Post-burn year 6	Post-burn year 10
Walnut	15	Head and Backing			10/96	6/97	6/00	6/03	6/06
Unknown	12	Head and Backing	15 –60	75	12/95	6/96	6/99	6/02	6/05
Stoneman	16-50	Head and Backing	15-100	40-80	9/97	10/97	6/01	6/04	6/07
Twin Springs	15-32	Head and Backing	20-60	40-75	10/97	10/97	6/01	6/04	6/07
Howard	15-50	Head and Backing	15-100	40-80	9/97	10/97	6/01	6/04	6/07

We surveyed sites prior to the prescribed burn and within 1 to 11 months after the burn *(table 2)*. Sites will be surveyed again at 3, 6 and 10 years after the burn. These follow-up surveys are intended to capture changes such as tree mortality, which may be delayed for several years after the burn that caused it.

Component Data Collection

We surveyed all the individual habitat components on each site. DBH and height were recorded for mature ponderosa pine, oaks, and snags. Down logs were characterized by species, minimum diameter, maximum diameter, and length. Compass bearing from largest end of the log and whether the tree was cut or fallen was recorded. The compass bearing assisted us in identifying the log after the burn. Additional data collected on each component included presence/absence of leaves, twigs, bark, cracks, cavities, litter depths, and animal usage for later analysis.

Changes in Data Collection

As we began study design, we considered a variety of sampling methods. Difficulties in estimating the extent of change with rare components led us to believe the best method would be a total count of habitat components within known area sites. Although we have consistently conducted a total survey of habitat components on the sites, the methodology for conducting the total survey has changed as we have learned from the post-burn sites.

Variable Plot Method—Few Tags

When we began the project, we based surveys on groups of ponderosa pine. The location of a central point in each ponderosa pine group was recorded by using a global positioning system (GPS), and one or more trees were marked with an aluminum tag bearing a group number. One point consisted of either a single component or multiple components, i.e., GPS point R080813A recorded presence of two down logs and both were tagged with the identifier number. A map of all points was produced, showing the relationships of the points to each other on the ground. Points were easily relocated; however, because the size of points varied, one could not quickly summarize which habitat components were within the point without checking tags.

Variable Plot—All Items Tagged

The first change we made was to begin tagging all the habitat components with aluminum tags, which identified the components associated with the group central point. Although some tags melted in the burns, the tagging reduced the total time needed for post-burn data collection *(table 3)*. Tagging all the components increased the time needed to set up a site by 2 person-days; however, tagging reduced the time needed for post-burn monitoring from 14 person-days to 8 person-days.

We continued to have some confusion on the edges of groups, since often a tree or a log could logically be recorded in either of two groups.

Table 3—*Person-days required for monitoring a plot through the first post-burn reading by method.*

Method	Setup	Post-burn	Total
Variable plot—few tags	8	14	22
Variable plot—all items tagged	10	8	18
Grid—all items tagged	10	2	12

Grid—All Items Tagged

Post-burn monitoring at Walnut revealed that a better method was needed. We could reconstruct some, but not all the groups from our data. It sometimes was very time consuming to reconstruct groups, particularly if a group was greatly changed by the burn. Since this was our most complex site, the problems with our methods were amplified. Because we could not reconstruct all of the groups at Walnut, the post-burn data for that site were truncated to include only data from the groups that could be reconstructed with certainty.

The difficult and time-consuming nature of the post-burn monitoring at Walnut led us to change our methods. We avoided using a grid at first because we thought it would take more time. After experience with the other two methods, we realized that laying out a grid could greatly reduce the time needed to read sites after a burn. We began laying out grid cells 30.48 m (100 feet) on each side, and continued tagging all the habitat components. Grid cell corners were marked with tagged rebar stakes. Each 929 sq. m. (10,000 sq. ft.) cell was issued a number. Grid cells were numbered so that each cell could be identified by unique alphanumeric code. All habitat components were tagged, sketched, and characteristics summarized by cell.

The final improvement made was a sketch map of each grid cell showing where the habitat components were in relation to each other within the cell boundary. The net effect of these changes was a dramatic decrease in the time needed to monitor a site post burn *(table 3).*

Results

Pre-burn—Site Habitat Description

Table 1 shows the pre-burn density of each habitat component for each site we monitored. Structural complexity (dog hair thickets, varying diameter of ponderosa pine) was low on the Howard and Unknown sites and moderate on the Stoneman and Twin Springs sites. The Walnut site is a very complex site with not only an abundance of old-growth, but also dog hair thickets and multiple age classes present.

Snags

We sampled 138 snags > 15 inches (38 cm) dbh, almost all of which were either ponderosa pine (87 percent) or Gambel oak (10 percent).

At all sites except Walnut Canyon, some snags were lined, i.e., duff and debris moved away from the base of snag. Snag lining was a common practice on all USDA Forest Service burns.

Twenty-nine snags (21 percent of all snags) were consumed by fire or converted to logs. The individual sites did not differ significantly in numbers of snags lost *(fig. 1).* The range of snag loss was 12-38 percent. Nine snags were created. Snags created by the prescribed fires were created predominately (six of the nine snags) at Walnut Canyon National Monument where old-growth trees were converted to snags. Two oaks, one each from the Howard and Twin Springs site, became snags. Average diameter for the snags gained are larger than the average pre-burn snag diameter.

Fourteen Gambel oak snags were included in the data. In the post-burn condition, 8 of the 14 oak snags remained. Initial results suggest that oak snags might be at higher risk of loss from prescribed burns than ponderosa pine snags. The additional sites that have not yet been burned will increase our sample size. Oak snags, however, are also extremely rare on these landscapes.

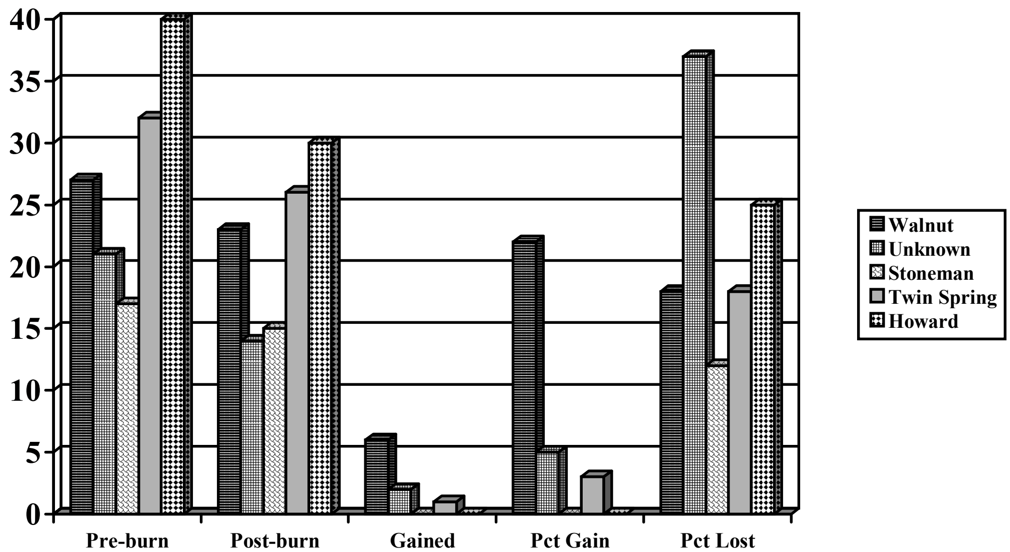

Figure 1—Snag data by site.

Logs

We sampled 342 logs > 15 inches (38 cm) dbh. Logs varied in diameter, length, decay condition, and use. Ponderosa pine, Gambel oak, and juniper represented 90.24, 7.38, and 2.38 percent, respectively, of the sample logs.

Fifty-three percent of all logs were lost. Log loss did not differ greatly by species. The range of log loss was 36-61 percent *(fig. 2).* The prescribed burns created 15 logs. New logs created are located predominantly at Walnut Canyon National Monument (13 of the 15 logs) where conversions from old-growth tree to log and from snag to log were nearly equal. Average diameter and lengths for logs lost and created were very similar. Logs remaining in the post-fire condition were slightly smaller in diameter and 5 feet (1.5 m) longer based on the average of all logs monitored.

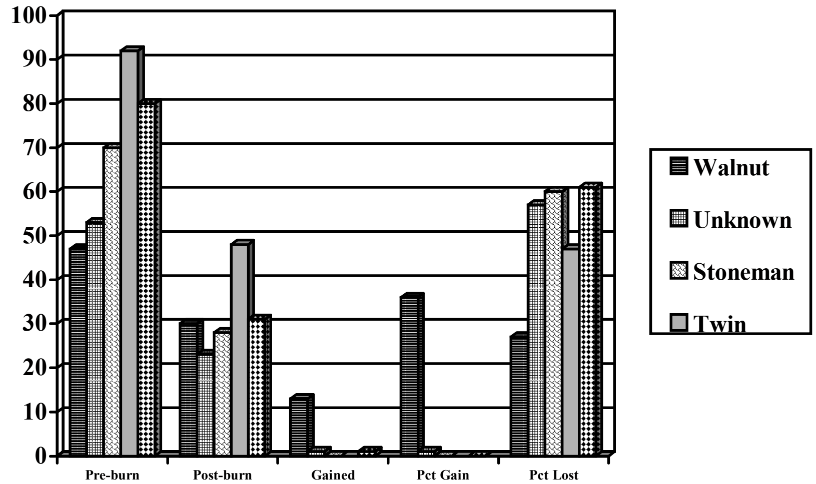

Figure 2—Log data by site.

Oaks

We sampled 282 oaks >10 inches (25.4 cm) dbh. All of our sites had oaks on them, but most oaks were on the three sites considered ponderosa pine/Gambel oak cover types (Howard, Twin Springs, and Stoneman). Both the Walnut and Unknown site recorded a few oaks.

Six percent of the total oaks were lost. The range of oak loss on the ponderosa pine/Gambel oak cover types was 0-9 percent *(fig. 3)*. The one oak at Unknown went unscathed; however, two of three oaks on the Walnut burn were killed. The third oak was charred badly. The three oaks on Walnut Canyon National Monument site were not in a clump; however, all three were adjacent to dog hair thickets where the fire got rather hot.

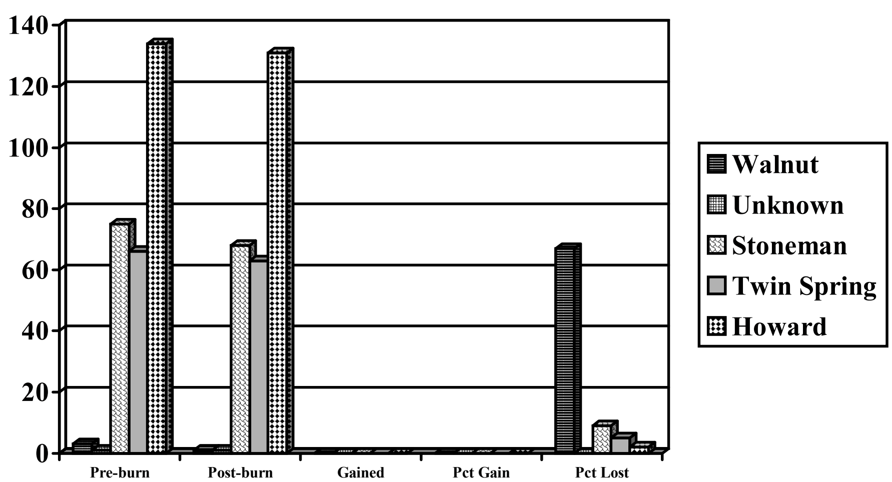

Figure 3—Oak data by site.

Mean diameter of oaks lost, 40.1 cm (15.8 in.), was slightly higher than the average pre-burn diameter (36.1 cm./14.2 inches). The possibility of delayed oak mortality and conversion of live oak to snag is one of the reasons for planning a 10-year monitoring effort.

Old-growth Ponderosa Pines

We sampled 680 old-growth trees on the five sites. The Walnut site contained a lower number of old-growth trees because of a site selection decision. The crew who set up Walnut avoided large clumps of old trees that did not contain other components in order to increase the sample size of the more rare habitat components.

Immediate post-burn monitoring found that few old-growth trees had died during or immediately after the prescribed fires *(fig. 4)*. Most of the trees that did die were on the Walnut Canyon National Monument site. The affected trees are now either snags or logs, and resulted in gains in the log and snag components. Old growth tree loss across the sites ranged from 0 to 6 percent.

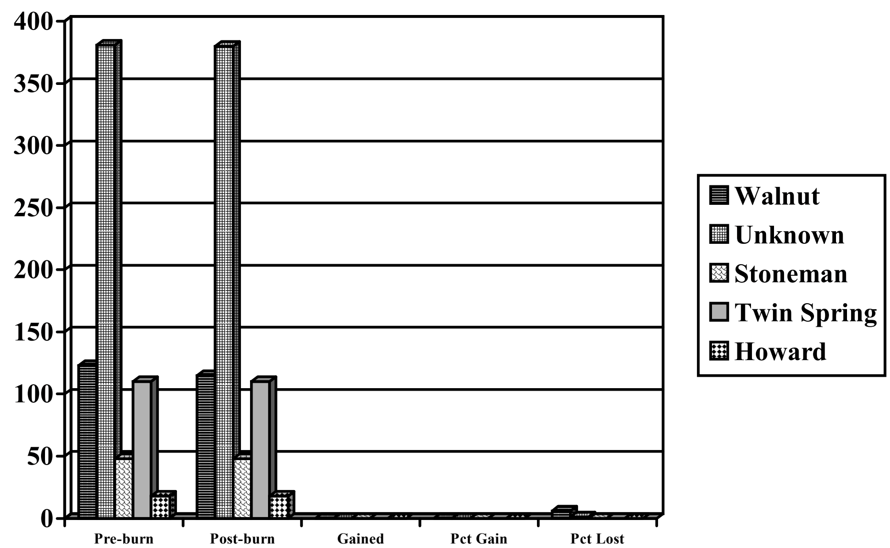

Figure 4—Old-growth pine data by site.

Survey Methods

Because the time saved by using the grid method will occur each time a site is monitored post-burn, the difference in the total time required for each sampling method will increase with the second and third post-burn reading. By the end of the project, after four post-burn readings of each site, we would have 64 person-days invested in a site using our original method, compared with 18 person-days with the grid method *(table 3)*.

Because most monitoring efforts will not require the detailed data we are collecting on each habitat item, our recommendation for future monitoring is to use a grid, tag each item, and use sketch maps of each cell. The pre-burn setup time without the detailed data on each item should be about half of what we have estimated. Post-burn site monitoring time is cut by about 25 percent without the detailed data collection. We would estimate reducing the total time for setting up a site and monitoring it twice to be approximately 8 person-days, or if the site is monitored four times after the burn, 11 person-days. Two post-burn measurements may well be enough, after the delay between the burn and tree mortality rates are well understood.

Discussion

Our monitoring has attempted to determine the effect of prescribed fire on wildlife habitat components. Our preliminary monitoring findings represent what we would expect to happen when conducting a fall prescribed fire where average 1,000-hour fuel moistures are approximately 15 percent. Our preliminary results describe the effects of prescribed burning in the fall in managed ponderosa pine stands with a sparse or scattered overstory of old trees. Under these prescribed burning conditions, our results show about 50 percent of the logs and about 20 percent of snags being consumed with little or no immediate gains *(fig. 5)*. Live oaks have been reduced by 6 percent and little immediate mortality of large old-growth ponderosa pines has occurred.

Recent forest management direction in the southwestern U.S. for snags and logs has come primarily through plans for the Mexican spotted owl and northern goshawk. These management plans recommend the use of prescribed fire to protect habitat from catastrophic wildfire and to improve understory vegetation (grasses, shrubs, forbs, wildflowers) beneficial to prey species for these raptors.

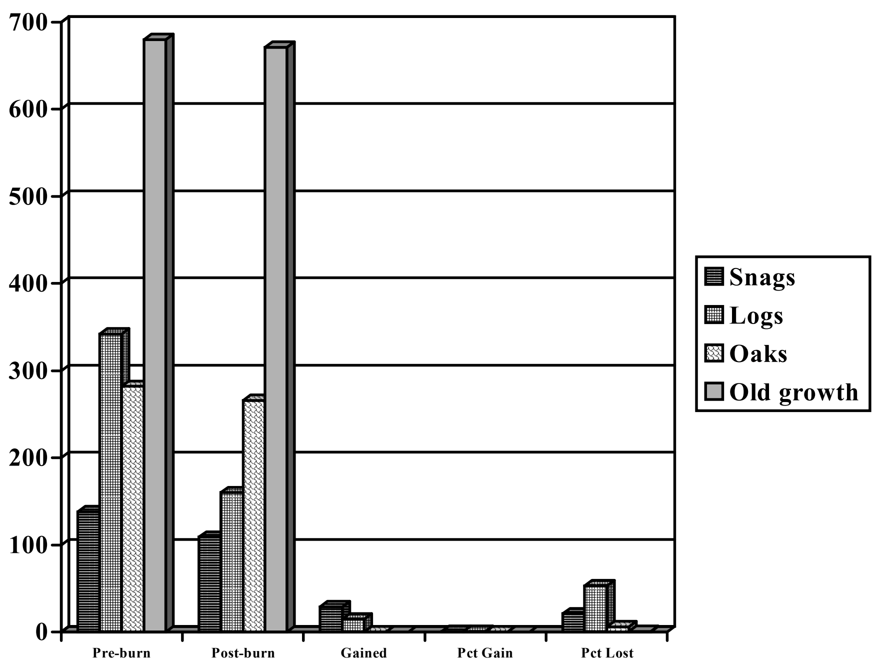

Figure 5—Habitat component data from five sites combined.

Horton and Mannan (1988) found that nearly half of all snags burned down, logs decreased by 42 percent and 56 percent, and prescribed fires in southeastern Arizona killed few large trees. Snags greater that 50 cm dbh were most impacted.

In a recent study of snag abundance, Ganey (1999) found that Forest Service snag standards were seldom met, even in unlogged forests. Our preliminary findings as well as these studies, suggest that densities of snags are often below those required by Forest Service guidelines and will be reduced further by the use of prescribed fire. Our initial results would suggest that oak snags might be at higher risk from prescribed burns than ponderosa pine snags. Our results to date are inconclusive; however, we have shown that fire kills some oak trees. On one site, the burns killed all of the few oaks on the site, potentially greatly altering the habitat for wildlife using oak, despite the small statistical effect.

Data for logs in the pre-fire monitoring found that nearly 66 percent of all logs monitored were cut. These logs may have been the snags that were felled in the 1960s (general practice) to lessen wildfire threat from snags catching fire. They also may have been cull trees, which were felled during past logging. These logs were generally hard and full of pitch, which may have led to their loss. Many of these artificially-created logs might still be standing as snags or old-growth, if not for past fire prevention and cull policy.

Historical logging practices, especially the removal of large old-growth trees on many forested areas combined with fire prevention techniques, undoubtedly played a role in what we found. It is our opinion, based on the preliminary findings, that gains in logs and snags will only occur where there is abundant old-growth to allow for the conversions. It will take a long time to grow the trees to be old enough and large enough to get us out of this dilemma. Accumulated debris around the base of snags, oaks, and mature pines can greatly affect how hot the fires burn and how these habitat components are impacted (Harrington 1985, Horton and Mannan 1988). Dog hair thickets, stumps in the root zone, or thick duff areas may also be needed before enough heat is generated to cause the old-growth kill. Areas such as designated wilderness or stands with abundant old-growth trees will allow for gains in logs and snags.

Harrington and Sackett (1992) reported almost 40 percent old-growth ponderosa pine mortality at the Chimney Spring Prescribed Fire Research Area at Fort Valley. Their study took place within the same general area where we have been doing our monitoring. The duff layers and tree densities have been less in our study plots than in Harrington and Sackett's, study and one or both of these factors may account for any differences.

In Harrington and Sackett's (1992) study, mortality did not appear until several years after the burns; thus, a comparison with their results will be more appropriate after long term monitoring. To date, we have not found comparable heavy mortality in old ponderosa pine trees.

An unanswered question is how subsequent re-entries with prescribed fire will affect wildlife habitats. The most common thought is that fire events occurred in southwestern ponderosa pine every 7-15 years, and some managers would like to approximate that interval where possible. Our results raise a question about the gains and losses for logs, snags, oaks, and old-growth components with re-entry burns.

Management Implications

Through the evolution of our monitoring method, we have arrived at a relatively efficient means of monitoring the effects of prescribed fire on wildlife habitat. The use of a grid design, along with tagging each habitat component and sketch mapping each cell, proved much more efficient than the variable plot method for us. The grid with tagging and cell mapping may often be the best way for managers to obtain desired or required monitoring data on the effects of prescribed fire. The pre-burn setup time without the detailed data on each item should be about half what we currently need, and post-burn plot monitoring time should be cut by about 25 percent. We would estimate reducing the total time for setting up a plot and monitoring it twice to be approximately 8 person-days, or if the plot is read four times after the burn, 11 person-days. After the delay between the burn and expected tree mortality is worked out, two post-burn measurements may well be enough.

Forest managers should expect a decrease in logs and snags immediately after prescribed burning activities. Our data show that logs and snags will be reduced by approximately 50 and 20 percent, respectively. Managers should expect only a few logs or snags to be created immediately by the burn unless the site contains a high density of old trees and snags. Some additional snags and down logs may be gained later after the burn. Whether or not these changes in key wildlife habitat components are acceptable depends on how many are present before the fire.

The Stoneman burn, which experienced the lowest snag losses, had nearly every snag lined. Other Forest Service burns lined only some snags. It appears that lining may be an effective mitigation tool for reducing snag losses during prescribed burns.

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