

Effects of Prescribed Fires and a Wildfire on Biological Resources of Oak Savannas in the Peloncillo Mountains, New Mexico

Gerald J. Gottfried

USDA Forest Service, Rocky Mountain Research Station, Phoenix, Arizona

Peter F. Ffolliott

School of Natural Resources and the Environment, University of Arizona, Tucson, Arizona

Daniel G. Neary

USDA Forest Service, Rocky Mountain Research Station, Flagstaff, Arizona

Abstract—Private and public land managers are attempting to reintroduce fire into the ecosystems of the Peloncillo Mountains to reduce the density of woody species, increase the herbaceous plant cover, and improve the area's ecological diversity. The Cascabel Watershed Study, which includes 12 small gauged watersheds, was started in 2000 to evaluate the impacts of cool-season (November–April) and warm-season (May–October) prescribed fires on biological and physical components of the oak (*Quercus* spp.) savannas that are common to the Southwestern Borderlands Region. The Whitmire Wildfire in May 2008 modified the original experimental design. All three fire treatments resulted in low severity burns. The effects of the different fire treatments on tree overstories, herbaceous production, ground cover, selected wildlife species, and bird populations are presented. Measurements did not indicate many significant differences among treatments or with pre-fire conditions. For example, almost 78 percent of the overstory trees on the watersheds survived the fires. The main exception was a large increase in grass and total herbaceous plant production of early-growing species after the fires; annual grasses and forbs are not common at Cascabel. The fires also produced statistically significant increases in the production of late-growing grass species but the changes were not as large.

Introduction

Fires caused by lightning or Native American people were the main disturbance in the Madrean Archipelago prior to the completion of the transcontinental railroad and the introduction of large herds of cattle into the region. The range was overstocked with cattle as ranchers, often belonging to large corporations, competed with their neighbors to control access to the land (Hadley 2005). The resulting overgrazing caused a decline in the herbaceous cover that previously carried natural fires throughout the landscape. Consequently, the density of trees and woody species and debris increased and the production of herbaceous species declined. Biodiversity and productivity of many sites within the Madrean Archipelago decreased. Aggressive fire suppression by land management agencies also contributed to the decline in fires.

Ranchers in the Upper San Simon, San Bernardino, and Animas Valleys became concerned about landscape changes that were resulting

from the lack of fire. The Malpai Borderlands Group was formed in 1992 by ranchers and similar minded individuals and organizations with the goal to “restore and maintain natural processes that create a healthy landscape” (McDonald 1995:485). Officials of the Coronado National Forest and Bureau of Land Management shared a similar view about the need to reintroduce prescribed and natural fires into the region. The Coronado National Forest and Malpai Borderlands Group worked together to formulate the Peloncillo Programmatic Fire Plan to reintroduce fire into the Peloncillo Mountains that straddle the Arizona–New Mexico border. The efforts resulted in four landscape prescribed fires between 1995 and 2007. The fires occurred in the warm season prior to the monsoon rains. However, there were questions about the effects of warm-season fires on several listed species, particularly the lesser long-nosed bat (*Leptonycteris curasoae*), which requires nectar and pollen from the Palmer agave (*Agave palmeri*), and the New Mexico ridge-nosed rattlesnake (*Crotalus willardi obscurus*). Some people recommended cool-season burns that might be less detrimental. However, there was little scientific information available to support either position on the burning season or to assist managers with general knowledge about the ecology and hydrology of the ecosystem.

The U.S. Forest Service, Rocky Mountain Research Station established the Southwestern Borderlands Ecosystem Management Unit to provide public and private land managers with scientific information to support management decisions. The Cascabel Watershed Study was a research project specifically developed to answer questions about

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the impacts of burning season on oak savanna ecosystem resources (Gottfried and others 2007, 2012). The Cascabel Study can be divided into research about the biological components of the oak savanna ecosystem and research about the physical environment, for example, hydrology, erosion, and sedimentation. This manuscript will report on the effects of fires on the biological resources.

Cascabel Watershed Study

The objective of the study was to determine the impacts of cool-season (November–April) and warm-season (May–October) prescribed burning on oak savanna hydrologic and biological resources (Gottfried and others 2007, 2012). The Cascabel Watersheds consist of 12 small watersheds located in the oak savannas on the southeast side of the Peloncillo Mountains. The watersheds range in size from 20 to 60 acres covering about 451.3 acres and are located between 5380 and 5590 feet in elevation. Geology, physiology, and hydrology of the study area have been described in articles cited by Ffolliott and others (2011b) and Gottfried and others (2012). The surface soils are very gravelly or very cobbly sand or sandy clay loams (Robertson and others 2002). Emory oak (*Quercus emoryi*) is the dominant tree species with alligator juniper (*Juniperus deppeana*) a common co-dominant species. Various species of grama grass (*Bouteloua* spp.) dominate the understory. Sets of two Parshall flumes were installed in each drainage as were sediment dams, basins, and channel cross sections. Two full weather stations were set up and these are supported by seven tipping bucket rain gauges. Measurements of fire effects, soil erosion and deposition, overstory trees, herbaceous vegetation, and wildlife use were collected in each watershed at permanent sampling points arranged on transects that were located perpendicular to the stream channel. There were 35 to 45 points on each watershed depending on its size and shape for a total of 421 sampling points. Sampling procedures varied depending on the resource being monitored.

Burning Treatments and Fire Effects

After a pretreatment sampling period, the watersheds were partitioned into three groups of four with one group receiving the cool-season prescribed burn, one receiving the warm-season prescribed burn, and one group reserved as controls. The cool-season watersheds were burned by crews from the Douglas Ranger District of the Coronado National Forest in March 2008 and three of the warm-season watersheds were burned on May 20, 2008. However, the fire escaped on May 21 and burned the remaining unburned watershed, the control watersheds, and about 4,000 acres in adjacent areas. It was named the Whitmire Fire. The study design was modified appropriately to account for the wildfire treatment on five of the watersheds.

Fire severities were determined on the 421 points using a system developed by Hungerford (1996) that relates fire severity to the appearance of litter, duff, woody material, and soil condition. Classification of severity ratings at the points on each watershed were extrapolated to a watershed basis by Stropki and others (2009). They determined that 85% of the area receiving the cool-season burn had been exposed to a low severity fire, 5% had been exposed to a moderate severity fire and the remaining 10% of the area had been unburned. The spatial distribution of severities was similar on the watersheds that had been affected by the warm-season burn and the wildfire. However, Neary and others (2010) measured locations on the watersheds where high-severity fires had occurred, particularly where heavy accumulations

of organic material had accumulated. Statistical analyses indicated no significant differences in burn severities among the watersheds receiving the cool-season or warm-season prescribed burns or the wildfire. Therefore, the data were combined to compare pre-treatment and post-treatment responses of the resources.

Soil water repellency was measured using the drip test developed by Letey and others (2000). The occurrence and levels of soil water repellency was limited in extent and magnitude regardless of treatment. Approximately 90% of the area had no soil water repellency, 5% had slight water repellency, and the remaining points had moderate to strong levels of repellency.

Fire Effects On Biological Resources

Overstory Trees

The overstory tree cover was re-measured after the three fire treatments and the results were pooled because all watersheds had received low severity burns and no significant differences were detectable (Ffolliott and others 2011b). Approximately 78% of the trees that were present before the prescribed fires and wildfire initially survived. Eighty percent of the oak trees of all species and 75% of the juniper trees of all species survived. Scorch or top kill, was observed on 80% of the surviving oak and juniper trees. Thirty percent of the oak had one-third or less of the crown burned, 45% had between one-third and two-thirds affected and 25% had greater than two-thirds damaged. The relative proportions were similar for the junipers. Many of the severely burned trees might not survive into the future but basal sprouting could replace some of the dying trees. Sprouting was observed on 37% of the oaks and on 11% of the junipers. Large trees ($\geq$ than 9 inches in diameter at the root collar) were more common on the watersheds than smaller trees and proportionally more large trees survived. The damage to large trees could be attributed to accumulations of slash and other organic material at their bases. The spatial distribution of trees at Cascabel was not impacted by the burning treatments.

Herbaceous Plant and Shrub Production

The production of early-growing and late-growing grasses was significantly greater after the three fires than before (Ffolliott and others 2012b). Depending on the event, there was a five to seven-fold increase in the production of early-growing grass species. Increases in late growing species were also significant but of a smaller magnitude. For example, the early growing grass production on the warm-season burned watersheds increased from 75 pounds/acre to 400 pounds/acre. Fire effects on the minor forb component were inconsistent. The cool-season prescribed burn did not affect forb production, but the warm-season burn and the wildfire did result in increases. Late-season forbs were not affected by the fires. Total herbaceous production, which includes grasses and forbs, increased relative to pre-treatment condition because of the dominance of grasses in the understory. The increased production has been attributed to the increased soil water availability related to reductions in tree overstory and litter and duff layers and to increased soil nutrients. The growth of shrubs generally was not affected by the burning events, except for the late-season growth of shrubs on the watersheds impacted by the wildfire.

The wildfire did produce an increase in warm season shrub production mainly because of tree sprouts. The persistence of these effects into the future is unknown.

Palmer Agave

Palmer agave, which is protected by the State of Arizona, is important because it provides pollen and nectar to the Federally listed lesser long-nosed bats that migrate into the southwestern United States in the summer (Slauson and others 1999). The agave species occurs on rocky slopes in the oak savannas of the Southwestern Borderlands region. Concern about damage to this species was one reason for the Cascabel study. Information about the agave population on the watersheds was not collected prior to the burning events but a survey was conducted on the plots afterwards (Ffolliott and others 2010). The agave was found on 12.9% of the plots visited after the fires. The occurrence of agave could not be related to topography, soil surface characteristics, or to surrounding vegetation. No burned agave plants were found on the sample plots but an unknown number of burned or partially burned plants were observed outside the established plots. There was no pattern in the location of dead or injured agaves. Average agave production on the watersheds following the fires was about 0.25 pounds/acre with a range of a trace to 16.7 pounds/acre on individual watersheds. Ffolliott and others (2010) could not conclude if the Cascabel treatments had an effect on the Palmer agave population because of the lack of pretreatment data.

Wildlife

Mammals—The prescribed burns and the wildfire did not affect the use of the watersheds by two keystone species—Coeus white-tailed deer (*Odocoileus virginianus coeusi*) and desert cottontail (*Sylvilagus audubonii*) (Ffolliott and others 2012a). Fecal pellets were counted in the spring and autumn at the permanent sampling points. The area around each point was cleared after each survey. There were no differences in deer or cottontail use related to the three low-severity fires. However, counts in the spring after the winter season were higher than counts in the autumn after the monsoon rains. It appears that the deer use the savannas during the winter when weather conditions are relatively mild and move into the higher, cooler, and moister elevation woodlands and forests during the warm summer. The same pattern of higher spring use by the cottontail was observed. It was hypothesized that this could be related to high birth rates during the winter and subsequent predation during the summer.

Birds—Surveys of bird species and numbers were conducted around a subset of sampling points on each watershed during the spring and autumn before and after the fires (Ffolliott and others 2011a). Bird observations were made for 5-min at each point following the procedures described by Braun (2005). Some species were observed frequently while others were tallied occasionally. More bird numbers and species were tallied in the autumn after the monsoon rains than in the spring after the winter rains. This difference could be related to greater availability of food following the monsoon period. Some common sightings in both seasons included the Ash-throated Flycatcher (*Myiarchus cinerascens*), Bushtit (*Psaltiriparus minimus*), Mexican Jay (*Aphelocoma ultramarina*), Turkey Vulture (*Cathartes aura*), and Mourning Dove (*Zenaida macroura*). A more complete list of species is presented in Ffolliott and others (2011a). Calculations of bird species richness, species diversities, and evenness for both seasons suggest that the three fire treatments had little consistent effect on the ecological diversity at Cascabel. It was difficult to isolate the impact of the prescribed burns or the wildfire because of the large variability in tallies of species and numbers.

Herpetofauna—No New Mexico ridge-nosed rattlesnakes were encountered on the Cascabel Watersheds. However, 8,951 lizards

belonging to 10 species were identified at Cascabel between 2004 and 2010 (Goode 2011, Unpublished report). It is difficult to draw conclusions about the effects of fire on the lizard population because of the variability of rainfall, vegetative cover, and lizard numbers on the plots. A preliminary conclusion was that the fires did not affect the lizard population.

Conclusions

The Cascabel Watershed Study was established to determine the impacts of cool-season and warm-season prescribed fires on the ecology and hydrology of Madrean oak savannas. The effect of burning season on natural resources was an important concern among public and private land managers. The Whitmire Wildfire in 2008 modified the statistical design so that the current analyses evaluate the impacts of cool season and warm season prescribed fires and a wildfire on the biological and hydrologic resources. This paper discussed the impacts on the biological resources at Cascabel. The physical aspects of the study are reported elsewhere (Gottfried and others 2012).

The three fire treatments, regardless of prescription or timing, burned at low severity and produced similar impacts on the biological resources. The data from the treatments were combined and subsequent analyses compared pre-treatment with post-treatment conditions. The reduction in tree survival was minor and inconsequential in terms of management options (Ffolliott and others 2011b). The production of grasses and general herbaceous cover was the only resource that exhibited a significant change related to the fires and that was a positive increase in production (Ffolliott and other 2012b). The fires did not affect deer or cottontail use of the total area, probably because of a lack of significant changes to the tree cover. The lizard population probably was not affected by the fires but that needs further analyses, and no fire effects could be determined from the bird surveys.

It is concluded that the low-severity fires at Cascabel did not have major impacts on most biological resources of the oak savannas. Fire managers might use the Cascabel Watershed results as an initial guide since there is little information available on fire effects in the region's oak savannas, but realize that different pre-fire conditions or weather could produce other results (Ffolliott and others 2011b). Prescribed fires ignited under warmer and drier conditions or in denser stands of trees and brush could burn more severely and have more drastic impacts. Managers will have to consider all options as they develop and execute programmatic fire plans.

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