Response of Selected Plants to Fire on White Sands Missile Range, New Mexico[1]

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Abstract

Little was known about the ecology, impacts, effects, and history of fire related to many plants and communities within White Sands Missile Range. I began by identifying the known aspects and the gaps in knowledge for White Sands Missile Range. I analyzed existing data available for the Installation taken from the Integrated Training and Area Management (ITAM) program for 1988 to 1999. Burn plots were identified at 34 sites with fires occurring sometime within that 11 yr span. Selected plant species were analyzed to identify the response to fire including change in frequency, cover, and structure. Analysis of data indicated varied responses to fire and identified a need for long term monitoring to account for natural variability.

Introduction

Fire is a major factor influencing the ecology, evolution, and biogeography of many vegetation communities (Humphrey 1974, Ford and McPherson 1996). In the Southwest, semi-desert grasslands and shrublands have evolved with fires caused by lightning strikes (Pyne 1982, Betancourt and others 1990). Fires have maintained grasslands by reducing invading shrubs (Valentine 1971). The impact these fires have on the ecosystem depends not only on current biological and physical environment but also on past land use patterns (Ford and McPherson 1996). Fires impact communities by affecting species diversity, persistence, opportunistic invading species, insects, diseases, and herbivores. Plant species diversity often increases after fires and some communities are dependent on fire to maintain their structure (Jacoby 1998). Savannas often change to a woodier community when fire is suppressed (Jacoby 1998).

The effects of fire on semi-desert grasslands and shrub invasion have been debated. Buffington and Herbel (1965) did not consider fire a main factor, though others have (Bock and Bock 1988, Pyne 1992, Ford and McPherson 1996). Many have stated that a combination of factors including fire suppression, competition, drought, grazing, rodents, and rabbits have played a significant role in the impact of fires on these communities (Branscomb 1956, Humphrey 1958). A change in fire frequency and intensity has occurred in the past 80 yr and has been correlated to grazing (Baisan and Swetnam 1997). Grazing impacts areas by reducing the fine fuel composition. Factors associated with grazing are an increase in rodent activity, increased erosion, increased seed dispersal by livestock, increased seed source of trees and shrubs, and reduced competition from perennial grasses (National Wildfire Coordinating Group 1984).

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Little was known about the fire ecology of many plants and communities within White Sands Missile Range (WSMR) and the deserts of the southwestern United States. This research identified known aspects and gaps in knowledge for White Sands Missile Range.

Study Area

White Sands Missile Range covers over 828,800 ha (2,210,117 ac) in south central New Mexico. Terrain includes steep, rocky, mountains; steep to moderate footslopes, level to rolling grasslands, dunes, lava flows, and salt flats. Vegetation communities include Chihuahuan desert scrub, Chihuahuan desert grasslands, montane shrublands, juniper savannah, pinyon-juniper woodlands, and ponderosa pine woodlands. The maximum elevation is 2,783 m at Salinas Peak. Rainfall typically occurs during the summer (July, August and September) as short, intense, localized storm events that account for 55 to 64 percent of the total annual precipitation (Barlow and others 1983). The intensity of rains generally results in massive runoff and very little infiltration especially in steep areas and areas with exposed bedrock. Average precipitation varies from 200 mm in the basin to 400 mm in the mountains.

The major fire season for southern New Mexico occurs from May to early July when temperatures are high and relative humidity is low (Kaufman and others 1998). Records kept by the Lincoln National Forest from 1964 to 1994 indicate that 60 percent of the fires started by lightning occurred during April to June and 28 percent occurred during July to September (Kaufman and others 1998). Barrows (1978) identified high starts in June (60 percent), July (18 percent), and May (17 percent). Although the highest rate of lightning ignition occurs at the end of July, the relative humidity and fuel moistures are high enough to limit fire activity. Most fires (60 percent) that have been documented on WSMR were human caused (201), 20 percent (84) were unknown causes, and 20 percent (75) were from lightning strikes. This is a typical Southwestern fire occurrence pattern (Kaib and others 1996, Kaufman and others 1998). July had the most fires reported with 84, followed by June with 75, and May with 60. Other months are high for the area in comparison to Kaib and others (1996) and Kaufman and others (1998) and are dominated by human caused fires.

Methods

Vegetation transect data were obtained from the Integrated Training Area Management (ITAM) program at WSMR. These data included pre and post-fire data for 34 sites. Data were collected by belt transects and Daubenmire quadrats. Belt transects were 100 m long and 2 m wide. Sites were read generally once a year with the number and height class of each species documented. Ten Daubenmire quadrats were placed at 10 m increments along each belt transect. These 34 sites were identified by WSMR ITAM personnel as having had fires sometime during 1988 to 1999. In some cases the date of the fire was known, but on most plots only presence of a fire in the past was recorded.

Daubenmire quadrats were analyzed in an analysis of variance (ANOVA) comparing species cover within the same plots over time. Sites with pre and postfire data were analyzed to determine if cover changed significantly. Significance was determined by the 90 percent confidence interval. Daubenmire quadrats were added in 1996, and only 21 sites had sufficient data to analyze. Belt transects were analyzed by comparing prefire mean density with postfire mean density.

Description of analysis is based on change in frequency, cover, or structure. A positive response was identified by one of these factors increasing. A negative response was based on a decrease. Structure was identified by categorical class and discussion assumed an increase in size structure was a positive response.

Results and Discussion

Analysis of Daubenmire quadrats (*table 1*) and belt transects (*table 2*) produced varied responses of plants to fire. Some trends were found, but confounding factors such as differing methodologies, plot surveys, and localized differences in precipitation make it difficult to form major conclusions.

Table 1—*Yearly mean cover (standard error) of Daubenmire quadrats containing each species with results of analysis of variance including significant F values for Land Condition Trend Analysis plots on White Sands Missile Range, New Mexico. Each plot consisted of 10 quadrats. Fires occurred between 1996 and 1997.*

No. of plots	Species	1996	1997	1998	F	P
6	blue grama (*Bouteloua gracilis*)	33.4 (12.7)	56.5 (14.5)	55.1 (12.9)	6.016	0.028
3	hairy grama (*Bouteloua hirsuta*)	36.7 (24.0)	a	52.21 (7.2)	0.50	0.53
1	black grama (*Bouteloua eriopoda*)	36.9 (34.7)	73.4 (12.8)	a	13.6	0.001
1	Snakeweed (*Gutierrezia sarothrea*)	7.5 (6.2)	51.8 (21.0)	a	32.78	<0.001
1	alkali sacaton (*Sporobolus airoides*)	37.8 (32.5)	a	20.8 (15.8)	3.962	0.055
1	Tobosa (*Pleuraphis mutica*)	22.3 (7.7)	41.8 (6.3)	a	5.672	0.035
1	Wolftail (*Lycurus setosus*)	18.3 (3.3)	a	36.7 (6.3)	3.484	0.089
1	Wolftail (*Lycurus setosus*)	26.5 (5.1)	50.5 (7.2)	a	7.796	0.023
1	Creosotebush (*Larrea tridentata*)	33.4 (4.6)	a	17.2 (5.7)	4.896	0.058

[a] indicates no data available.

The grama grasses were positively impacted by fire. Blue grama increased significantly on all six plots after fire. This is consistent with other findings that blue grama is positively impacted by fire (Wright and Bailey 1980, Ahlstrand 1982). Black grama increased significantly on the only plot analyzed. This contradicts some previous studies indicating a negative response to burning (Buffington and Herbel 1965). The impact of fire on black grama depends on various burn and climatic conditions, and as with many plant species, generalizations regarding impacts must be made with care. Hairy grama was identified as having a positive response on two plots and a negative response on one plot. Location variation may be the reason for the differences observed, as well as the timing of the burns involved. The two positive response plots were burned in March and burned under much cooler conditions then the one negative response. Additionally, data for the negative response were from 2 to 4 yr post-fire. There may have been an initial increase during the first 2 yr and then a decline. Other studies have documented hairy grama having variable responses to fire based on drought or wet years (Wright and Bailey 1980, Ahlstrand 1982). Unfortunately there were no precipitation data with specificity for this site.

Table 2—*List of plant species and number of plots with positive or negative responses on plots after analysis of belt transects on White Sands Missile Range, New Mexico. Response was defined as an increase (positive) or decrease (negative) in frequency within a plot.*

Common name/Scientific name	Belt transect Response Positive	Negative	Change in structure (shrub height)
Apache plume (*Fallugia paradoxa*)	2		
banana yucca (*Yucca Bacata*)		5	
creosotebush (*Larrea tridentata*)		1	1
desert rose (*Rosa stellata*)		1	
plains prickly pear (*Opuntia phaeacantha*)	3	2	
false indigobush (*Dalea formosa*)	2	2	
four-wing saltbush (*Atriplex canescens*)	3	2	5
mesquite (*P. glandulosa*)		2	
New Mexico agave		1	
pineapple cactus (*Neollydia intertexta*)	2		
purple prickly pear (*Opuntia macrocentra*)		4	
sand sage (*Artemisia filifolia*)		1	
skunkbush (*Rhus trilobata*)	1	2	
soaptree yucca (*Yucca elata*)	2	4	4
sotol (*Dasylirion wheelerii*)	1	1	
tarbush (*Flourensia cernua*)	1	1	2
winterfat (*Krascheninnikovia lanata*)		2	

Alkali sacaton has been identified as being positively impacted by fire (Wright and Bailey 1980), but the one plot analyzed here had a negative response. This site is located near the eastern boundary of WSMR. Sacaton recovers in 2 to 4 yr to pre-fire conditions (Wright and Bailey 1980), and the plot surveys analyzed here provided only 2 yr post fire data. This negative response may be the short term impact. Timing of the fire may also be a factor, as burns in spring or fall can be more detrimental to this species than burns during the natural regime of May through September (Cox and Morton 1986).

Tobosa increased significantly at one site based on cover in a one year period after fire. This is similar to findings from Britton and Steuter (1983), who found that, depending on the precipitation, tabosa can revegetate quickly and biomass can increase 2 to 3 times.

Creosotebush decreased at one site. This corresponds with the response observed by Brown and Minnich (1986) in the Sonoran Desert, where recovery of creosotebush was quick and density was similar to pre-fire years in the second post-fire year. On three sites, there was neither a positive nor negative response. On one site, the structure of the creosotebush community changed as larger plants (1 to 2 m) were found in higher frequencies after the fire.

Apache plume responded positively to fires on 2 plots. Banana yucca (5 plots), redjoint prickly pear (2 plots), and pineapple cactus (2 plots) were negatively impacted by the fires. However, Worthington and Corral (1987) identified no mortality of banana yucca after the fire in the Franklin Mountains.

Many species had varied impacts, with a combination of positive, neutral, or negative response being associated with different plots. These include plains prickly pear, false indigobush, mesquite, New Mexico agave, sotol, tarbush, and four-wing saltbush. The variation of impact observed among these species may be associated with the type of fire, season of fire, fire behavior, location, and vegetative communities.

One of the difficulties in using this data set is that species are not identified as resprouting or sprouting from seed. In some cases, species such as soaptree yucca were identified as having a change in structure. This change in structure is important in the fire ecology of the system. If the change in structure is due to burning of the above surface portion of the plant and resprouting, the ecological impact is different than if that structure change includes sprouting of new propagules. This is an important distinction when trying to support fire adaptation in plants.

Fire plays a major role in many of the vegetation communities that occur on White Sands Missile Range. These communities on WSMR are structurally different from similar communities in the southwest because of the accumulation of fine fuels and high densities of closed canopy piñon woodlands. The impact of fire suppression on these fuel loads on WSMR cannot be determined, because comprehensive historical fire suppression documentation is not available. Historical reports that do exist indicate that many fires were actively attacked, but the degree and success in which those fires were observed, located, and controlled is unknown.

Analysis of these long term data suggests that sampling immediately prior to the fire and 1 year post fire does not provide an adequate identification of plant species trend. Variability was high on many plots prior to being burned. Impacts observed based on these types of analyses may reflect the variability of the system rather than the impact of the fire. I recommend that plots be sampled several years prior to fires, although management often does not have this luxury. Incorporating other long term sampling data may provide the manager information to identify the long term trends in relation to fires.

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