OCCURRENCE AND PRODUCTION OF AGAVE ON THE CASCABEL WATERSHEDS FOLLOWING THREE BURNING EVENTS

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Agaves are among the more conspicuous plants in the drylands of the Southwestern Borderlands region in almost any landscape whether natural or manipulated. All agaves have succulent or semi-succulent leaves that form rosettes from a few inches to several feet across, but there are many variations to this basic pattern (Turner et al. 1995, Phillips and Comus 2000). Various species of agave are sources of food, fences, rope, medicine, and liquor. Surprisingly, however, little information is available on the effects of disturbances such as the occurrence of fire on the status of agave in the region. This paper reports on the status of *Agave palmeri* following prescribed burning treatments and a wildfire on the Cascabel Watersheds in the Peloncillo Mountains of southwestern New Mexico. Slauson et al. (1999) reported that nectar and pollen from this agave species are the primary foods for the federally listed lesser long-nosed bat (*Leptonycteris curasoae*).

Agave palmeri inhabits rocky slopes in the oak savannas of the Southwestern Borderlands region in southeastern Arizona, southwestern New Mexico and neighboring states in northern Mexico (Irish and Irish 2000). Such a habitat is found on the Cascabel Watersheds. The Rocky Mountain Research Station, U.S. Forest Service and its cooperators established these watersheds to evaluate the impacts of burning events on the ecological and hydrologic characteristics of the oak savannas in the region (Gottfried and Edminster 2005, Gottfried et al. 2007). This paper reports on the effects of cool-season and warm-season prescribed burning treatments and a wildfire on the occurrence and production of *Agave palmeri* on these watersheds.

CASCABEL WATERSHEDS

Twelve small watersheds, ranging from 20 to almost 60 acres in size, in the Peloncillo Mountains of southwestern New Mexico were (collectively) the study areas. The areal aggregation of these watersheds, the Cascabel Watersheds, is 451.3 acres. The watersheds are located between 5,380 and 5,590 feet in elevation (Gottfried et al. 2000). The nearest long-term precipitation station indicates that annual precipitation averages about 23.5 inches, with nearly one-half occurring in the monsoonal summer. However, a prolonged drought was impacting the study areas at the time of this study. Vegetative, geologic, physiologic, and hydrologic characteristics of the Cascabel Watersheds have been described elsewhere (Gottfried et al. 2007) and, therefore, are not presented in this paper.

PRESCRIBED BURNING TREATMENTS AND WILDFIRE

The original objective of the research program on the Cascabel Watersheds was to evaluate the effects of warm-season (May through October) and cool-season (November through April) prescribed burning treatments on the natural resources of these watersheds including understory plants. These evaluations would then be compared to unburned (control) watersheds to determine the effects of these treatments. Four of the watersheds were burned during the cool-season in early March 2008. Three of the four watersheds to be burned in the warm-season were burned on May 20, 2008, with burning of the fourth watershed scheduled for a later date. However, wind gusts up to 60 mph blew firebrands onto the unburned fourth watersheds in the morning of May 21, 2008. The resulting wildfire crossed the boundary lines among the watersheds and then spread beyond the watersheds to burn approximately 4,000 acres.

The original objective of the research program on the Cascabel Watersheds had to be modified, therefore, to accomplish the objective of the program by evaluating the impacts of the prescribed burning treatments and the wildfire on the natural resources. The effects of these three burning events on the occurrence and production of *Agave palmeri* on the watersheds are reported in this paper. Corresponding information was not available before the burning events. This paper, therefore, only reports on the status of this agave species following the burns.

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FIRE SEVERITIES

A system that relates fire severity to the soil-resource response to burning (Hungerford 1996) was the basis for classifying severity of the prescribed burning treatments and the wildfire at the sample plots on the watersheds following the three burning events. Classifications of fire severity at the sample plots were then extrapolated to a watershed-basis to determine the percentages of the watersheds that were unburned or burned at low, moderate, and high fire severities (Stropki et al. 2009). These extrapolations indicated that all of the Cascabel Watersheds had been exposed to a low burning severity regardless of the event.

STUDY PROTOCOLS

On each of the Cascabel Watersheds, between 35 and 45 primary sample plots had been located along transects perpendicular to the main stream systems and situated from ridge to ridge to provide the sampling basis to obtain pre-burning data sets on natural resources (Gottfried et al. 2007). The interval between the plots varied with the size and configuration of the watershed sampled. A total of 421 plots were located originally on the 12 watersheds. This sampling design had been and continues to be used in studies of natural resources on the watersheds.

Occurrence was noted and the production of *Agave palmeri* was estimated on 9.6 ft^2 plots centered over the primary sample plots in the fall of 2009, almost 20 months following the cool-season prescribed burn and 17 months after the warm-season prescribed burn and the wildfire. Information on the occurrence and production of *Agave palmeri* was obtained on 417 of the 421 plots located originally due to missing plots. Production of agave was estimated by the double-sampling method outlined originally by Pechanec and Pickford (1937). Samples of the plant were collected on temporary plots to develop the correction factors necessary to convert field estimates of green weight to actual (oven-dried) weights of production.

RESULTS

Occurrence and production (standing biomass) of *Agave palmeri* on the Cascabel Watersheds following the three burning events were similar. This finding was not surprising, however, because all of the watersheds had been exposed to the same fire severity (Stropki et al. 2009. Therefore, the respective data sets were pooled to describe the occurrence and production of *Agave palmeri* on the watersheds at the time of sampling.

Occurrence

Agave palmeri was found on 54 (12.9 percent) of the 417 plots on the watersheds after the burning events. The occurrence of entire plants or plant parts on these plots was random and non-normal in its distribution on the watersheds. Neither topography (slope position, slope percent, or aspect) nor surface characteristics (percent of rockiness, bare soil, or plant cover) of the plots were related to the occurrence of *Agave palmeri* following the burning events. Presence of the trees, shrubs, or herbaceous plants on the plots was also unrelated to the occurrence of agave.

While none occurred on the plots, an unknown number of burned or partially burned *Agave palmeri* were scattered on the watersheds following the burning events. Similar to the situation observed with the tallied plants," however, there was no apparent pattern in the occurrence of these dead or fire-damaged plants.

Production

Average production (standing biomass) of *Agave palmeri* on the watersheds following the burning events was about 0.25 pounds per acre. This value was a fraction of one percent of the average production of all understory plants (an estimated 134.2 pounds per acre) in the fall of 2009. Average production of the *Agave palmeri* on the individual Cascabel Watersheds ranged from a trace to almost 16.7 pounds per acre. (Average production of *Agave palmeri* on the 54 plots with the plant was 10.7 pounds per acre, ranging from a trace to almost 100 pounds per acre.) The production levels of agave were random and non-normal in their distribution. Neither watershed characteristics nor production of the other plant species on the 9.6 ft^2 plots were related to the production levels of agave.

DISCUSSION

There is a general lack of information on the effects of fire on *Agave palmeri* in the Southwestern Borderlands region. However, in one study, Scott (1999) found an average of 2.39 surviving stalks per acre following the Baker Burn of 1995 in the Peloncillo Mountains. He thought that this post-fire population of agave would be sufficient in providing food to the migrating bats in the region. Slauson (2002) reported later that initial mortality of *Agave palmeri* after a prescribed burn in the same area was

3.3 percent. Slauson indicated that this mortality should not decrease the food reserves for either the migrating bats or reproductive resources and survivorship of the plant. The rosette shape of the plant and an adaption for carbohydrate storage in the center of the rosette protects much the food reserves of the plant from fire. Nevertheless, it has been concluded that a "significant" decline in *Agave palmeri* numbers as a result of a fire could reduce the numbers of bats and other organisms that are dependent on a steady flow of nectar and pollen from the plant (Howell and Roth 1981).

Worthington and Corral (1987) studied the effects of fire on the densities of another agave species following a "cool burn" in the Chihuahuan Desert of western Texas. These investigators tallied the occurrence of *Agave lechuguilla* on "belt transects" approximately 6.5 feet wide and 165 feet long established on burned and unburned sites 16 months following the fire. Five parallel transects were located on each site. Worthington and Corral reported that the density of *Agave lechuguilla* on the unburned site was 24.5 plants per acre, while they tallied no agave on the burned site. They could not conclude explicitly that the fire eliminated the agave on the burned site, however, because occurrence of the plant had not been tallied on either of the sites before the fire.

CONCLUSIONS

A similar "inconclusive" conclusion on the effects of fire on *Agave palmeri* on the Cascabel Watersheds is reached in this study because pre-fire estimates of the occurrence and production of the plant were not available. The results reported in this paper, therefore, represent a "case study" on the status of *Agave palmeri* following the three burning events on the watersheds at the time that the plant was sampled. Further monitoring will be required to determine the long-term effects of these burning events on the plant.

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REFERENCES

Gottfried, G. J., and C. B. Edminster. 2005. The Forest Service, Rocky Mountain Research Station's Southwestern Borderlands Ecosystem Management Project: Building on 10 years of success. In: Gottfried, G. J., B. S. Gebow, L. G. Eskew, and C. B. Edminster, compilers. Connecting mountain islands and desert seas: Biodiversity and management of the Madrean Archipelago II. USDA Forest Service, Proceedings RMRS-P-36, pp. 237-240.

Gottfried, G. J., D. G. Neary, and R. J. Bemis. 2000. Watershed characteristics of oak savannas in the Southwestern Borderlands region. Hydrology and Water Resources in Arizona and the Southwest 30:21-28.

Gottfried, G. J., D. G. Neary, and P. F. Ffolliott. 2007. An ecosystem approach to determining the effects of prescribed fire in Southwestern Borderlands oak: A baseline study. In: Fire in grassland and shrubland ecosystems: Proceedings of the 23rd Tall Timbers Fire Ecology Conference. Tall Timbers Research Station, Tallahassee, Florida, pp. 140-146.

Howell, D. J., and B. S. Roth. 1981. Sexual reproduction in agaves: The benefits of bats; cost of semelparous adverting. Ecology 62:3-7.

Hungerford, R. D. 1996. Soils: Fire in Ecosystem Management Notes: Unit II-I. U.S. Forest Service, National Advanced Resources Technology Center, Boise, Idaho.

Irish, M., and G. Irish. 2000. Agaves, yuccas, and related plants. Timber Press, Portland, Oregon.

Pechanec, J. F., and G. D. Pickford. 1937. A weight estimate method for determination of range or pasture production. Journal of the American Society of Agronomy 29:894-904.

Phillips, S. J., and P. W. Comus. 2000. A natural history of the Sonoran Desert. Arizona-Sonora Desert Museum Press, Tucson, Arizona.

Scott, P. 1999. Mutualists out of synchrony: Agave flowering and nectar bat visits in the southern Peloncillos and Chiricahua Mountains in 1997. Toward integrated research, land management, and ecosystem production in the Malpai Borderlands: Conference summary. USDA Forest Service, Proceedings RMRS-P-10, p. 115.

Slauson, L. A. 2002. Effects of fire on the reproductive biology of *Agave palmeri* (Agavaceae). Madrono 49:1-11.

Slauson, L., V. Dalton, D. Dalton, and D² Chiropterology. 1999. Effects of prescribed burning on the Palmer agave and the lesser long-nosed bat. In: Gottfried, G. J., L. G. Eskew, C. G.

Curtin, and C. B. Edminster, compilers. Toward integrated research, land management, and ecosystem production in the Malpai Borderlands: Conference summary. USDA Forest Service, Proceedings RMRS-P-10, pp. 111-114

Stropki, C. L., P. F. Ffolliott, and G. J. Gottfried. 2009. Water repellent soils following prescribed burning treatments and a wildfire in the oak savannas of the Malpai Borderlands region. Hydrology and Water Resources in Arizona and the Southwest 39:5-8.

Turner, R. M., J. E. Bowers, and T. L. Burgess. 1995. Sonoran desert plants. University of Arizona Press, Tucson, Arizona.

Worthington, R. D., and R. D. Corral. 1987. Some effects of fire on shrubs and succulents in a Chihuahuan Desert community in the Franklin Mountains, El Paso County, Texas. In: Powell, A. M., editor. Contributed papers of the second symposium on resources of the Chihuahuan Desert regions. The Chihuahuan Desert Research Institute, Alpine, Texas.