Plant Recovery and Deer Use in the Chisos Mountains, Texas, following Wildfire

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Abstract: Although an extremely important biome, little has been studied concerning specific plant responses to wildfire within the pinyon (*Pinus* spp.)-juniper (*Juniperus* spp.) woodland. A wildfire in the semi-arid Chisos Mountains, Texas, during 1980 provided an opportunity to examine the phenological response of desert plant species to burning. Consequently, we examined the response of vegetation and white-tailed deer *(Odocoileus virginianus carminis)* to wildfire for 2 years in the Chisos Mountains, Big Bend National Park (BBNP), Texas. Permanently established, random plots (1 m^2) were established shortly after the fire and all individual stems of plants were identified by species and monitored twice/month. Forbs responded immediately (within 2 weeks post-burn) following a spring drought. Mexican pinyon pine *(Pinus embroides)* and alligator juniper *(Juniperus deppeana)* began crown regrowth 2 months after the fire. Grasses responded rapidly in open, meadow areas. Deer use of the burned area increased following the fire, but later decreased to pre-fire rates. When fire is properly managed, habitat quality for deer and other herbivores may be increased, and critically important meadow areas can be protected from pinyon-juniper invasion.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 56:352–364

The pinyon-juniper forest, which occupies over 24 million ha in the southwestern United States (Tidwell 1987), provides important and often critical wildlife habitat (Barger and Ffolliott 1972, Frischknecht 1975). Many pinyon-juniper woodlands have been converted to grasslands for livestock (O'Rourke and Ogden 1969, Aro 1971, Barney and Frischknecht 1974), which result in improved wildlife habitat for deer and elk *(Cervus elaphus)* (Reynolds 1964, McCulloch 1966, Clary et al. 1974, Short and McCulloch 1977, Short et al. 1977). Studies in this biome are usually conducted within pinyon-juniper woodlands low in tree basal area with an extensive grass understory. Additionally, Gamble's oak *(Quercus gambelii)* in many pinyon-juniper stands in Arizona composes over 25% of tree composition (Barger and Ffolliott 1972). Remarkably, given its importance, the pinyon-juniper woodland biome rarely has been studied concerning effects of fire on the diverse understory plant species present. Additionally, few studies have examined the phenological responses of understory and midstory plant species of the pinyon pine-juniper woodland to wildfire.

The Pinyon-juniper biome also is an important forested community for nongame migrant birds species. Balda and Masters (1980) reported that 73 species of birds are found in the juniper-pinyon-juniper woodland, with 5 of these species dependent on the biome. Similarly, Goguen and Mathews (1988) found a diverse array of species of migrant non-game birds ($N = 41$ species) in their study.

The opportunity to study recovery of plants after wildfire arose in BBNP, Texas, when a human-induced wildfire burned more than 81 ha of pinyon-oak-juniper woodland and oak shrubland on 21 March 1980. The fire varied in intensity depending on fuel load and understory plant species composition. We used this opportunity to establish study plots and monitor vegetation recovery through early winter 1981 to describe plant species recovery and deer use of the burn.

This study was funded by the Rob and Bessie Welder Wildlife Foundation, Sinton, Texas. We also thank the BBNP staff for providing funds and equipment to perform this study. We appreciate the reviews of P. F. Ffolliott, D. A. Miller, D. Arner, B. H. Koerth, and B. Warren of earlier drafts of the manuscript. This is publication number WF-179 of the Forest and Wildlife Research Center, Mississippi State University, Mississippi, and 579 of the Welder Wildlife Foundation.

Methods

Study Area

The Chisos Mountains, BBNP, Texas, occupy more than 57 km^2 and are entirely within the park boundary. Elevations range from 1,282 m to more than 2,740 m at Emory Peak. The park is located 113 km south of Marathon, Texas (Fig. 1).

Vegetation associations of the Chisos Mountains included pinyon-oak-juniper, pinyon-juniper grassland, oak shrubland, and stipa (*Stipa* spp.) meadows. The wildfire occurred within the pinyon-oak-juniper, oak shrubland, and stipa meadow associations. Principal tree species included Mexican pinyon pine *(Pinus edulis),* alligator juniper *(J. deppeana),* drooping juniper *(J. flaccida),* and oak species [gray oak *(Q. grisea)*, Emory oak *(Q. emoryi),* and Graves oak *(Q. gravesii)*]. Grass species included needlegrass (*Stipa* spp.), three-awn (*Aristida* spp.), side-oats grama *(Bouteloua curtipendula),* muhly grass (*Muhlenbergia* spp.), sprangletop *(Leptochloa dubia),* and bluegrass (*Poa* spp.). Succulents occurred on drier slops and a wide variety of herbaceous forbs occurred throughout the mountain range. Krausman and Ables (1982) provided a detailed discussion of the plant species of the Chisos Mountains. All scientific and common names followed Correl and Johnston (1970).

Precipitation normally ranges from 22 to 68 cm, most of which occurs between July and October. Snow accumulation was light with <8 cm with any individual storm. Temperatures were moderate, rarely below freezing during winter and exceeding 33 C during summer.

Vegetational Analysis

To determine temporal changes in plant species growth and composition, we randomly located 7 1-m^2 permanent plots 1 week after the fire. Four plots were with-

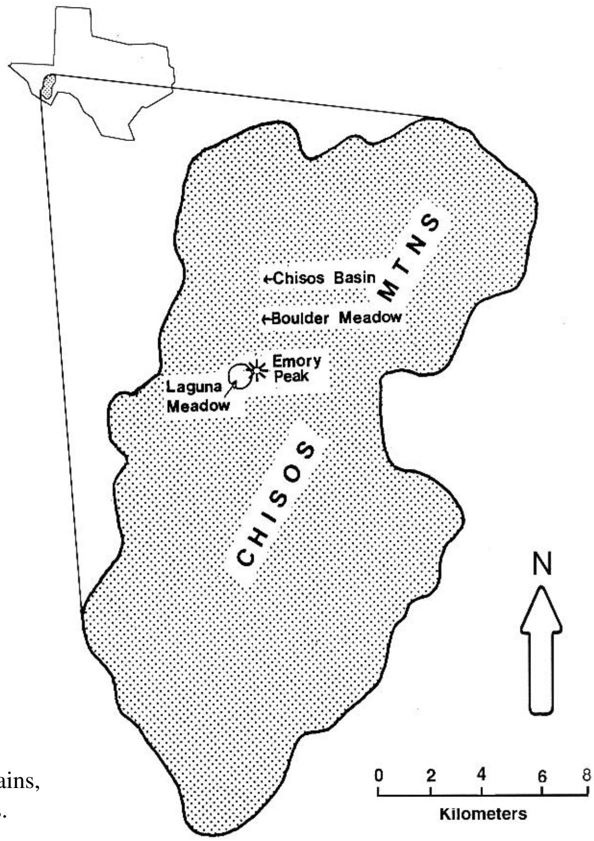

Figure 1. The Chisos Mountains, Big Bend National Park, Texas.

in the burned area and 3 were controls on adjacent unburned areas. We made written descriptions, color slides, and detailed diagrams of individual plants of each plot once every other week until growth had ceased in fall (20 Oct 1980). Distribution of plots within the plant associations was 3 (2 burned, 1 control) in the pinyon-oak-juniper, 2 (1 burned, 1 control) in the oak shrubland, and 2 (1 burned, 1 control) within the stipa meadow.

During the second year of the study, we established 6 additional plots on 18 May 1981 (14 months after the fire) on burned areas devoid of plant cover (i.e., only bare ground was present) to assess plant species which would invade severely burned areas. Four plots were in the woodland, and the stipa meadow and oak shrubland each had one plot. Plots within the woodland were placed randomly in locations varying in burn severity, including 1 plot in open woodland with most trees killed, one plot in closed woodland with trees burned but canopy living, and 2 plots in moderately burned woodland with an open canopy and few trees killed.

We also randomly selected individuals of common plant species and monitored their response during the study. These included 1 each of pinyon pine, alligator juniper, century plant *(Agave havardiana),* prickly pear (*Opuntia* spp.), sotol *(Dasylirion leiophyllum),* basketgrass *(Nolina erumpens),* and Gambel's Oak. Additionally, we monitored dwarf oak *(Q. intricata)* stems for acorn production within each of the plots, and classified plots as low (0%–25% of stems with acorns), moderate (26%–50%), high (51%–75%), and very high (76%–100%) production of acorns.

Deer Density Assessment

We placed a pellet-group transect in the burned area to determine white-tailed deer density. The transect consisted of 2 parallel lines, each with 10 circular, 0.004-ha plots which traversed 3 vegetational associations. Sampling occurred 10 times, 50 to 60 days apart. We calculated deer abundance with the formula: deer abundance = (*N* pellet groups/ha) / (*N* days between samples).

We compared estimates of white-tailed deer use of the burned area during our study with those obtained by Krausman and Ables (1982) which we used as a pre-fire density estimate (1972–1974). Our deer transect traversed the same area sampled by Krausman and Ables (1982). We compared average deer use of the area using a *t*-test. We used the square-root transformation, assuming that the pellet-group data followed a Poisson distribution.

Weather Monitoring

We obtained rainfall and temperature data from the National Park Service weather station at the Chisos Basin (1,615 m). For comparison, we compiled average monthly high and low temperature and average monthly precipitation from 1960 to 1982.

Results and Discussion

The Wildfire and Associated Conditions

The fire occurred during a fall–spring drought (October–May; Fig. 2), and vegetation in the Chisos Mountains was under moisture stress. Less than 5.8 cm of rainfall had been recorded during the 7 months prior to the fire, compared to the expected 16 cm based on the 1960–1982 monthly averages.

Intensity of the fire was variable (unpubl. records, BBNP staff). Because of the dryness of vegetation, the fire moved swiftly in most areas. However, in some locations, the fire was intense and slow-moving resulting in mortality of adult overstory trees.

Plant Recovery Plots

Pinyon-Oak-Juniper Woodland.—Regrowth of overstory trees began 2–3 months after the fire. Alligator junipers that burned with more than 70% crown kill began sprouting basally after 4 months. Canopy growth of light to moderately burned trees began within 2 months. This initiation of canopy and basal growth in May was an unexpected result as the drought persisted (Fig. 3). However, pinyon pine is more drought resistant than juniper (Tueller and Clark 1975). Additionally, average month-

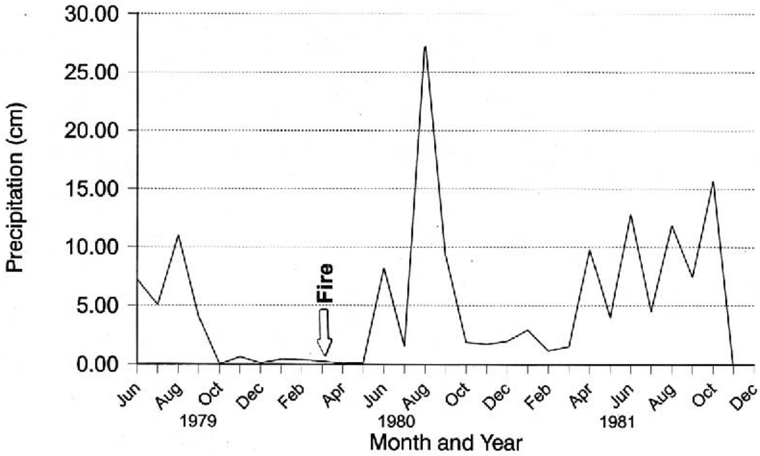

Figure 2 Monthly precipitation (cm) recorded at the Chisos Basis, Big Bend National Park, Texas, during the study period, 1979–1981.

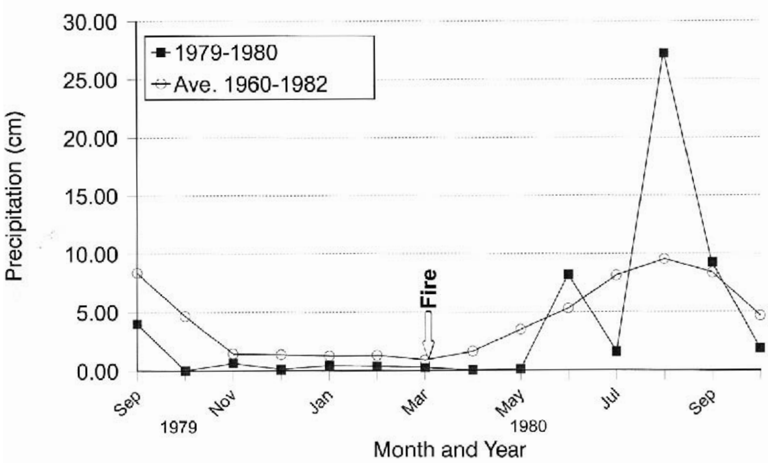

Figure 3. Comparison of precipitation occurring during the study period prior to and after the wild fire and the 22-year average (1960–1982) at the Chisos Basin, BBNP, Texas.

ly temperatures between the time of the fire and regrowth were 0.5 to 2.1 C less than the 1960–1982 averages. Also, a snowstorm that deposited 7.6 cm of snow within the Chisos Mountains in April 1981 may have added enough moisture to enable lightly to moderately burned trees initiate growth prior to the ending of the drought in June.

Grass and forb growth was slower in the pinyon-oak-juniper than growth in the oak shrubland vegetation association, partially because of less sunlight and rainfall resulting from more the more closed canopy of the pinyon-oak-juniper woodland. Grasses, including needlegrass, blue grama *(B. gracilis),* side-oats grama, three-awn, bull muhley, and bluegrass began to sprout in the control plot on 13 May 1980 and 1 month later on the burned plots. Previous studies also found that three-awn, muhly, and blue grama respond well to burning (Reynolds and Bohning 1956, Dwyer and Pieper 1967, Ahlstrand 1982). Hopkins et al. (1948), Anderson et al. (1970), Wink and Wright (1973), and Wright (1974) reported a poor response by side-oats grama to burning with mortality ranging from 1% to 51%. We found side-oats grama responded well once summer rains began. Forb response was later than the grasses with principal forb species including stevia *(Stevia serrata),* thoroughwort *(Eupatorium wrightii),* noseburn *(Tragia ramosa),* and snoutbean *(Rhynochosia texana)* not sprouting until 3.5 months after the fire and after approximately 7 cm of rainfall.

Similar growth and plant species composition occurred during the second year. The large amount of rainfall resulted in a more extensive response (as evidenced by the number and amount of sprouting and new growth observed bi-weekly) by all plant species. Plant species composition changed little.

Within the control during the first year, growth by prickly pear had not appeared until 1 September 1980, near the end of the growing season. Prickly pear on the burned sites grew new pads by 7 July 1980. Similar response by prickly pear to fire has been observed by Reynolds and Bohning (1956) and Heirman and Wright (1973). Even severely burned prickly pear plants had new pads growing from the base by the end of July 1980. Century plant regrowth was minimal for both plots during the first year. However, burned century plants did exhibit growth and a tolerance to moderate burning. Regrowth of leaves was extensive during the second growing season after the fire once precipitation had occurred. Severely burned century plants never recovered. Previous studies have found similar responses by *Agave* spp. with extensive burning (Kittams 1973, Ahlstrand 1982). Deer consumed the center of many plants (25%–50%) which were burned.

The vegetative response by understory vegetation was not as great as reported in other studies (Arnold et al. 1964, Ffolliott et al. 1977). An explanation may be that the typical coniferous stands studied previously were less dense than those studied here. The fire did not kill more than 5% of the overstory trees, and the dense canopy prevented any extensive biomass increase by the understory.

Oak Shrubland.—The dominant oak species was dwarf oak that normally attains a height of 1.1 to 1.4 m. Only charred stems and ash remained immediately following the burn. The fire within this vegetation association was more severe with large pinyon pines and junipers never recovering. However, dwarf oak and silktassel *(Garrya lindheimeri)* began sprouting by 5 May 1980 on the burned plot. Growth on the control did not occur until 4 months later. By this time, the oak and silktassel had attained heights ranging from 7.6 to 15.2 cm on the burned plot. Browsing by deer was extensive during the initial stages of growth when stems and leaves were succulent. Several species of forbs including false dandelion (*Pyrrhopappus* spp.) and false nightshade *(Chamaesaracha conoides)* began to sprout at the same time. This response was in part because of thundershowers in June. By the end of the growing season, the principal plant species in the burned plot were dwarf oak, silktassel, needlegrass, and blue and side-oats grama.

Growth during the second year was extensive for dwarf oak and silktassel. In many locations, bare ground was covered completely with oak stems of heights ranging from 45.7 to 61.0 cm by the end of the growing season. The oaks had successfully flowered and produced mature acorns. The grasses and several forbs species flowered and seeded. The control plot had very few forb and grass species compared to the very rich burned area (11 species versus 3 species) probably because of the dense canopy of the mature oaks.

Although by the end of the second growing season the height of the dwarf oaks was less than one-fourth that of the controls, diversity of grass and forb species within the burned oak shrubland was greater. The green growth of the dwarf oaks and silktassel likely attracted the white-tailed deer, as evidenced by the extent of browsing (>25% stems browse) and deer use of the oak shrubland association. The production of acorns after only 2 years of growth was remarkable and obviously provided a food source to several wildlife species. Oaks on the control plot did not exhibit as great an acorn production (low to moderate production) as those plants that were burned (moderate to very high). An important point to consider is that the dwarf oak plants were burned to the ground. Although the biomass of the unburned plat was probably greater, it was in the form of unpalatable stems and leaves. The biomass of the burned area, however, was in a more palatable form to most wild herbivores. In areas where dwarf oak was sparse, stands of blue grama were present.

Stipa Meadow.—The dominant species of grass was needlegrass *(Stipa tenuissima).* Ten days after the fire had occurred, at least 50% of the burned grass clumps had green sprouts. The fire had swept rapidly over the dry above-ground portions and did not damage the root stock. Most clumps (80%) had new leaf blades, 17.8 to 20.3 cm in height, within 1 month on the burned plot. The grass within the control plot also exhibited green-up at this time with a 60% to 70% of the leaf blades green. Within the burned plot, groups of horseweed *(Conyza canadensis)* seedlings were present within and bordering the meadow. The growth of needlegrass and horseweed was enhanced by a snowstorm that occurred in early April. Rapid growth of the grasses occurred and by the end of the year average height of the blades was between 51 to 61 cm. Several plants had flowered and successfully produced seed.

Blue grama growth and flowering was extensive on the borders of the meadow where needlegrass was not dominant and standing rainwater was minimal following thundershowers. Hairy grama *(B. hirsuta)* and bluegrass were abundant (composing between 25%–50% of ground cover) 5 months after the fire.

Growth of grass species was rapid during the second year after the fire with

Table 1. Plant species invasion (assessed on 2 Nov. 1981) on plots following a wildfire, Chisos Mountains, Big Bend National Park, Texas.

Vegetation Association	Overstory condition[a]	Seedling establishment (months after fire)	Counts		Ground coverage (%)
			Species	Stems	
Pinyon-oak-juniper					
Closed canopy	Alive	13.5	4	≥13	75.0
Open canopy	Dead	13.5	2	3	2.0
Open canopy	Moderate	13.5	2	≥20	80.0
Open canopy	Moderate	13.5	4	≥15	70.0
Oak shrubland	NA	13.5	6	14	30.0
Stipa meadow	NA	19.0	3	≥7	20.0

a. Alive = canopy alive with little to no damage (<10%) from fire; dead = trees and associated canopy killed by fire; moderate = partial canopy kill by fire present, but tree alive with new growth present.

greater than 25% of needlegrass plants exceeding 122 cm in height with extensive flowering and seeding. Areas within the meadow had needlegrass seedlings present as early as 25 January 1981. Throughout the meadow, dense stands of horseweed were present with extensive flowering and seeding (between 75%–100% of stems).

Needlegrass is fire resistant given that the fire only removes above-ground stems. However, Wright et al. (1979) stated that needlegrass is sensitive to burning and time of the fire is critical concerning grass survival. Other studies indicate that moderate burning is not detrimental to *Stipa* spp. growth and reproduction (Kittams 1973). Our results indicate that stipa *(Stipa tenuissima)* is quite fire and drought resistant. Also, the dense growth of several species of grama indicates that fire within desert mountain grasslands may be an important tool in maintaining the grassland type. The meadows within the Chisos Mountains may, in fact, be maintained by periodic fires. Within the Chisos Mountains, fire occurs every 70 years (Moir 1982) and prevents juniper and pinyon invasion. Boulder Meadow (Fig. 1) had numerous junipers growing within it and given the fire suppression activities of the National Park Service in the past, pinyon-juniper invasion is likely without fires (O'Rourke and Ogden 1969, Aro 1971, Barney and Frischknecht 1974).

Plant Invasion Plots

Few plant species exhibited an ability to rapidly reestablish on burned plots. The only plots with a significant change regarding plant species growth were those within the woodland plots with living canopy (Table 1). Within the more open canopy stands (open as a result of the death of overstory trees), fewer seedlings were found or were able to survive for any extensive period of time. Dwyer and Pieper (1967) found that 1 to 2 years after burning, bare ground on some of their areas was still extensive.

General Observations of the Plants Throughout the Burn

Numerous plant species exhibited a positive response (vegetative growth, flowering, fruiting) to the fire (Table 2). Additionally, several species found typically

Table 2. Common plant species found on plots following a wildfire in the Chisos Mountains, Texas, 1980 and 1981.

Common name	Scientific name
Muhly grass	*Muhlengergia emersleyi*
Mugwort	*Artemesia* spp.
Snakewood	*Xanthocephalon* spp.
Dwarf oak	*Quercus intricata*
Gayfeather	*Liatris punctata*
Morning glory	*Ipomoea lindheimeri*
Wolftail	*Lycurus phleoides*
Mexican catch-fly	*Silene lacinata*
Skeleton-leaf golden-eye	*Viquieria stenoloba*
Bedstraw	*Galium* spp.
Bluets	*Hedyotis* spp.
Bromegrass	*Bromus anomalus*
Scarlet standing cypress	*Impomposis aggregata*
Hawkweed wild-buckwheat	*Eriogonum hieracifolium*
James wild-buckwheat	*E. jamesii*
Tall wild-buckwheat	*E. tenellum*
Sawtooth stevia	*Stevia serrata*
Globemallow	*Spairalcea angustifolia*
Snoutbean	*Rhynchosia texana*
Evolvulus	*Evolvulus* spp.
Feather dalea	*Dalea formosa*
Oxeye	*Heliopsis parvifolia*
Gila	*Gilia* spp.
False night-shade	*Chamaesaracha coniodes*
Verbena	*Verbena wrightii*
Blue grama	*Bouteloua gracilis*
Hairy grama	*B. hirsuta*
Blackfoot	*Melampodium elucanthum*
Squirreltail	*Sitanion hystrix*
Pine deervetch	*Lotus oroboides*
Lovegrass	*Eragrotis cilianensis*
Pennyroyal	*Hedeoma* spp.
Rain lily	*Cooperia Drummondii*
Noseburn	*Tragia ramosa*
Texas madrone	*Arbutus texana*
Damianita	*Chrysactinia mexicana*
White-thorn acacia	*Acacia constricta*
Claretcup cactus	*Echinocereus triglochidiatus*
Nipple cactus	*Mammilaria* spp.
Agrito	*Berberis trifoliata*
Stemmed bitterweed	*Hymenoxys scaposa*

within the lower desert regions of the park (≤975 m), also were in the burned area. These species indicated an ability to recover from moderate to light burning and included sotol, basketgrass, lechugilla *(Agave lechuguilla),* prickly pear, and century plant. Previous studies generally agree that fire reduces densities of these plant species (Reynolds and Bohning 1956, Cable 1967, Ahlastrand 1982). However, we found that mortality of sotol and basketgrass occurred only when greater than 70% of the plant was burned, concurring with the observations of Kittams (1973). An interesting occurrence during the first growing season was that severely burned century plants, sotol, and basket grass plants flowered. Flower stalks were initially observed 5 weeks after the fire. It seems that when these plant species are severely damaged by burning, which inevitably results in death, nutrients remaining in the roots and vegetative parts are used for reproductive purposes given that the parent plant is mature enough. Several stalks were eaten by deer by 13 May 1980 and seed was never produced.

White-tailed Deer Use of Burned Area

Deer abundance was low on the first sample (26 May 1980) with 0.9 pellet-groups/ha-day (pg/h-d) but increased to a maximum of 8.1 pg/h-d on 16 March 1981 (Fig. 4). On 2 November 1981 there was lesser deer use (2.8 pg/h-d). Thus, deer use increased as the understory vegetation biomass increased. The decline after 13 July 1981 may signify a stabilization in use and deer that had shifted their feeding areas to include the burn may have left the area once forage response had diminished at the end of the second growing season.

Using the data of Krausman and Ables (1982), an average pg/h-d of 2.1 ± SE = 0.51, $N = 8$, was obtained, contrasted with the average for this study of 4.61 ± SE = 0.60, $N = 10$. These averages differ significantly (t-test, $P = 0.018$, df = 16).

The level of deer use we observed on the burned area was expected as previous studies found similar results in burned pinyon-juniper woodland (Reynolds 1964, McCulloch 1966, Short et al. 1977, Short and McCulloch 1977). The increase in deer use during the first growing season was likely in response to the increasing forage availability and palatability. Initially, deer used the burned cacti and fallen trees.

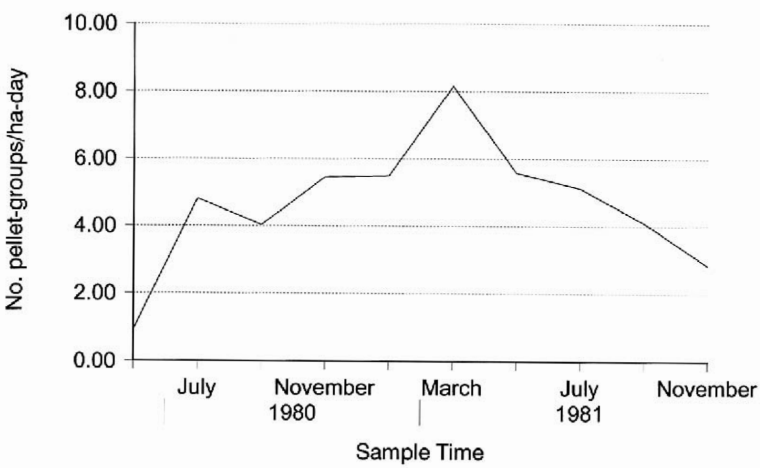

Figure 4. Relative abundance of white-tailed deer assessed using pellet-group counts within the wildfire area during 1980–1981, Big Bend National Park, Texas.

Once rainfall had increased and herbaceous response occurred, the deer then fed on the more succulent and nutritious forage source.

Summary and Conclusions

The wildfire that occurred on 21 March 1980 in the Chisos Mountains in BBNP, Texas, was initially believed to be a disaster by many of the park staff and park visitors. The park was in the middle of a drought where rainfall prior to the fire for 1980 was 1.07 cm. However, understory vegetation responded positively once summer thundershowers occurred in July 1980 with a total annual rainfall of 54 cm. The great vegetative response continued during the second growing season following the fire because of another wet summer and winter period with 71 cm of precipitation by the end of November 1981.

There was little change in vegetative composition within the types monitored. By the end of the study, the stipa meadow was virtually unrecognizable as being burned. Evidently, the fact that the area had been suffering from a drought had no effect on the rapid response of individual stipa plants. Additionally, the extremely dry nature of the above-ground portion of the plants prior to the fire resulting in a swift ground fire caused little damage to the root stock. The principal change observed in the oak shrubland was a decrease in average height from 1.1 to 1.4 m down to 0.3 m. Ground cover was extremely variable ranging from 20%–100%. The response of the pinyon-juniper woodland was variable depending upon severity of the burn and location (slope and aspect). Some severely burned areas will take a considerable time to fully recover because most of the dominant overstory was killed. Other areas suffered a light ground fire that killed trees <5 cm in diameter, opening the canopy and permitting understory vegetation biomass to increase.

Deer use increased during the middle of the study. As forage production stabilized, deer use began to decrease and by the end of the study, use was approximately 25% of the observed maximum.

When fire is correctly applied within arid woodland habitats, it can serve several managerial purposes, including thinning of overstory and understory shrubs and trees, reducing fuel load, and increasing forage production for herbivores. Special consideration obviously has to be taken within desert or semi-desert environments concerning climatic conditions. If the drought had not broken when it did in this study, the understory response observed may not have occurred.

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