Population Reactions of Selected Game Species to Aerial Herbicide Applications in South Texas

SAMUEL L. BEASOM AND CHARLES J. SCIFRES

Highlight: Aerial spraying 80% of a mature honey mesquite brushland in alternating strips with 2,4,5-T + picloram (1:1) at 1.12 kg/ha did not adversely affect populations of white-tailed deer, nilgai antelope, wild turkeys, or feral hogs. Complete treatment (100% sprayed) apparently exceeded the threshold of suitability for all game species surveyed except nilgai antelope. White-tailed deer densities were inversely correlated with production and species diversity of forb populations following aerial spraying. With restoration of the forbs at 27 months after treatment, there were no differences among treatments in deer numbers. Javelina populations, apparently as a result of controlling pricklypear, were significantly reduced by both spray treatments. Reductions in javelina densities were apparent at the final census, 27 months after herbicide application.

The term, "range management," generally connotes increasing the grazing capacity of rangeland. During the past century, much of the rangeland of South Texas has become "thicketized" by the increased density and stature of woody species (Johnston 1962), reducing its productivity for livestock. Extensive brush control efforts have been employed to check woody-plant encroachment and increase grass production for domestic livestock (Lehmann 1960). Range improvement efforts in the Rio Grande Plain of Texas have been characterized by mechanical brush control often followed by conversion of land use to tame pasture. Only recently have game animals been considered of adequate economic importance for incorporation of their habitat requirements into range improvements programs. As their economic value has increased (Teer and Forrest 1968), the impact of range improvement practices on game animal habitat has emerged as a critical variable for consideration in proposed vegetation manipulation schemes.

The structure and composition of vegetation, particularly the relative proportions of various woody and herbaceous components, determine habitat quality for game species. Alterations of vegetative cover serve to either accelerate or retard plant succession and, subsequently, may have varying influences on different wildlife species. For example, game species such as white-tailed deer (*Odocoileus virginianus*), which depend heavily on forbs and browse (Davis and Winkler 1968; Everitt and Drawe 1974), are negatively affected by excessive control of these plants in favor of range grasses (Box 1964; Goodrum and Reid 1956; Davis and Winkler 1968). Brush control, however, can be conducted such that it benefits white-tailed deer (Blakey 1947; Box and Powell 1965; Krefting and Hansen 1969; Darr and Klebenow 1975). Wild turkeys (*Meleagris gullopavo*) are benefitted by relatively small cleared areas in forests or brushland (Walker 1962; Lehmann 1960). However, extensive clearing has led to either reductions or elimination of wild turkey populations (Glazener 1958; Leopold 1959; Walker 1962). The effect of brush control on nilgai antelope (*Boselaphus tragocamelus*), feral hogs (*Sus scrofa*), and javelinas (*Pecari tajacu*) apparently has not been studied.

Since aerial sprays of herbicides such as 2,4,5-T [(2,4,5-trichlorophenoxy)acetic acid] at rates feasible for range improvement do not effectively control many common woody species in South Texas mixed-brush (*Prosopis-Acacia*) communities, mechanical brush control has been more widely practiced than chemical treatments. Therefore, most research on the influence of brush control on wildlife habitat on the Rio Grande Plain has been conducted following treatments such as chaining and/or root plowing. However, with the advent of herbicides such as picloram (4-amino-3,5,6-trichloropicolinic acid), which broaden the spectrum of species controlled (Bovey and Scifres 1971), aerial spraying for range improvement has gained considerable popularity in South Texas. Apparent differences in the effect of herbicides on woody-plant communities, as compared to broadcast mechanical methods, are that (1) spraying is completed much more rapidly, causes less physical disturbance of the habitat, and vegetation change is less abrupt than with mechanical control; (2) competition is reduced by removal of the brush canopy but with the trunks and branches left standing; and, (3) the forb component is reduced, at least in the season of herbicide treatment, rather than the usual increase stimulated by the soil disturbance of mechanical control. The objective of this research was to compare partial with complete aerial spraying of South Texas mixed-brush communities to investigate the potential for improving rangeland for livestock grazing without detriment to game populations that are economically croppable.

Authors are assistant professor, Department of Wildlife and Fisheries Sciences; and professor of range sciences, Texas Agricultural Experiment Station, Texas A&M University, College Station 77843.

The report is published with approval of the Director, Texas Agr. Exp. Sta. as TA 12468.

The cooperation of H. Pinnel, owner; A. Durham, ranch manager at project inception; and M. Brownfield, game manager; El Sauz Ranch, Raymondville, Tex., in providing land and partial financial assistance for this research is gratefully acknowledged.

Manuscript received April 2, 1976.

Study Area

The study area is located in dense mixed brush on the El Sauz Ranch near Raymondville, Willacy County, Tex. (Fig. 1). The soil is predominantly Delfina and Lozano fine sandy loam. There is no record, since the organization of the ranch as an operational unit in 1940, of any brush control practices being applied to the study area. Study pastures were grazed yearlong at an average of 1 animal unit/10 ha as a cow/calf operation. The study area was not commercially hunted and the harvest of all game species reported herein was light.

The terrain is level to gently rolling with no natural drainages. The vegetation consists of an almost continuous covering of woody plants. Durham (1975) reported a woody plant density of 661 plants/ha on the area. The major overstory species is honey mesquite (*Prosopis glandulosa* var. *glandulosa*), which accounts for 72% of the woody plant density. Other important woody species and their relative contribution to composition include huisache (*Acacia farnesiana*) (15%), spiny hackberry (*Celtis pallida*) (4%), lime pricklyash (*Zanthoxylum fagara*) (3%), bluewood (*Condalia obovata*) (2%), lotebush (*Ziziphus obtusifolia*) (1%), narrowleaf forestiera (*Forestiera angustifolia*) (1%), retama (*Parkinsonia aculeata*) (>0.5%), and desert yaupon (*Schaefferia cuneifolia*) (<0.5%). In addition to the relatively dense woody plant cover, the area supported over 495 pricklypear (*Opuntia* spp.) plants/ha, the majority of which ranged between 1.5 and 1.8 m tall and covered circular areas of from about 2 to 3.5 m in diameter.

Materials and Methods

On May 11 to 15, 1973, approximately 2,050 ha of rangeland were aerially sprayed with 2,4,5-T + picloram (1:1) at 1.12 kg/ha in 47 liters/ha of a diesel oil:water (1:4) emulsion. One area, approximately 0.97 km wide and 4.42 km long (430 ha), was treated in parallel strips (strip-sprayed), varying from approximately 185- to 200-m wide, and alternated with untreated strips about 30-m wide. A total of 17 untreated strips resulted from this design. Another area, approximately 1,620 ha of the same vegetation type, was completely treated as one continuous block (block-sprayed). A third area, approximately 1,000 ha, was left untreated. The areas were contiguous, allowing the animals to move among the treatments by free choice (Fig. 1).

White-tailed deer, nilgai antelope, wild turkey, feral hog, and javelina populations in each area were aerially censused by helicopter at 3, 9, 15, 21, and 27 months post spray. Each census period lasted 2 days; and each area was represented by two counts (one during early morning and one during the late afternoon) during each of the five periods.

Each of the areas was flown using strip transects covering approximately 30% of the total acreage. The transects were flown at a height of 15 to 25 m and a speed of 32 to 40 kph. An observer on each side of the aircraft counted the wildlife species from the flight line out to approximately 33 m resulting in a series of 0.2 km wide belt transects.

Response of woody species to the aerial sprays was determined by at least two workers estimating the canopy reduction of each species along a line transect at 3, 15, and 27 months after treatment. The transects were 0.95 km long and located approximately 0.25 km apart. At least 15 such transects were evaluated in each treated area. At 15 and 27 months after herbicide application, woody plants completely defoliated were inspected for basal sprouts. In this paper, "plant kill" will refer to those plants completely defoliated and without development of basal sprouts at 15 and 27 months after treatment. Response of pricklypear to the sprays was evaluated by estimating the chlorotic or necrotic cladophyll area. Complete necrosis was required for the pricklypear to be considered killed by the sprays.

In each of 10 of the treated and untreated strips, 12 exclosures were established on May 22, 1973, to allow monitoring of the forb population without the influence of grazing. Vegetation composition was similar in all treated areas (Durham 1975). The exclosures, 1.5 m tall and 3.5 m in circumference, were constructed of welded wire, 6 gauge with 10- by 10-cm openings. The exclosures were spaced approximately 200 m apart, in the approximate center of the treated area. At the end of each of four periods within the growing season to 27 months post spray, forbs in the exclosures were counted by species; their topgrowth was then harvested to within 2.5 cm of ground line, oven-dried, and weighed. The growing periods were arbitrarily separated into spring (April 1 to June 15); early to midsummer (June 15 to July 15); mid- to late summer (July 15 to August 31); and late summer to fall (September 1 to October 31). Immediately following harvest of the protected areas, exclosures were then moved approximately 10 m from the original location to begin the next growing session.

Within 15 days of the wildlife censuses in August, forb density by species was recorded in 0.25 m^2 sampling areas immediately adjacent to lines supporting the grazing exclosures. Sampling number was determined by the point of inflection on the Species-Area curve.

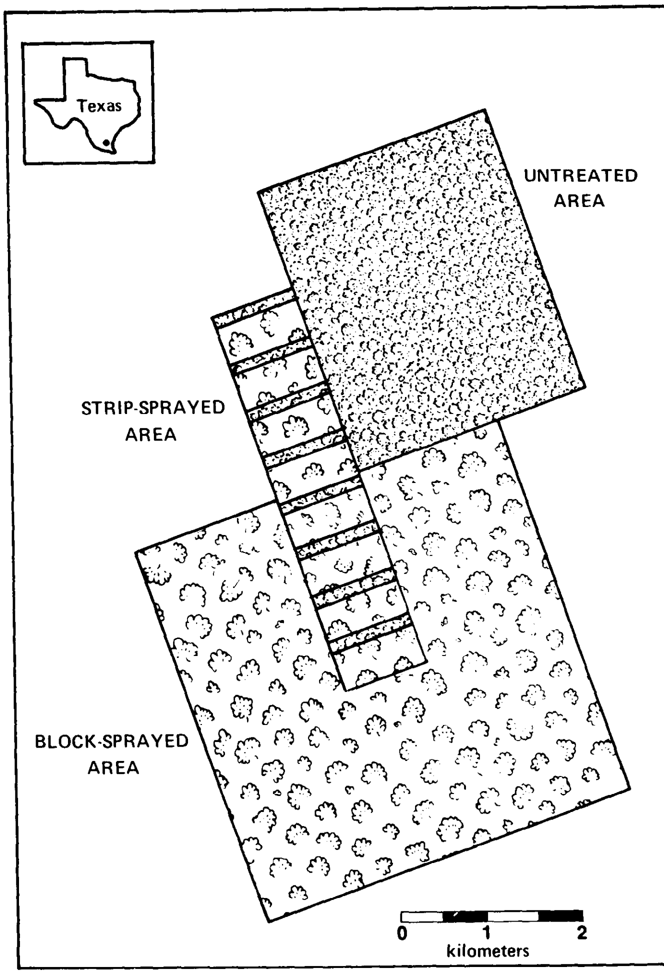

Fig. 1. *Location of study and layout of treatments where response of five wildlife species to aerial application of 2,4,5-T + picloram at 1.12 kg/ha to South Texas mixed brush was evaluated from application in May, 1973 to August, 1975, near Raymondville, Tex.*

Results and Discussion

Response of Woody Plants

High levels of defoliation of woody plants occurred by 3 months after application of the aerial sprays (Table 1). Where the herbicide combination was applied in strips, 69% of the total woody plant canopy was removed, and an overall canopy reduction of 86% occurred in block-sprayed area. In the treated areas, 97% of the honey mesquite and 95% of the spiny hackberry canopies were removed by late summer the year of treatment. The pricklypear was chlorotic, losing turgor, and some of the larger plants were beginning to collapse at only 1 month after spray application. At 3 months after spray appli-

Table 1. Percentage defoliation of primary woody species at 3, 15, and 27 months after aerial application of 1.12 kg/ha of 2,4,5-T + picloram on May 11 to 15, 1973, to a mixed-brush stand near Raymondville, Tex., where wildlife populations were monitored.

Species	Defoliation (%) at months post treatment 3	15	27
Honey mesquite	97	96	92
Huisache	38	18	12
Spiny hackberry	95	89	65
Lime pricklyash	33	33	20
Bluewood	5	0	0
Lotebush	98	47	21
Narrowleaf forestiera	35	0	0
Pricklypear[a]	55	86	92
Weighted average, block sprayed[b]	86	79	72
Weighted average, strip-sprayed[b]	69	63	58

[a]Refers to chlorotic or necrotic area of cladophyll.
[b]Adjusted value as % composition × canopy reduction summed for all species and adjusted for area treated; i.e., vaues multiplied by 0.8 for strip sprayed.

cation, green cladophyll area of pricklypear was reduced by 55% (Table 1). The herbicide combination is established as highly effective for honey mesquite control (Scifres and Hoffman 1972); but the response of pricklypear, spiny hackberry, lime pricklyash, and lotebush was more rapid than usually occurs (Fisher et al. 1972). This rapid response was attributed to excellent plant growth, favorable soil moisture, moderate air temperatures, and bright days during and for 30 days following spray application.

Narrowleaf forestiera and lime pricklyash were the only species with which response to the herbicide treatment was significantly different ($P<0.05$), between the block- and strip-sprayed areas. Defoliation values 3 months after treatment were 9 and 57% for lime pricklyash and 0 and 71% for narrowleaf forestiera on the strip- and block-sprayed areas, respectively. These differential reactions could not be attributed to range site or herbicide application differences. Although the difference in defoliation was temporary with narrowleaf forestiera, it was apparent throughout the study with lime pricklyash (Table 1).

Canopy replacement by 27 months after herbicide application resulted in an overall woody-plant canopy reduction of 72% on the block-sprayed pasture and 58% on the strip-sprayed area (Table 1). By 27 months after application of the herbicide, species most affected relative to canopy reduction were honey mesquite and spicy hackberry. The herbicide killed 76% of the honey mesquite and 40% of the spiny hackberry. Green cladophyll area of pricklypear was reduced, on the average, by 92% and was virtually eliminated from most of the sprayed areas. Canopy of huisache was largely replaced by final evaluations.

Response of Forbs

Within 2 months following herbicide application, forb production was reduced from approximately 200 kg/ha in the untreated areas to about 30 kg/ha in the pastures aerially sprayed. By fall, the year of treatment, oven-dry forb production was 500 kg/ha in the untreated areas as compared to 25 kg/ha in the sprayed areas. There was a concomitant increase in grass production in the sprayed as compared to untreated areas, 2,000 and 900 kg/ha, respectively, in October, 1973 (Durham 1975). By 27 months post treatment, there was little difference in forb production between sprayed and unsprayed aras with oven-dry topgrowth yields ranging from 375 to 500 kg/ha which was similar to untreated areas the year of spraying.

Table 2. Number of species by family, frequency (%), and density (plants/m²) of forbs at 15 and 27 months after aerial application of 2,4,5-T + picloram at 1.12 kg/ha to a mixed brush stand near Raymondville, Tex., where wildlife populations were monitored.

Time of observation and plant	No. of species S[a]	No. of species U	Avg frequency S	Avg frequency U	Avg density S	Avg density U
15 months post treatment						
Amaranthaceae	1	1	3	4	0.14	0.30
Compositae	6	12	6	11	0.34	0.80
Cruciferae	1	1	8	29	0.50	5.95
Euphorbiaceae	0	1	0	1	0	0.70
Labiatae	0	1	0	3	0	0.28
Leguminosae	0	4	0	3	0	0.78
Oxalidaceae	1	1	11	36	1.21	2.80
Portulacaceae	0	1	0	3	0	0.14
Plantaginaceae	1	2	4	23	0.20	0.77
Solanaceae	2	2	6	9	2.25	0.35
Umbelliferae	0	1	0	6	0	0.28
Urticacieae	1	1	15	22	2.35	3.00
Verbenanceae	0	2	0	6	0	0.53
Total	13	30	—	—	4.99	16.68
27 months post treatment						
Amaranthaceae	1	1	3	7	0.56	1.32
Commelinaceae	0	1	0	5	0	0.20
Compositae	14	14	8	13	0.82	1.79
Convolvulaceae	0	1	0	13	0	1.32
Cruciferae	1	1	50	33	3.67	5.95
Euphorbiaceae	3	4	8	25	0.44	3.16
Labiatae	1	2	1	6	0.36	0.90
Leguminosae	3	5	9	16	1.08	0.90
Linaceae	1	1	16	3	0.68	0.04
Malvaceae	2	2	12	24	1.54	1.86
Onagraceae	1	0	10	0	0.28	0
Oxalidaceae	1	1	10	12	2.52	3.72
Polemoniaceae	1	1	17	21	3.84	2.92
Portulacaceae	1	0	1	0	0.16	0
Plantaginaneae	2	1	12	5	1.64	0.40
Solanaceae	2	2	2	5	0.56	0.84
Umbelliferae	2	0	3	0	0.49	0
Urticaceae	1	1	5	7	3.12	0.40
Verbenaceae	2	2	2	17	0.39	2.38
Total	39	40	—	—	22.15	28.19

[a]"S" refers to sprayed and "U" refers to untreated areas.

Species diversity of forbs was also significantly reduced the year after treatment. At 15 months post treatment, only 13 species of forbs were noted in sample quadrats on the treated area, whereas 30 species were identified in quadrats from untreated area (Table 2). By 27 months post treatment, no difference in diversity was noted as numbers of species on treated and untreated areas approached equality (Table 2).

Karnes sensitivebriar (*Schrankia latidens*), dozedaisy (*Aphanostephus* spp.), *Parthenium* spp., round copperleaf (*Acalypha radians*), western ragweed (*Ambrosia psilostachya*), and sawtooth fogfruit (*Phyla incisa*) were some forbs species temporarily eliminated from treated areas. At least two other forbs, beach groundcherry (*Physalis viscosa*) and erect dayflower (*Commelina erecta*), were reduced in density by approximately 75% due to treatment. All these species have been reported as major food plants for white-tailed deer in South Texas (Davis 1951; Drawe 1968; Chamrad and Box 1968; Everitt and Drawe 1974).

Response to Wildlife

White-tailed deer numbers on the strip-sprayed area remained relatively constant (approximately 13 to 17/100 ha) throughout the study period. On the block-sprayed area, however, deer numbers at 15 to 27 months post treatment were reduced to about 40% of the original density (12/100 ha) but returned to nearly 11/100 ha at 27 months after application of the spray (Fig. 2). By contrast, post treatment deer numbers increased by roughly 100% on the untreated area at 9 to 21 months then dropped to around 9/100 ha at 27 months. Although deer numbers on the untreated area at 9 months post treatment increased dramatically, there were also slight increases observed on the other two areas. It is likely that this circumstance resulted from increased visibility for the February count (because of natural canopy reduction), the difference in size of study areas (if deer moved between areas), and/or deer ingress from outside the study areas. Regardless, deer use of the untreated area was relatively higher at this time period than on either of the treated areas. Deer density on the block-sprayed area was significantly lower ($P<0.05$) at 15 and 21 months post treatment than on the other areas; however, no differences were detected at 27 months post treatment.

Correlation between deer density and forb production on the block-sprayed and untreated areas, to 21 months post treatment, indicated that approximately 44% of the variation in deer

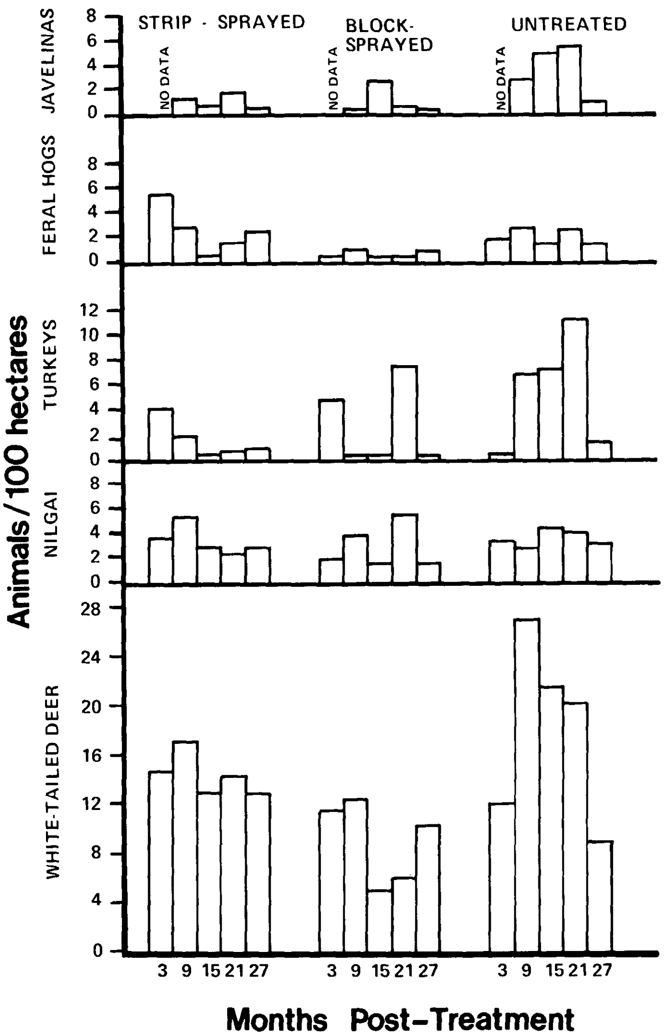

Fig. 2. *Average density (animals/100 ha) of white-tailed deer, nilgai antelope, feral hog, wild turkey, and javelina during various census periods following aerial application from May 11 to 15, 1973, of 1.12 kg/ha 2,4,5-T + picloram to 80% of the brushland in alternating strips (strip sprayed), complete treatment (block sprayed), or no treatment of South Texas mixed brush near Raymondville.*

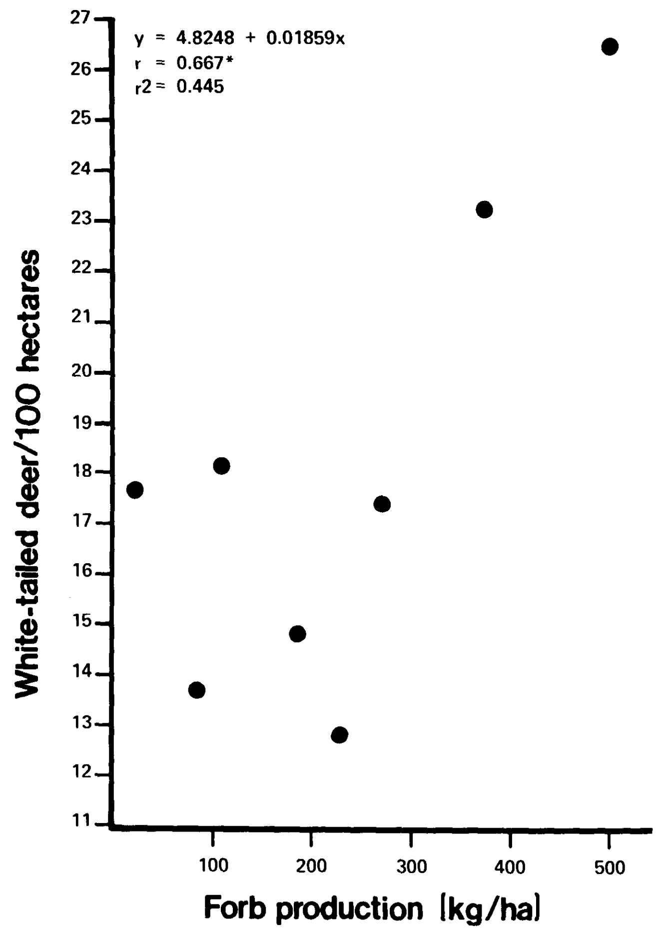

Fig. 3. *Relationship between oven-dry topgrowth production of forbs (kg/ha) and average deer density (animals/100 ha) after aerial application of 2,4,5-T + picloram at 1.12 kg/ha to South Texas mixed brush near Raymondville.*

density was accounted for by variation in forb production (Fig. 3). When effects of treatments on the forbs were apparently eliminated, by at least 27 months post spray, forb production on the treated areas equalled that on the untreated; and white-tailed deer numbers approached pretreatment levels. The importance of forbs to white-tailed deer previously has been reported by McMahan (1966), Chamrad and Box (1968), McCaffery and Creed (1969), and McMahan and Inglis (1974). The brush canopy reduction by the herbicide undoubtedly further reduced the availability of food for white-tailed deer. However, reduction in brush canopy apparently had a much less orderly relationship to deer numbers than forb production.

Nilgai antelope appeared unaffected by either of the spray treatments. There were no significant ($P>0.05$) differences in between-area counts for any of the five census periods. This apparent lack of response to the treatments was interpreted as a lower sensitivity to vegetation shifts which resulted from the sprays. Sheffield (1970) reported that the diet of the nilgai antelope in South Texas is more variable than that of deer; they are less dependent on forbs and browse and more dependent on grasses. He also showed that nilgai antelope readily shift the kinds of foods eaten in response to plant availability. This ability to shift probably facilitated their population maintenance on all study areas.

Wild turkey counts (both within and between areas) were highly variable but generally tended to show an increase on the untreated area and a decrease on the treated areas following spray application. With the exception of a significantly ($P<0.05$) higher count at 27 months post treatment on the untreated area as compared to the block-sprayed area, no other significant ($P>0.05$) differences were noted between areas within sample dates. These turkeys usually occurred in aggregations of 10 to 30 birds; and since there were probably no more than three or four of these aggregations on any one area, relatively high inherent variability and low precision of estimates is likely. Regardless of the problems associated with adequately sampling the turkeys, it is important that they did not discontinue utilizing the treated areas, for at least some of their daily activities, after spraying. This situation may have been different, however, if roosting trees had not been available in untreated areas.

The varied nature of the diet of the wild turkey (Glazener 1967) probably also partly explains the lack of treatment response. These birds are seasonally opportunistic, consuming native grass seeds during the spring and summer and utilizing forb seeds and woody plant fruits in fall and early winter. As a result, a shift in plant composition favoring one food group over another, as long as food is available yearlong, probably has a small effect on wild turkeys. The greater plant diversity on the untreated area resulted in a more stable yearlong supply, which possibly explains its supporting a slightly higher number of birds. The increase in plants such as bristlegrasses (*Setaria* spp.) (Durham 1975), the most preferred summer foods of the wild turkey in South Texas (Beasom 1975), likely also attributed to the lack of aversion for the treated areas.

Feral hog populations were generally similar to the strip-sprayed and untreated areas throughout the study (Fig. 2) and were consistently, although not significantly ($P>0.05$), lower on the block-sprayed area. These similarities and differences are likely related to food availability. Fruiting parts of woody plants make up approximately 50% of the summer, fall, and winter diet of feral hogs; and, the availability of woody plant fruits is positively correlated with body quality of feral hogs (Springer 1975). This probably accounted for the consistently lower counts of feral hogs in the block-sprayed area in which very few fruits, especially honey mesquite legumes, were produced following aerial spraying.

No data are available on javelina populations for the initial census period. However, the four subsequent censuses consistently (Fig. 2) resulted in significantly ($P<0.05$) higher average populations on the untreated area than the treated areas. The significantly lower counts of javelina on the sprayed areas, as compared to the untreated area, are probably a result of the almost total elimination of their singularly most important food item, pricklypear. Jennings and Harris (1953) found that pricklypear comprised 78% of the javelina diet in South Texas and that it was present in each of the 107 animals they examined.

Conclusions

These data indicate that it is possible to aerially spray with herbicides (in alternating strips) as much as 80% of mature honey mesquite brushland with no significant effects on white-tailed deer, nilgai antelope, wild turkeys, or feral hogs. The large-scale, block spray seemed to exceed the threshold of suitability for species surveyed except for nilgai antelope. Javelina populations were significantly reduced by both treatments. The response of all wildlife species seemed dictated by food availability. Important factors for consideration, in addition to the amount of brush treated are pattern, timing, effectiveness, and type of control treatment. Sprayed areas in this study may have had a different effect had they been wider or narrower. Also, response of vegetation to various control measures is unquestionably seasonally different; and the effectiveness of the various control measures available is an interspecific variable (Scifres et al. 1973). These factors should be considered when planning a brush management program to maximize the beneficial response for both livestock and wildlife.

Literature Cited

Beason, S. L. 1975. Range management trends and wild turkey food habits. *In:* Rangeland Resources Reseach, 1971–74. Texas Agr. Exp. Sta. PR-3341. p. 54-55.

Blakey, H. L. 1947. The role of brush control in habitat improvement on the Aransas National Wildlife Refuge. Trans. North Amer. Wildl. Conf. 12: 179-185.

Bovey, R. W., and C. J. Scifres. 1971. Residual characteristics of picloram in grassland ecosystems. Texas Agr. Exp. Sta. Bull. 1111. 24 p.

Box, T. W. 1964. Changes in wildlife habitat composition following brush control practices in South Texas. Trans. North Amer. Wildl. Conf. 29: 432-438.

Chamrad, A. D., and T. W. Box. 1968. Food habits of white-tailed deer in South Texas. J. Range Manage. 21:158-164.

Darr, J. W., and D. A. Kelebenow. 1975. Deer, brush control, and livestock on the Texas Rolling Plains. J. Range Manage. 28:115-119.

Davis, R. B., and C. K. Winkler. 1968. Brush vs cleared range as deer habitat in South Texas. J. Wildl. Manage. 32:321-329.

Drawe, D. L. 1968. Mid-summer diet of deer on the Welder Wildlife Refuge. J. Range Manage. 21:164-166.

Durham, G. P. 1975. Vegetation response and management of South Texas rangeland following chemical and mechanical brush control. MS Thesis, Texas A&M Univ., College Station. 116 p.

Everitt, J. H., and D. L. Drawe. 1974. Spring food habits of white-tailed deer in the South Texas Plains. J. Range Manage. 27:15-19.

Fisher, C. E., H. T. Wiedemann, J. P. Walter, C. H. Meadors, J. H. Brock, and B. T. Cross. 1972. Brush control research on rangeland. Texas Agr. Exp. Sta. MP-1043. 18 p.

Glazener, W. C. 1958. Wildlife management as a part of range management in Texas. Amer. Soc. Range Manage. Ann. Meeting 11. 10 p. (mimeo).

Glazener, W. C. 1967. Management of the Rio Grande turkey. *In:* The wild turkey and its management. The Wildl. Soc., Washington, D.C. p. 453-492.

Goodrum, P. D., and V. H. Reid. 1956. Wildlife implications of hardwood and brush control. Trans. North Amer. Wildl. Conf. 21:127-141.

Jennings, W. S., and J. T. Harris. 1953. The collared peccary in Texas. Texas Game and Fish Comm., Austin. 31 p.

Johnston, M. C. 1962. Past and present grasslands of southern Texas and northern Mexico. Ecology 44:456-466.

Krefting, L. W., and H. L. Hansen. 1969. Increasing browse for deer by aerial applications of 2,4-D. J. Wildl. Manage. 33:784-790.

Lehmann, V. W. 1960. Problems of maintaining game on ranges subjected to brush control. Proc. World Forest. Congr. 5:1807-1809.

Leopold, A. S. 1959. Wildlife in Mexico, the game birds and mammals. Univ. of Calif. Press, Berkeley. 568 p.

McCaffery, K. R., and W. A. Creed. 1969. Significance of forest openings to deer in northern Wisconsin. Wisconsin Dep. Nat. Resources, Madison. Tech. Bull. 44. 104 p.

McMahan, C. A. 1966. Suitability of grazing enclosures for deer and livestock research on the Kerr Wildlife Management Area, Texas. J. Wildl. Manage. 30:151-162.

Scifres, C. J., and G. O. Hoffman. 1972. Comparative susceptibility of honey mesquite to dicamba and 2,4,5-T. J. Range Manage. 25:143-146.

Scifres, C. J., R. W. Bovey, C. E. Fisher, and J. R. Baur. 1973. Chemical control of mesquite. Chap. 4. *In:* Mesquite, growth and development, management, economics, control, uses. Texas Agr. Exp. Sta. Res. Monogr. 1:24-32.

Sheffield, W. J. 1970. The nilgai antelope in Texas. Caesar Kleberg Research Program in Wildlife Ecology, Ann Rep. Texas Agr. Exp. Sta., College Station. p. 147-167 (mimeo).

Springer, M. D. 1975. Food habits of wild hogs on the Texas Gulf Coast. MS Thesis, Texas A&M Univ., College Station. 71 p.

Teer, J. G., and N. K. Forrest. 1968. Bionomic and ethical implications of commercial game harvest programs. Trans. North Amer. Wildl. amd Nat. Resources Conf. 33:192-202.

Walker, E. A. 1962. Brush control and wildlife. Ann. Meet. Nat. Audubon Soc. 58. 21 p. (mimeo).