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Herbicide effects on cross timbers breeding birds

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Abstract

We censused breeding nongame birds on replicated 5- and 6-year post herbicide-treated (tebuthiuron and triclopyr) and untreated cross timbers rangeland in central Oklahoma. Twenty species of breeding birds were observed. No treatment effects were detected for total bird density, species diversity, or richness; however, species composition varied considerably among treatments. Control sites supported species associated with closed canopy woodlands, and treated sites supported species associated with brushy and prairie habitat. Generally, control sites had greater foliar cover, fewer snags, and less slash and herbaceous cover than treated sites. Densities of 6 of the 7 most abundant bird species were correlated variously with habitat variables. We concluded that changes in habitat structure resulted in differences in bird species composition among treatments.

Key Words: breeding nongame birds, herbicides, habitat alteration, Oklahoma, tebuthiuron, triclopyr

Herbicides are used widely in range management to suppress growth of unwanted vegetation and thereby improve grazing for cattle. Studies have examined effects of phenoxy herbicides (Warren et al. 1984, Gruver and Guthery 1986), glyphosate (Morrison and Meslow 1984a, Santillo et al. 1989), and picloram (McComb and Rumsey 1983) on nongame birds, but effects of tebuthiuron and triclopyr have not been evaluated. Because herbicides such as 2,4,5-T are no longer available, use of triclopyr and tebuthiuron has increased, particularly on central and western rangelands. We examined effects of 5- and 6-year post tebuthiuron- and triclopyr-induced habitat alterations on breeding nongame birds in grazed hardwood forests in the cross timbers region of central Oklahoma. Effects of herbicides on wildlife in this region are only beginning to receive research attention (Boggs et al. 1990a, 1990b, 1991; Lochmiller et al. 1991).

Methods

Study Area

The cross timbers region consists of 3–4 million ha of post oak (*Quercus stellata* Wang.) and blackjack oak (*Q. marilandica* Muenchh.) woodlands in the south-central United States and is the ecotone between eastern deciduous forests and western prairies. Dominant herbaceous vegetation includes little bluestem (*Schizachyrium scoparium* [Michx.] Nash), indiangrass (*Sorghastrum nutans* [L.] Nash), and western ragweed (*Ambrosia psilostachya* [T. & G.] Farw.) (Ewing et al. 1984). The midstory is dominated by coralberry (*Symphoricarpus orbiculatus* Moench.), poison ivy (*Rhus radicans* L.), and redbud (*Cercis canadensis*). Vegetation in this region has been altered, in part, by thinning the overstory with herbicides to enhance production of forage for livestock (Engle et al. 1987, McCollum et al. 1987). Average annual precipitation is 831 mm; the majority occurs from April through October. Soils of the region are variable and were described by Gray and Stahnke (1970).

Our study was conducted on the Cross Timbers Experimental Range (Payne Co., Okla.), which lies at the western edge of the cross timbers region (Lochmiller et al. 1991). We used nine 32.4-ha

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pastures representing 3 replications of 3 experimental treatments: (1) tebuthiuron (N-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-N, N'-dimethylurea) (Elanco Product Co., Division of Eli Lilly and Co., Indianapolis, Ind. 46285); (2) triclopyr ([(3,5,6-tricloro-2-pyridinyl)oxy] acetic acid) (Dow Chemical Co., Midland, Mich. 48674); and (3) a control (no herbicide). Herbicides were applied aerially at 2.2 kg/ha in March 1983 (tebuthiuron) and June 1983 (triclopyr). Both herbicides were effective, but tebuthiuron was less variable in tree kill (52–99%) than triclopyr (8–100%) (Stritzke et al. 1987). All pastures were grazed by yearling cattle from mid-April through September 1988 and mid-March through September 1989. Stocking rate was set each year relative to expected levels of forage production to result in 50% utilization as measured by end-of-season residue of herbaceous standing crop.

Vegetation

One 10.8-ha grid was placed in each of 3 control, 3 tebuthiuron, and 3 triclopyr pastures. Each grid was ≥100 m from the edge of the pasture. Grids were separated by 0.4–2.9 km and contained 30 stations (6 × 5 pattern) 60 m apart with intermediary flags every 30 m. All vegetation measurements were made once in either 1988 or 1989 in 0.04-ha circular plots using each grid station as the center of the plot (Noon 1980). We assumed that annual changes in the vegetation characteristics that we measured were negligible from 1988 to 1989 (i.e., 5 to 6 years post-treatment).

In 1988, foliage height diversity was measured twice (Balda 1975) at 10 randomly chosen stations on each of the 9 grids: (1) in March and early April when birds began to establish territories and (2) in May and June when nesting had begun and eggs of some species were beginning to hatch. Foliage height diversity was measured using a density board divided into 4 height intervals that corresponded to low ground (0–0.3 m), high ground (>0.3–1.0 m), low shrub (>1.0–2.0 m), and high shrub (>2.0–3.0 m) (Noon 1980). We recorded meaurements 11.3 m from each grid station in the 4 cardinal directions (Noon 1980) by counting the number of squares in each height interval >50% obscured by foliage.

We estimated density of snags and slash (i.e., naturally downed debris) in summer 1988 at all stations with the point-quarter method (Smith 1980) by measuring the distance to the closest snag (≥8 cm in diameter) and the closest slash (≥1.5 m long, ≥8 cm in diameter) in each quarter of each 0.04-ha plot (Noon 1980). We estimated snag basal area using the formula given by Smith (1980:670). We estimated slash volume using a formula for the volume of a tapering cylinder (Renken 1988). We made ocular estimates of percentages of herbaceous ground and shrub cover at all stations in summer 1988. We measured foliar cover of the overstory (above elbow height) in summer 1989 at all stations using a forest densiometer (Lemmon 1957).

Breeding Birds

Breeding nongame birds were censused on all grids using the spot-mapping method (Int. Breeding Bird Census Comm. 1970). During each visit, auditory and visual observations of birds were recorded on detailed maps of each grid. Data from these maps were transferred to individual species' maps for each grid. Resulting maps were used to estimate densities (number of territorial males/10.8 ha) for each species for each grid (Int. Breeding Bird Census Comm. 1970). Partial territories were included if >50% of the observations were within the grid boundaries. Grids were visited in the mornings and evenings, alternating starting points to reduce temporal variation. Time/visit/grid was approximately 3 hours. All visits were made under favorable weather conditions (i.e., no precipitation or fog, wind ≤32 kph).

Grids were visited 8 times (24 visits/treatment) from 16 March through 15 August 1988 and 6 times (18 visits/treatment) from 23 March to 26 August 1989. Inclement weather reduced the number of acceptable visits/plot, particularly in 1989, and may have resulted in underestimation of absolute densities of breeding birds and omission of cryptic and rare species (Dawson 1981). We assumed that such constraints were constant on all grids and thereby did not bias our comparison of densities of individual breeding birds (particularly common species) among the treatments.

Statistical Analyses

The Shannon diversity index was used to determine diversities of bird species and foliage height for each grid (Brower and Zar 1984). Chi-square approximations from the Kruskal-Wallis H-test were used to determine differences in territorial male density and vegetation measurements among the 3 treatments (SAS Inst., Inc. 1988). If the overall treatment effect was significant for a bird species, Wilcoxon 2-sample tests (using z-values [SAS Inst., Inc. 1988]) were used to compare its densities between treated and control sites and between the 2 herbicide treatments. Because of small yearly sample sizes (n = 3/treatment), the 2 years of breeding bird data were combined (n = 6/treatment) before analyses. Spearman rank correlations were calculated to examine relations between habitat variables and the 7 most abundant (across all treatments) bird species and total bird density. Annual estimates of bird densities on each of the 9 grids in 1988 and 1989 (n = 18) were paired with the single estimates of vegetation characteristics made on each grid. Minimum significance level was $P<0.05$.

Results

Vegetation

Early and late foliage obscurity and total foliage density did not differ significantly among treatments (Table 1), although the lowest values were recorded on herbicide sites in 7 of 8 cases (4 height strata × 2 sampling periods). Foliage obscurity and total foliage density increased from early to late measurements on control and tebuthiuron plots but not on triclopyr plots (Table 1).

No differences ($P>0.05$) among treatments occurred in snag density, snag basal area, slash density, slash volume, foliar cover, or shrub cover; however, snag density, snag basal area, slash

Table 1. Average habitat characteristics of herbicide-treated and untreated cross timbers 5 to 6 years post-treatment.

Habitat variable	Treatment: Control	Tebuthiuron	Triclopyr	P[1]
Foliar obscurity by ht stratum (m)				
Mar–Apr				
0–0.3	79.2	88.2	89.6	0.393
>0.3–1.0	69.8	66.5	74.1	0.670
>1.0–2.0	64.9	48.7	67.1	0.118
>2.0–3.0	59.8	41.7	62.8	0.113
Total foliage density	273.7	245.1	293.6	0.148
Foliage ht diversity	1.99	1.93	1.99	
May–Jun				
0–0.3	94.5	96.2	88.7	0.099
>0.3–1.0	86.0	80.2	73.8	0.202
>1.0–2.0	78.3	59.6	69.7	0.670
>2.0–3.0	76.3	51.7	66.3	0.113
Total foliage density	335.1	287.7	298.5	0.561
Foliage ht diversity	2.00	1.96	1.99	
Foliar cover (%)	81.39	30.29	36.99	0.051
Herbaceous cover (%)	27.99	87.5	74.28	0.050
Shrub cover (%)	31.66	21.68	37.95	0.202
Snag density (snags/ha)	59.3	218.7	250.0	0.061
Snag basal area (m^2/ha)	1.24	6.11	6.82	0.067
Slash density (slash/ha)	207.3	794.7	579.3	0.061
Slash volume (m^3/ha)	21.34	39.83	28.08	0.587

[1]From chi-square approximations of the Kruskal-Wallis H-test; n = 3/treatment.

Table 2. Cumulative densities of songbirds and woodpeakers and community indices on herbicide-treated and untreated cross timbers in Oklahoma, 1988–89.

Species	Treatment			
	Control	Tebuthiuron	Triclopyr	P^2
Yellow-billed cuckoo	6.0[1]	0	3.0	0.054
Red-bellied woodpecker	8.5	4.0	1.0	0.052
Red-headed woodpecker	0	2.0	0	0.119
Downy/hairy woodpecker	1.0	2.0	4.0	0.431
Great crested flycatcher	4.5	1.0	1.0	0.250
Eastern phoebe	1.0	0	0	0.368
Blue jay	6.0	2.0	5.0	0.451
Carolina chickadee	11.0	8.0	10.0	0.815
Tufted titmouse	28.5A[3]	5.0B	9.5B	0.003
Bewick's wren	0A	17.0B	11.0B	0.004
Eastern bluebird	0A	7.5B	0A	0.034
Blue-gray gnatcatcher	24.5	35.5	32.0	0.198
Black-and-white warbler	8.0A	0B	1.0AB	0.028
Louisiana waterthrush	6.0A	0B	0B	0.002
Summer tanager	1.0	1.0	0	0.588
Northern cardinal	40.0	44.5	48.0	0.553
Indigo bunting	0A	6.0B	4.0AB	0.026
Painted bunting	1.0	1.0	2.0	0.738
Field sparrow	7.0	23.0	18.0	0.058
Total density	154.0	159.5	149.5	0.827
Number of species	16	16	15	
Shannon diversity	3.19	3.01	2.95	

[1]Total number of territorial males observed on 3 replications (10.8 ha each) of each treatment for 2 consecutive years (n = 6).
[2]From chi-square approximations of the Kruskal-Wallis H-test.
[3]Different letters within rows indicate significant differences among treatments with Wilcoxon 2-sample tests.

density, and foliar cover were significantly different at $P<0.10$ (Table 1). Herbaceous ground cover was greater on treated sites than on untreated sites ($P<0.05$).

Breeding Birds

We observed 20 territorial species during the breeding bird survey. Sixteen species were observed on control sites and tebuthiuron sites, and 15 species were observed on triclopyr sites (Table 2). Species diversity was highest on control sites (3.19) and lowest on triclopyr sites (2.95), but overall differences were small. The northern cardinal (*Cardinalis cardinalis* [L.] Bonaparte) and the blue-gray gnatcatcher (*Polioptila caerulea* [L.] Sclater) were the most abundant species on all treatments. The Bewick's wren (*Thryomanes bewickii* [Audubon] Sclater) and indigo bunting (*Passerina cyanea* [L.] Vieillot) were observed only on herbicide-treated sites (Table 2). The Louisiana waterthrush (*Seiurus motacilla* [Vieillot] Swainson) was observed only on control sites (Table 2).

Total density of territorial males did not differ ($P>0.05$) among treatments (Table 2). Densities of the tufted titmouse (*Parus bicolor* L.), Bewick's wren, eastern bluebird (*Sialia sialis* [L.] Vieillot), black-and-white warbler (*Mniotilta varia* [L.] Vieillot), Louisiana waterthrush, and indigo bunting were significantly different among the 3 treatments. Treatment effects were nearly significant (P = 0.052–0.058) for the yellow-billed cuckoo (*Coccyzus americanus* [L.] Vieillot), red-bellied woodpecker (*Melanerpes carolinus* [L.] Swainson), and field sparrow (*Spizella pusilla* [Wilson] Bonaparte). Individual species' responses to specific herbicides were variable (Table 2), but they generally were consistent with known biological preferences of the breeding species observed. For example, tufted titmouse, black-and-white warbler, and Louisiana waterthrush are known to prefer forested habitats, and they had significantly greater densities on control sites than tebuthiuron sites (Table 2).

Although we frequently observed pileated woodpeckers (*Dryocopus pileatus* [L.] Boie), we could not establish accurate density estimates because average territory size (53–160 ha) (Renken and Wiggers 1989) was larger than our grid size. The American crow (*Corvus brachyrhynchos* Brehm) and the brown-headed cowbird (*Molothrus ater* [Boddaert] Swainson) also were observed on our study sites. We could not accurately census the American crow because of its large territory size. The brown-headed cowbird was observed mainly in association with cattle using the grids and therefore could not be accurately mapped.

Correlations of the densities of 6 of the 7 most abundant species and habitat characteristics were variable (Table 3). Species-specific preferences were evident; e.g., densities of blue-gray gnatcatchers, field sparrows, and Bewick's wren were correlated negatively with most habitat characteristics associated with foliage structure and density. Densities of the northern cardinal and total breeding birds were not correlated with any habitat variable.

Discussion

Our control sites were characterized by greater foliar cover, fewer snags, and less slash and herbaceous cover than herbicide-treated sites. Five to 6 years post-treatment, habitat characteristics of triclopyr and tebuthiuron sites did not differ significantly, but tebuthiuron sites tended to have less woody vegetation than triclopyr sites.

At 5–6 years post-treatment, total density, diversity, and richness of breeding birds did not differ among treatments. Osaki (1979) found no treatment effects on total abundance of birds in brush fields treated 6 to 7 years previously with 2,4,5-T. However, Savidge (1978) found a 2-fold increase in total number of birds on untreated brush fields as compared to brush fields treated 6 years previously with 2,4,5-T. She believed that the collapse of dead brush structure on treated sites was responsible for the decline in nesting density. In our study, dead brush (i.e., snags) remained standing.

Although total bird density, diversity, and richness did not show any treatment effects on our study, species composition differed for the 3 treatments. Nongame birds that required closed canopies declined in density or disappeared and other species, such as some cavity-nesting species, increased in abundance. Some species such as the Bewick's wren and eastern bluebird were found only on herbicide-treated sites. We believe that was due to the increased density of snags on these sites which may serve as temporary nesting habitat. The red-headed woodpeaker (*Melanerpes erythrocephalus* [L.] Swainson) and the eastern bluebird were observed only on tebuthiuron sites. These species are typically found in open woodlands or park-like settings that characterize the type of habitat created by the use of tebuthiuron. Control sites supported species associated with closed canopy woodlands, such as the black-and-white warbler and the Louisiana waterthrush. Morrison and Meslow (1984b) also found that densities of species dependent on deciduous trees decreased post-treatment.

Balda (1975) suggested that birds established territories based on vegetative characteristics before foliage has completely leafed out. However, we did not find that breeding birds showed differing correlations with early and late foliage measurements. Bird species presence/absence was generally as expected for the region (Gryzbowski 1986) and for the most part, species were correlated logically with habitat variables, based on our field observations and extant literature (e.g., Kahl et al. 1985). However, the tufted titmouse was anomalous. We had expected ubiquitous distribution, but tufted titmouse density was negatively correlated with characteristics of herbicide-treated sites (e.g., snag density) and was greater on control sites than herbicide sites. Kahl et al. (1985) reviewed studies of habitat characteristics and found that the tufted titmouse did not respond consistently to any particular variable. We suspect that tufted titmouse density was influenced by

Table 3. Spearman rank correlations of habitat variables with the most abundant bird species on herbicide-treated and untreated cross timbers in Oklahoma (n = 18).

Habitat variable	Individual Species: Blue-gray gnatcatcher	Field sparrow	Tufted titmouse	Carolina chickadee	Bewick's wren	Red-bellied woodpecker
Early[1] foliage ht diversity	–0.29	–0.56**[3]	0.70***	0.16	–0.64***	0.18
Late[2] foliage ht diversity	–0.65***	–0.66***	0.68***	0.15	–0.54**	0.05
Early[1] total foliage density	–0.61***	–0.45*	0.36	0.12	–0.25	–0.11
Late[2] total foliage density	–0.56**	–0.79***	0.49**	0.09	–0.30	0.17
Foliar cover	–0.55**	–0.79***	0.32	1.00***	–0.40*	0.40*
Herbaceous cover	0.59**	0.79***	–0.75***	–0.14	0.72***	–0.39
Shrub cover	–0.49**	–0.55**	0.31	0.15	–0.21	–0.16
Snag density	0.36	0.33	–0.60***	–0.06	0.67***	–0.43*
Snag basal area	0.45*	0.21	–0.55**	0.01	0.63***	–0.38
Slash density	0.33	0.36	–0.64***	–0.13	0.67***	–0.31
Slash volume	0.29	–0.18	–0.04	0.05	0.17	–0.39

[1]Early = March–April.
[2]Late = May–June.
[3]* (P<0.10), ** (P<0.05), *** (P<0.01).

factors that we did not measure.

Woody vegetation on North American rangelands has been manipulated with various herbicides, as well as fire and mechanical methods (e.g., chaining and discing). Effects of these management practices on nongame birds have varied (Peterson and Best 1987, O'Meara et al. 1981, Webb and Guthery 1983). For example, chaining of pinyon-juniper woodlands in Colorado decreased nongame bird density and richness 15 years post-treatment (O'Meara et al. 1981). Size of the area and the percentage of woody vegetation removed also determined the extent of impact to nongame birds (Rollins 1983, Webb and Guthery 1983). In general, mechanical methods such as chaining that disturb the entire plant community can be more pernicious to habitats of nongame birds than management options such as herbicides that target specific plant types.

Management Recommendations

Lochmiller et al. (1991) concluded that applications of tebuthiuron and triclopyr increased the diversity of habitats on the Cross Timbers Experimental Range and increased preferred habitat types of cottontail rabbits (*Sylvilagus floridanus* [J.A. Allen]). Similarly, herbicide applications, 5–6 years post-treatment, increased overall richness of breeding nongame birds on the Experimental Range by providing a mosaic of habitat types, which included the closed-canopy oak forest. Our results showed that several nongame bird species that do not regularly breed in closed oak forests were prevalent on herbicide-treated sites. For example, the Bewick's wren and indigo bunting bred only on herbicide treatments, and the eastern bluebird and red-headed woodpecker bred only on tebuthiuron-treated sites. However, it is important for managers to note that elimination of the oak forest by herbicides would reduce the overall richness of breeding nongame birds because some species (e.g., Louisiana waterthrush and eastern phoebe) bred only in such forested habitats. If fragmentation and isolation of small acreages of the closed-canopy oak forest of the cross timbers occur as a result of increased herbicide use, additional research should be conducted to assess effects on forest-dependent nongame birds.

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