NOTES

BLACK-CAPPED VIREO BREEDING HABITAT IN NORTH-CENTRAL TEXAS

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The Black-capped Vireo (*Vireo atricapilla*), listed as endangered by the U.S. Fish and Wildlife Service, breeds in southwestern Oklahoma, central Texas, and northern Mexico (Grzybowski 1995, Wilkins *et al.* 2006). Its breeding habitat is typically composed of low, deciduous shrubs and trees of irregular heights, heterogeneity that may result from local environmental conditions (*e.g.*, soil type, climate) or must be maintained by periodic disturbance (*e.g.*, wildfire, prescribed burning) (Graber 1961, Grzybowski 1995). Habitat loss (*e.g.*, land-use conversion, vegetation succession), habitat degradation (*e.g.*, grazing by domestic livestock, browsing by wild herbivores), and nest parasitism by the Brown-headed Cowbird (*Molothrus ater*) precipitated the species' decline (Ratzlaff 1987). Since the vireo's listing as endangered (Ratzlaff 1987), most of its management (*e.g.*, cowbird removal, habitat manipulation) and research has taken place at a few prioritized study sites in Texas (*e.g.*, Grzybowski *et al.* 1994, Stake and Cimprich 2003, Pope *et al.* 2013) and Oklahoma (*e.g.*, Grzybowski *et al.* 1994). Smith *et al.* (2012) added to our understanding of vireo-habitat relationships in the southwestern portion of the breeding range in Texas. Information regarding the vireo's occurrence, abundance, and reproductive status in relation to habitat characteristics is still lacking for north-central Texas.

In April 2011, four wildfires called the Possum Kingdom Complex burned 51,000 ha in Stephens, Palo Pinto, and Eastland counties in north-central Texas (McFarland *et al.* 2012). The vireo's breeding range overlaps the area burned in these wildfires (Grzybowski 1995). Few vireo detections have been recorded in these counties, however (Wilkins *et al.* 2006, McFarland *et al.* 2013), and no information regarding the abundance or reproductive status of the vireo in this region has been published. In 2012, we searched for vireos at the 753-ha Possum Kingdom State Park, located in the northwest portion of Palo Pinto County and centrally located between three well-studied vireo sites in Texas and Oklahoma, the Kerr Wildlife Management Area (~440 km southwest, Texas), the Fort Hood Military Reservation (~300 km southeast, Texas), and the Wichita Mountains National Wildlife Refuge and adjacent Fort Sill (~220 km north, Oklahoma). There had been unpublished reports of male vireos at Possum Kingdom State Park in some years before the 2011 wildfire, which affected >70% of the park. We did not detect any vireos in the park in 2012 but did locate males, females, and fledglings during point counts and systematic searches in 2013 and 2014.

From 27 March to 26 June 2013 and from 23 March to 29 April 2014, two independent observers conducted each point count at ~2-week intervals along a grid of points spaced 400 m apart across the entire park. We used this spacing to minimize the risk of recounting individuals while maximizing the number of points we could visit

within the park's boundaries. Observers surveyed each point three times in 2013 and 2014, representing six independent surveys per point per year. During surveys, from 06:30–13:00, observers recorded all singing male vireos detected within 100 m of each point over 5 min. Although other species were not the focus of the study, we also recorded all singing male Golden-cheeked Warblers (*Setophaga chrysoparia*) and vocalizing cowbirds detected during our surveys. We did not count during inclement weather (e.g., excessive rain or wind >~20 km/hr) or any other conditions that could inhibit our ability to detect the vireo.

In addition, to assess the vireo's breeding at this site, we systematically searched for females and fledglings at intervals of ~2–4 weeks from 27 March to 29 June 2013 and 23 March to 10 July 2014 along a 200-m grid established for vegetation measurement (see below). This smaller grid aligned with our larger 400-m grid so that our systematic surveys included the space between our count points. When we detected a vireo by either method, we checked if it was banded and searched the surrounding area for additional vireos. We recorded the coordinates of all vireos with hand-held Global Positioning System units and documented the behavior of all individuals observed.

We detected the first male vireo during a point count in burned vegetation in early May 2013, then found another in late May and a third in early June during systematic surveys in burned vegetation adjacent to mature woodland in the western portion of Possum Kingdom State Park. During systematic surveys in the same area in late June, we noted two males plus a family group (one male, one female, and two fledglings estimated to be ~1 week old). In 2014, during systematic surveys, we again detected vireos in burned vegetation in the western portion of the park (two males and one female in late May; three males, one female, and one fledgling estimated to be ~1 week old in early July). Also in 2014, we found vireos during point counts and systematic surveys in burned vegetation in the southeastern (six males in late April; two males and one female in late May; two males and two females in early July), central (three males in early July), and northern (one male in early July) portions of the park. No birds were banded, so the total number of detections over multiple visit can not specify the total population. But the number of vireos detected within the park increased over the three years after the fire.

There were no pre-fire vegetation data for Possum Kingdom State Park, but the fire's intensity within the park was high (K. Skow, unpubl. data); most vegetation was completely cleared from plateaus, leaving only snags in previously wooded areas. After the fire, mature vegetation remained only along slopes and draws. At the end of the vireo's breeding season in both 2013 and 2014, we sampled vegetation along a grid of points spaced 200 m apart and aligned with our bird-count points. At each vegetation-sampling point and at points located 5 m from the grid point in each cardinal direction, we recorded percent canopy cover of all live and dead woody plants ≥2 m to the nearest 10% with a tubular densitometer and canopy height to the nearest 0.5 m with a retractable meter stick. We apportioned canopy cover by tree species, considering snags as a separate category. We then established a circle of radius 5 m around the center point and divided the circle into four quadrants based on the four cardinal directions. Within each quadrant, we visually estimated percent shrub cover for all live and dead woody plants <2 m, percent herbaceous cover, and percent bare ground to the nearest 10%. As for trees, we divided our overall shrub measurements by species within the shrub layer, again segregating snags as a separate category.

We categorized our vegetation-sampling points as (1) mature woodland representing pre-fire conditions ("unburned"), (2) burned areas that were not occupied by vireos ("burned"), and (3) burned areas that were occupied by vireos ("occupied"). The last included all vegetation-measurement points within 200 m of a vireo detection. We then estimated the means and standard deviations for overall canopy cover and height, species-specific canopy cover and height, overall shrub cover, species-specific shrub cover, herbaceous cover, and bare ground within unburned, burned, and occupied

vegetation for each year of our study (Table 1). Given the small number of sampling points located in vegetation occupied by vireos compared to that in unburned and burned vegetation, we did not compare the vegetation categories statistically.

As expected, mean percent canopy cover and mean canopy height were much greater in unburned than burned and occupied areas (Table 1). Ashe juniper (*Juniperus ashei*) was the dominant canopy species of unburned areas, constituting ~80% of the available canopy cover both years. The remaining ~20% of canopy cover was composed of 8 deciduous species in 2013 and 11 deciduous species in 2014 (e.g., cedar elm, *Ulmus crassifolia*; Texas oak, *Quercus buckleyi*; shin oak, *Q. sinuata*). The mean height of Ashe juniper in unburned areas was 3.2 m in 2013 and 3.8 m in 2014. Mean overall canopy cover was minimal in burned and occupied areas, regardless of year (Table 1).

By contrast, mean percent shrub cover was greater in burned and occupied areas than in unburned areas and appeared to increase across all areas with time since the 2011 wildfire, most notably in areas occupied by vireos (Table 1). We recorded 14 and 19 species in the shrub layer of unburned areas in 2013 and 2014, respectively. Ashe juniper was the most prominent species in the shrub layer of unburned areas (33% of shrub cover in 2013, 36% in 2014). The remainder (67% in 2013 and 64% in 2014) was composed of deciduous species. In 2013, the three most prominent deciduous species in the shrub layer of unburned areas included shin oak (13%), snags (9%), and willow (*Salix* spp.; 7%). In 2014, the three most prominent deciduous species in the shrub layer of unburned areas included shin oak (11%), prickly pear (*Opuntia* spp.; 9%), and live oak (*Q. fusiformis*; 4%).

In burned areas, the number of shrub species was similar (14 in 2013 and 21 in 2014), but Ashe juniper was nearly lacking (0% of shrub cover in 2013, <1% in 2014). In 2013, the three most prominent shrub-layer species in burned areas were flame-leaf sumac (*Rhus lanceolata*; 23%) and shin oak (17%); snags constituted 18%. In 2014, the three most prominent shrub layer species were flame-leaf sumac (26%), prickly pear (*Opuntia* spp.; 25%), and shin oak (14%). We recorded fewer shrub species in occupied areas (6 in 2013 and 12 in 2014). As in burned areas, Ashe juniper was not a major component of the shrub layer in areas occupied by vireos (0% of shrub cover in 2013, <1% in 2014). In 2013, the three most prominent shrub species in occupied areas were shin oak (33%) and willow (14%), with snags representing 14% of cover. In 2014, the three most prominent shrubs in occupied areas were flame-leaf sumac (54%), shin oak (23%), and Texas elbow-bush (*Forestiera pubescens*; 2%). Herbaceous cover was more extensive and bare ground was less extensive in burned and occupied areas than in unburned areas (Table 1).

Table 1 Vegetation Measurements[a] in Unburned Areas, Burned Areas Not Occupied by Black-capped Vireos, and Burned Areas Occupied by Vireos at Possum Kingdom State Park, Palo Pinto County, Texas, Two and Three Years after a Wildfire

	2013			2014		
Variable	Unburned $n = 72$	Burned $n = 91$	Occupied $n = 4$	Unburned $n = 65$	Burned $n = 81$	Occupied $n = 16$
Overall canopy cover (%)	34 (23)	0.8 (2.4)	3 (6)	40 (18)	6 (10)	6 (12)
Overall canopy height (m)	4.9 (1.9)	0.7 (1.5)	1.3 (2.5)	4.6 (1.8)	2.0 (2.5)	3.3 (2.8)
Overall shrub cover (%)	10 (12)	16 (14)	18 (12)	11 (13)	17 (19)	31 (19)
Herbaceous cover (%)	27 (23)	41 (23)	59 (26)	22 (20)	39 (20)	33 (12)
Bare ground (%)	47 (26)	34 (22)	21 (27)	51 (22)	27 (22)	24 (13)

[a]Means with standard deviations.

Vegetation used by Black-capped Vireos breeding at our north-central Texas study site was similar to that the species uses in other parts of its breeding range, in that the cover of deciduous shrubs was greater than in nearby unoccupied habitat (Graber 1961, Grzybowski 1995). In contrast to Kerr Wildlife Management Area (Pope et al. 2013) and Fort Hood Military Reservation (Conkling 2010), at Possum Kingdom State Park vireos did not occupy mature oak–juniper woodland, during the years of our study. On the basis of studies in Texas (Kerr Wildlife Management Area and Fort Hood Military Reservation) and Oklahoma (Wichita Mountains National Wildlife Refuge and adjacent Fort Sill), Grzybowski et al. (1994) reported shrub cover in suitable habitat to range from 35 to 65%. Similarly, at the Fort Hood Military Reservation Bailey and Thompson (2007) found that vireos were more likely to inhabit vegetation patches with intermediate (50%) levels of deciduous shrub cover. Our results from the north-central portion of the Black-capped Vireo's breeding range indicate that the species can occupy and successfully breed in recently burned areas with less shrub cover (18% in 2013 and 31% in 2014).

The Black-capped Vireo's use of recently disturbed vegetation depends on factors that influence post-fire vegetation succession, such as pre-fire characteristics of the plant community, fire intensity, weather before and after the fire, and time since last burn (Grzybowski 1995). At Kerr Wildlife Management Area, Dufault (2004) found that the vireo use of vegetation was greatest within 2 years of prescribed burning. At the Fort Hood Military Reservation, vireo abundance increased 3 to 4 years after wildfire (Cimprich 2002). At Possum Kingdom State Park, we detected more vireos in 2014 (3 years post-wildfire) than in 2013 (2 years post-wildfire), a pattern consistent with other areas in Texas. While catastrophic from a social perspective, the 2011 wildfire provided an excellent opportunity to gain information on the vireo's responses to wildfire in an underrepresented portion of its breeding range. Additional research in north-central Texas would add to our knowledge of the Black-capped Vireo's ecology and help inform efforts to conserve it.

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