



Research Article

Habitat Selection by Juvenile Black-Capped Vireos Following Independence from Parental Care

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ABSTRACT If differences in ecological requirements result in juvenile birds using different habitats from breeding birds, then habitat management to protect those birds must protect both breeding and post-breeding habitats. We examined habitat selection by juvenile black-capped vireos (*Vireo atricapilla*) following their independence from parental care, in 2010–2013 on Fort Hood Military Reservation in central Texas, USA. The black-capped vireo is a federally endangered species that nests almost exclusively in shrub vegetation, but previous anecdotal observations indicate that juveniles may prefer riparian vegetation. We used mist-net capture rates and radio-telemetry to determine relative abundance of juvenile vireos across habitats, to quantify movement patterns and habitat selection, and to investigate how vegetation density and arthropod abundance influenced habitat selection. We captured juveniles at similar rates in shrub and riparian vegetation. Radio telemetry data indicated that juveniles selected riparian vegetation over most other available vegetation types, and tended to stay in riparian vegetation upon arrival. Juveniles selected areas characterized by more canopy cover, denser foliage, and more arthropods. Riparian vegetation provides this combination of features more than other vegetation types, indicating that cover and food are the basis for habitat selection by juveniles. Our results indicate that habitat conservation strategies for black-capped vireos should include protection of riparian vegetation near breeding areas, and more generally, that avian conservation strategies that focus only on breeding areas may potentially overlook other key habitats. © 2014 The Wildlife Society.

KEY WORDS endangered species, habitat use, juvenile movements, juvenile songbirds, post-breeding, post-fledging, radio-telemetry, riparian, *Vireo atricapilla*.

The time from when a bird leaves the nest until it migrates is a potentially critical yet relatively understudied stage of a migratory bird's life. Most research conducted during the post-breeding period has focused on the time that fledglings are still dependent on parental care (e.g., Weatherhead and McRae 1990, Anders et al. 1997, Cohen and Lindell 2004, Rush and Stutchbury 2008), with little research during the time that juveniles have become independent. This independent period, prior to migration, can last up to 3 months and holds many challenges for juvenile birds. They must prepare for migration by building up fat reserves as well as satisfy the elevated energetic demands associated with preformative molt (Hall 1996). To exacerbate these challenges, young birds

may be hindered by a lack of experience in foraging, navigating, and avoiding predators (Anders et al. 1997).

Differences in ecological requirements may result in juvenile birds using habitats differently from breeding birds. Habitat selection during the nesting season may differ from habitat selection during the post-fledging period (King et al. 2006). Indeed recent studies have demonstrated such differences for several migratory songbirds (King et al. 2006, Vitz and Rodewald 2010, Streby et al. 2011, Jenkins et al. 2013). Thus, the available evidence suggests that habitat shifts by juvenile birds following the termination of parental dependence may be common. Habitat conservation strategies generally focus on breeding areas and thus potentially overlook other habitats that could be important for juvenile birds (Faaborg et al. 1996, Cox et al. 2014).

We examined habitat selection by juvenile black-capped vireos (*Vireo atricapilla*; hereafter vireo) following their independence from parental care (35–45 days after fledging the nest; Grzybowski 1995). Previous work indicates that

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juvenile vireos may use different habitat than breeding adults. Grzybowski (1995) suggested that at Fort Hood, Texas juvenile vireos may move into taller and more mesic woodlands, and mist-netting after the breeding season found that independent juvenile vireos were frequently found associated with riparian vegetation (D. A. Cimprich, Fort Hood Environmental Division, unpublished data). This evidence suggested that systematic investigation of habitat use by juvenile black-capped vireos was warranted, particularly given that gathering data on the habitat needs of this endangered species is a priority in its recovery plan (U.S. Fish and Wildlife Service 1991). Effective population management requires knowing a species' habitat needs. If newly independent vireos require habitat different from that used by breeding birds, managers may need to protect those habitats. Current habitat management efforts for this species focus almost exclusively on protecting early successional shrub vegetation where adults breed (Cornelius et al. 2007).

Our primary objective was to test the hypothesis that, following independence from their parents, juvenile vireos select areas with riparian vegetation. First, we used mist-netting to determine the relative abundance of independent juvenile vireos in riparian and shrub vegetation. We predicted that juveniles would be captured at greater rates in riparian than shrub vegetation. Second, we used radio telemetry to examine vegetation types used by individual juveniles. We predicted that juveniles captured in shrub vegetation would move to and remain in riparian vegetation and that juveniles captured in riparian vegetation would remain in that vegetation. Finally, we investigated how vegetation characteristics and food availability influenced habitat selection. When juvenile birds move out of breeding habitat, the switch may be a response to vegetation characteristics and food availability, because juveniles of some species choose habitats with dense vegetation and high arthropod availability (McDermott and Wood 2010, Streby et al. 2011). We tested this hypothesis by comparing foliage density, canopy cover, and arthropod abundance in vegetation types used by juvenile vireos with randomly selected locations.

STUDY AREA

We conducted the study during the post-breeding season (mid-June to August) of the black-capped vireo from 2010 to 2013 on the Fort Hood Military Reservation in central Texas, USA. Military training is the primary land use on Fort Hood. Other uses include cattle grazing and maintenance of fish and wildlife habitat for conservation and recreation (Kostecke et al. 2005). Fort Hood has allowed land owners to graze cattle since 1942 (Fort Hood 2012), but recent assessments suggest that the combined effects of military training and continuous grazing have adversely affected the condition and sustainability of the habitat (Fort Hood 2012). Impacts of cattle grazing include a reduction of vegetative communities to primarily shallow-rooted species, causing extensive soil erosion (Fort Hood 2012). Fort Hood has rigorous endangered species management practices, including habitat restoration, controlled burns, and cowbird trapping (Cornelius et al. 2007). Major vegetation cover

types at Fort Hood are perennial grasslands (35%) and woodlands (49%) dominated by oak and juniper, whereas riparian vegetation is relatively rare (4%; Reemts and Teague 2007). We ignored the remaining 12% of cover types (water, bare ground, developed) because these areas are never used by vireos. We categorized broad vegetation types in the study sites as grasslands, riparian areas, shrublands, and non-riparian forests. Hereafter, we refer to these general vegetation types as grass, riparian, shrub, and forest. Black-capped vireos nested in shrub vegetation types, which consisted primarily of shin oak (*Quercus sinuata*), plateau live oak (*Quercus fusiformis*), Texas ash (*Fraxinus texensis*), and Ashe juniper (*Juniperus ashei*; Cimprich and Kostecke 2006). This vegetation formed a matrix of dense shrubs with interspersed open areas of bare rock or ground, primarily on mesa tops, and slopes. Riparian vegetation type was classified by association with rivers and streams, many of which were dry during the study because of drought conditions. Riparian vegetation was primarily giant ragweed (*Ambrosia trifida*), Roosevelt-weed (*Baccharis neglecta*), pecan (*Carya illinoensis*), honey-balls (*Cephalanthus occidentalis*), black willow (*Salix nigra*), and elm (*Ulmus* spp.). This vegetation formed both a dense understory and canopy adjacent to rivers, streams, and lakes. Dominant trees found in forests were Ashe juniper, plateau live oak, and Texas red oak (*Quercus buckleyi*). Grass vegetation types were comprised of little bluestem (*Schizachyrium scoparium*), Indian grass (*Sorghastrum nutans*), sideoats grama (*Bouteloua curtipendula*), honey mesquite (*Prosopis glandulosa*), and tall dropseed (*Sporobolus compositus*). For more detailed descriptions of Fort Hood land uses and vegetation associations see Cornelius et al. (2007).

We chose 2 study sites with both riparian and shrub vegetation. Sites had similar grazing pressure (320 and 354 animal units; Fort Hood 2012). Because of the difficulty catching independent juvenile vireos, we chose large study sites (5,496 and 6,534 ha) with enough places to net birds. We chose sites in close proximity to long-term intensive study sites to increase our chances of capturing birds of known age (i.e., banded as nestlings). Both sites had similar patch sizes and vegetation associations and were located on opposite sides of the military base, 18 km apart. Shrub vegetation was not adjacent to riparian vegetation in these areas, but separated by patches of grass and/or forest (4–123 ha patches).

METHODS

Juvenile Abundance in Riparian and Shrub Vegetation

To determine the relative abundance of independent juvenile vireos in each vegetation type, we conducted mist-netting 2–7 days a week from sunrise until about 1,000 hr in shrub and riparian patches (2012–2013 only). The dense understory in both vegetation types concealed nets similarly (see results below) and thus, birds should have been equally vulnerable to capture in both. We chose netting sites so that we sampled all substantial patches of shrub and riparian vegetation in the study sites at least once before we re-sampled patches. We attempted to keep mist-net hours (1 mist-net hour equals

1 12-m net open for 1 hr) equal between riparian and shrub vegetation by alternating vegetation type each netting day. We used 6- and 12-m mist-nets with recordings of either vireos or eastern-screech owls (*Megascops asio*) broadcast near each net to increase capture rates. We determined the age, sex, and dependency status of each captured bird. Juveniles with greater coverts that are in heavy molt may still be dependent upon parental care (personal observation) so we considered juveniles independent only if their greater covert molt was complete or near completion. We did not observe any of the birds that we radiotracked being provisioned by adults (see Results Section), indicating that molt status provides a reasonably accurate measure of independence. We excluded from analyses juveniles whose dependency status was uncertain.

Individual Habitat Selection

To examine habitats used by individuals, we fitted independent juvenile vireos with 0.27-g radio transmitters (Model LB-2X, Holohil Systems Ltd, Ontario, Canada) using the backpack method (Hallworth et al. 2009). Backpacks weighed <4% of each bird's body mass. Radio transmitters had a range of approximately 800 m. We attached transmitters to birds captured in riparian (29 birds) and shrub (42 birds) vegetation. Because of the limited battery life of transmitters (14 days on average), we could not track individual birds through their entire post-fledging period. Given the likelihood that the age of birds tracked varied, collectively the tracking data should cover most of the post-fledging, independent period. This assumption is supported by the fact that we recaptured and radiotracked 9 individuals that were banded as nestlings in intensive study sites and these individuals ranged from 51 to 83 days old (65.7 ± 3.6) on their initial tracking day. We located radio-tagged birds twice a day, with at least 2 hours between observations. We considered consecutive locations for an individual to be independent because the time between observations allowed sufficient opportunity for the birds to change vegetation type and because we witnessed juveniles traveling substantial distances during short durations (11 individuals moved at rates $>1,000$ m/hr).

For most individuals (82%), we were able to obtain data on the proportion of time spent in each vegetation type and movement patterns within each type of vegetation. When tracking birds, we approached them on foot as discreetly as possible to avoid influencing natural movements. When we first encountered a bird, we recorded the global positioning system coordinates of each location. When we could not resight an individual, usually because it was concealed by dense vegetation, we walked in a circle around the area with a strong radio signal to estimate the bird's location to ≤ 30 m. When we resighted juveniles, we observed them for at least 5 minutes and classified the dominant behavior as foraging if birds were seen making any gleaning maneuvers, perching if birds remained perched while under observation, or moving if it flew from perch to perch without any gleaning. Juveniles may be excluded from shrub vegetation by territorial adult birds. To investigate if adult vireos were excluding juveniles

from shrub vegetation, when we resighted birds we noted if they were 1) in close association (≤ 30 m) with conspecific adults or 2) not in close association with adults (no adult detected or adult detected >30 m from juvenile; 2012–2013 only).

Vegetation Characteristics and Arthropod Abundance

We conducted vegetation surveys at every other bird location (alternating between morning and afternoon locations, 2011–2013), as well as at random locations (2012–2013 only). We generated random points in ArcGIS 10.1 (ESRI, Redlands, CA) from a 300-m grid of points covering the study sites. We chose a 300-m interval based on the average distance birds moved between consecutive relocations. This allowed us to conduct surveys at all points that were in vegetation types available to birds. We assessed vegetation characteristics by determining the general vegetation category (as described above) and measuring canopy cover and foliage density at each bird and random location. We sampled vegetation in 10-m-radius circles centered on bird and random locations. We measured percent canopy cover at 20 points: 5 along 10-m transects in each cardinal direction from the bird location or random point. We considered canopy to be any vegetation >3 m above the ground and determined its occurrence using an ocular tube (James and Shugart 1970). To estimate understory foliage density, we collected data at 3 points, 1 in the center of the plot and 2 in random opposite cardinal directions, 10 m from the location center. Using a Robel pole, we gave foliage density scores ranging from 0 to 10, with 0 indicating no foliage and 10 indicating 100% foliage (see Robel et al. 1970 for details). We scored foliage density at 2 height intervals, 0–1 and 1–2 m above the ground, which we then averaged to represent the foliage layer.

To measure food abundance, we sampled arthropods at every other bird location and at most random locations in 2012–2013 using a hybrid version of the shake-cloth and branch-clipping method (Cooper and Whitmore 1990). We sampled 2 branches at each location, measured abundance by counting the number of arthropods collected in each sample, and averaged these numbers to get 1 estimate per location. We sampled branches between 0.5 and 2.0 m above ground. For each sample, we chose branches from either a locally dominant species or 1 on which we observed the focal bird. This method captures prey that gleaning birds, foraging at shrub height, may target, but is not suitable for collecting highly mobile arthropods or surveying inaccessible vegetation (e.g., high canopy). These samples do not necessarily represent the prey available to or eaten by vireos, but do provide a coarse estimate of arthropod abundance in the habitats in which the birds foraged. While banding, we collected fecal samples opportunistically to gather additional diet information. We examined fecal samples with a dissecting microscope and categorized the presence or absence of fruit and/or arthropods.

Statistical Analysis

We conducted all analyses using Program SAS (SAS Enterprise Guide version 6.1, SAS Institute, Inc., Cary, NC) unless otherwise noted. To compare means, we used the

Tukey-Kramer method and reported means ± 1 standard error, unless otherwise noted. To validate test assumptions, we examined the distribution of residuals. For the interpretation of estimates, we back-transformed variables that had been transformed. We considered all factors statistically significant at $P \leq 0.05$.

To test for a difference between vireo captures in riparian and shrub vegetation, we first standardized captures by dividing the number of independent juveniles captured by the number of mist-net hours (referred to as birds/net hour). We conducted separate analyses by year to estimate mean rates per year (PROC GLM). We then combined years and modeled birds/net hour by vegetation type using a mixed linear model and accounting for year as a random effect (PROC MIXED).

To analyze habitat selection, we calculated the percent available and percent use of each vegetation type for each individual juvenile vireo radio-tracked. Many studies use home range size to determine habitat selection. Because of the small number of locations we obtained for each individual, and because birds were sometimes highly mobile, calculating habitat use at the home range scale was not appropriate in our study. For each juvenile, we estimated the percent availability of each vegetation type by creating a 300-m buffer around each bird location and calculating the proportion of each vegetation type within the buffer (Geospatial Modeling Environment; Beyer 2012). We classified vegetation types based on ArcGIS vegetation polygon layers for Fort Hood (Reemts and Teague 2007). We used a 300-m buffer because it was the mean distance birds moved between consecutive locations. To compare proportions of vegetation types used with those available, we used compositional analysis (program bycomp.sas, SAS version 9.3). We conducted separate analyses by year for the years in which we had large sample sizes (2012 and 2013). We found no yearly variation in habitat selection and combined years for final analysis. We calculated movement rates (m/hr) using the distance and time between consecutive locations. We then compared movement rate by vegetation type, using only consecutive locations in the same vegetation type, with individual birds and year included as random variables to account for individual and yearly variation (PROC MIXED). To meet the normality assumptions of mixed models, we log transformed movement rates.

Using additive 2-factor analysis of variance (ANOVA) models (PROC GLM), we compared vegetation characteristics (percent foliage density and percent canopy cover) between bird and random locations by vegetation type. Because we did not survey random locations in 2010 and 2011 and because we found no variation in canopy cover or foliage density by year, we did not include year as a variable. To test for a difference in arthropod counts between bird and random locations by vegetation type, we developed an additive 2-factor ANOVA model (PROC GLM). To examine if arthropod counts varied over the course of the season, we developed linear regression models for each vegetation type and examined arthropod counts over time

(PROC REG). We found no yearly variation in arthropod numbers and did not include year in arthropod models. To meet the assumptions of both arthropod models, we log transformed arthropod counts.

We conducted this study in accordance with the University of Illinois Institutional Animal Care and Use Committee Permit Number 12052, the Federal Fish and Wildlife Permit TE023643-7, Federal Bird Banding Permit 21999, and Texas Scientific Permit Number SPR-0409-079.

RESULTS

Juvenile Abundance in Riparian and Shrub Vegetation

We accumulated 356 mist-net hours in shrub and 245 in riparian vegetation in 2012–2013. We captured similar numbers of birds/net hour in shrub and riparian vegetation (0.25 and 0.26, respectively; $F_{1, 77} = 0.04$, $P = 0.84$; Table 1). Capture rates did not differ statistically by year ($F_{1, 77} = 0.89$, $P = 0.38$; Table 1).

Individual Habitat Selection

We radiotagged and tracked 71 juvenile black-capped vireos in 2010–2013 and collected 1,370 locations (19.3 ± 1.2 locations per individual). Vegetation types within the study sites were available to juveniles in similar proportions (0.31 ± 0.03 forest, 0.26 ± 0.03 grass, 0.24 ± 0.04 riparian, 0.19 ± 0.03 shrub). When we compared vegetation types used by each individual to those available to each individual, juveniles did not use vegetation types in proportion to their availability (Wilks' Lambda: $F_{3, 68} = 28.61$, $P \leq 0.001$; Fig. 1). Juveniles selected riparian over forest and grass vegetation ($t_3 = 3.97$, $P \leq 0.001$; $t_3 = 7.92$, $P \leq 0.001$; respectively). Juveniles did not select riparian over shrub vegetation ($t_3 = 0.02$, $P = 0.98$). Shrub was selected over forest and grass vegetation ($t_3 = 3.67$, $P \leq 0.001$; $t_3 = 9.14$, $P \leq 0.001$; respectively). All other vegetation types were selected over grass (all $P \leq 0.001$). Nearly all juveniles captured in riparian vegetation remained in this vegetation type throughout the tracking period (24 of 26 individuals). In comparison, of the 32 juveniles captured in shrub, 11 remained in shrub, 11 moved into riparian vegetation, 4 moved to forest, and 3 moved between shrub and forest vegetation. The remaining 4 individuals showed variable movements across all vegetation types, many moving continuously throughout the tracking period.

Juveniles moved an average of $4,898 \pm 445$ m throughout the time we tracked them. The mean distance between consecutive locations was 263 ± 11 m. The mean time we sampled between consecutive locations was 10.7 ± 0.2 hr and movement rates averaged 80.3 ± 7.8 m/hr. Juveniles moved more quickly in forest and shrub than in other vegetation types (14.9 m/hr riparian, 13.7 m/hr grass, 16.7 m/hr shrub, and 17.0 m/hr forest), although differences among vegetation types were not significant ($F_{3, 887} = 0.17$, $P = 0.92$).

We detected juveniles in close association with conspecific adults at 27% of bird locations. We witnessed juveniles closely associating with adults and occasionally begging for food from adults feeding dependent fledglings, but we did not witness any adults feeding the older juveniles that we

Table 1. Capture rates (birds per net hour) and standard error of independent juvenile black-capped vireos in riparian and shrub vegetation at Fort Hood, Texas, 2012–2013. Number of individuals (*n*) are given in parentheses.

Habitat	2012			2013			Years combined		
	Capture rate	SE	(<i>n</i>)	Capture rate	SE	(<i>n</i>)	Capture rate	SE	(<i>n</i>)
Riparian	0.24	0.33	(15)	0.21	0.20	(43)	0.25	0.10	(58)
Shrub	0.47	0.48	(20)	0.14	0.16	(47)	0.26	0.10	(67)

were tracking. When using playbacks for mist-netting, juveniles responded positively to male songs and other conspecific vocalizations. Overall, we did not observe any evidence that suggested hostile behavior between adult and juvenile birds.

Juveniles were predominately foraging when resighted (407 of 473 locations where we documented activity). In the 111 fecal samples collected while banding vireos in 2012–2013, we found remains of arthropods in 103 samples, fruit in 3 samples, and 5 samples had no identifiable items. These results indicate that arthropods make up the bulk of the juvenile diet during this time period.

Vegetation Characteristics and Arthropod Abundance

We surveyed foliage density and canopy cover at 702 bird locations and 408 random locations in 2011–2013. As predicted, vireos were associated with dense understory vegetation and canopy cover, in all vegetation types, relative to random locations (Fig. 2). Foliage density was greater at bird than at random locations ($F_{7, 1,141} = 58.69$, $P \leq 0.001$; Fig. 2A). When analyzed by individual vegetation type, this was true for grass, riparian, and shrub (all $P \leq 0.001$), but not forest ($P = 0.80$). Canopy cover was also greater at bird locations than at random locations ($F_{7, 1,141} = 57.21$, $P \leq 0.001$; Fig. 2B) and, by vegetation type, was greater at bird locations than random locations in grass and riparian (both $P \leq 0.001$) but not in forest ($P = 1.00$) or shrub vegetation ($P = 0.61$).

To determine whether juvenile vireos selection of riparian vegetation might be associated with greater density vegetation, we compared canopy cover and foliage density among

vegetation types using only data from random locations. Canopy cover was greater in forest ($P \leq 0.001$) than all other vegetation types (forest: 0.57 ± 0.03 ; grass: 0.04 ± 0.01 ; riparian: 0.33 ± 0.04 ; shrub: 0.26 ± 0.02) but did not differ between riparian and shrub vegetation types ($P = 0.47$). Foliage density did not differ between riparian, shrub, and forest vegetation (all $P > 0.05$) but was greater in those vegetation types than in grass (all $P \leq 0.001$; forest: 0.50 ± 0.02 ; grass: 0.16 ± 0.01 ; riparian: 0.45 ± 0.04 ; shrub: 0.45 ± 0.02).

We sampled arthropods at 583 bird locations and 518 random locations from 2012 to 2013. We found no seasonal trend in arthropod abundance in forest, grass, or shrub vegetation ($F_{1, 270} = 0.13$, $P = 0.72$; $F_{1, 160} = 0.60$, $P = 0.44$; $F_{1, 242} = 0.79$, $P = 0.38$; respectively), but we found a weak negative relationship in riparian vegetation ($F_{1, 415} = 32.87$, $P \leq 0.001$; $R = 0.27$). We found no difference in arthropod numbers between bird and random locations ($F_{1, 1,093} = 0.06$, $P = 0.81$). However, arthropod abundance did differ among the 4 vegetation types ($F_{3, 1,093} = 8.74$, $P \leq 0.001$; Fig. 3) and the highest abundance was in riparian vegetation.

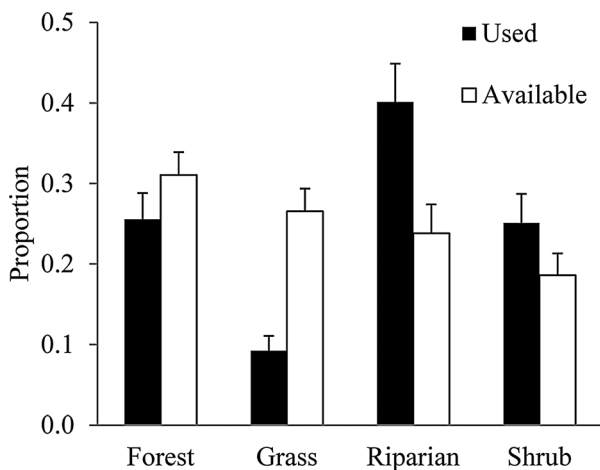


Figure 1. The proportion (± 1 SE) of vegetation types used versus those available to juvenile black-capped vireo locations at Fort Hood, Texas, 2010–2013.

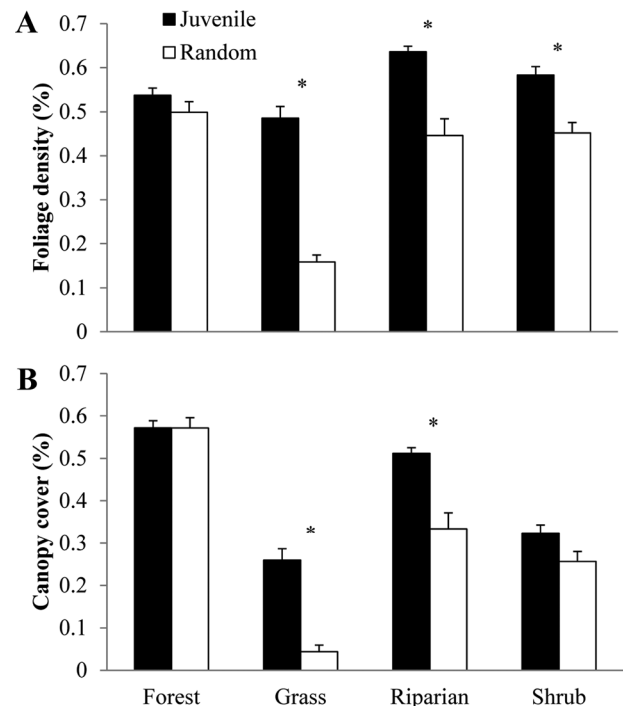


Figure 2. Mean (± 1 SE) foliage density (A) and canopy cover (B) at juvenile black-capped vireo locations and random locations at Fort Hood, Texas, 2011–2013. Statistically significant differences ($P < 0.05$) are denoted by asterisks.

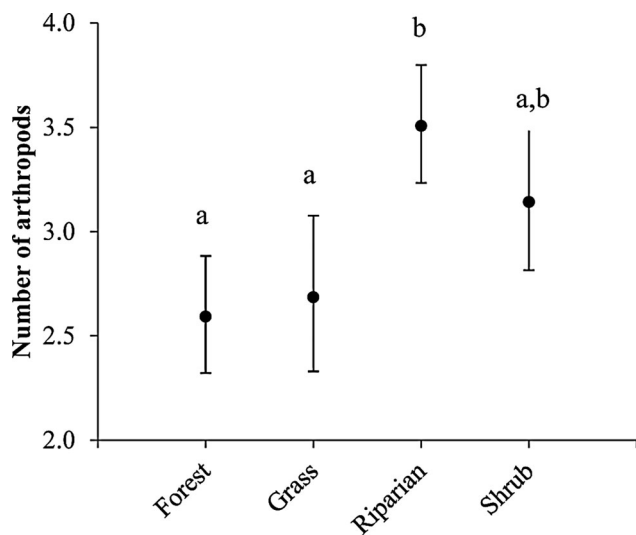


Figure 3. Mean ($\pm 95\%$ CI) arthropod abundance by vegetation type at Fort Hood, Texas, 2012–2013. Different letters signify statistically significant differences ($P < 0.05$).

DISCUSSION

Collectively our results indicate that juvenile black-capped vireos often move out of the shrub vegetation in which they were produced and into other vegetation types, particularly riparian vegetation. We captured juveniles at similar rates in shrub and riparian vegetation, even though vireos nest almost exclusively in shrub vegetation (Grzybowski 1995; but see Pope et al. 2013). Further, radio-tracked individuals demonstrated selection for riparian vegetation over most other available vegetation types and tended to select areas with increased foliage density and canopy cover. Use of habitat is likely a function of increased cover and food compared to other available habitats. These results suggest that riparian vegetation may be important for juvenile black-capped vireos, thus expanding what is considered necessary habitat for this endangered species.

Movement patterns of radio-tracked vireos provide insight into how juveniles appear to select habitat. Birds captured in shrub did not all move directly to riparian vegetation as might be expected if they had an innate preference for that vegetation type. Rather, they moved extensively and used denser vegetation in all vegetation types. Those that did move into riparian vegetation remained there, as did nearly all the vireos that were already in riparian vegetation when captured. Thus, birds may keep sampling areas until they encounter sites with the features they prefer (e.g., vegetation structure, food) and then restrict further movements. In our study sites, riparian vegetation provides more of the preferred attributes than do other vegetation types.

Our results contribute to the growing evidence that habitat selection for birds may differ seasonally, likely because of the different ecological requirements for birds in the breeding season compared with the post-breeding season (Vega Rivera et al. 1998, King et al. 2006, Akresh et al. 2009, Vitz and Rodewald 2010). Juvenile vireos tend to choose areas

characterized by dense canopy and foliage, suggesting that vegetative cover may be important in choosing habitats. Dense vegetation may provide cover and protection from the elements, which may be particularly important for young, inexperienced birds. Juvenile vireo selection of riparian vegetation did not appear to be solely a function of dense vegetation, but rather a combination of cover and food abundance. Given that foraging was the predominant activity observed, habitat selection decisions likely incorporate food abundance. Arthropods were most abundant in riparian vegetation, even though we found a slight decrease in abundance over the season. Previous work in other systems has demonstrated that riparian areas have more arthropods than other habitats (Vega Rivera et al. 1998, Iwata et al. 2010). Because juveniles are highly mobile and are not constrained by territoriality, they may be able to respond to variation in arthropod abundance and choose foraging areas accordingly (Uesugi and Murakami 2007). Overgrazing by cattle has been found to alter vegetation structure along small streams and rivers through reducing foliage density, canopy cover, vegetation diversity, and invertebrate abundance (Collins and Thomas 1991, Belsky et al. 1999). The birds we tracked were able to find areas with suitable vegetation, but overgrazing on our study sites may degrade habitat quality over time if no action is implemented. A decrease in grazing disturbance can positively affect riparian vegetation (Hough-Snee et al. 2013) and should be considered at Fort Hood, where $>188,000$ acres of land are grazed annually (Fort Hood 2010).

A potential difficulty in inferring if food and cover are attracting juveniles to these vegetation types is the possibility that they are forced to use those vegetation types by adults. Our observations indicate this is not the case because we observed juveniles in close proximity to conspecific adults while tracking them and because we captured many juveniles in mist-nets when we were broadcasting adult songs. These observations suggest adults tolerate juveniles, and this tolerance may be due to the duller, less conspicuous plumage of juveniles or the breakdown of adult territories prior to migration.

MANAGEMENT IMPLICATIONS

Our data indicate that juvenile vireos are selective in their habitat use and choose features different from those chosen by adults for breeding. Thus, management efforts for this species may be more effective if both breeding and post-breeding requirements are considered. Current conservation strategies for vireos on Fort Hood focus entirely on protecting and monitoring shrub vegetation and do not consider riparian areas. Prioritizing areas for management in proximity to riparian areas may add value to breeding habitat. Additionally, the quality of riparian vegetation available to vireos during the post-breeding period is potentially important, because juveniles must obtain sufficient food resources to build energy reserves for migration while avoiding predators (Faaborg et al. 1996). Protecting riparian vegetation from overgrazing so that a sufficient amount of dense vegetation cover is maintained may help provide

adequate habitat for this potentially critical life-history phase.

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