Journal of Mammalogy, 103(2):407–414, 2022
https://doi.org/10.1093/jmammal/gyab143
Published online December 9, 2021

Structural and environmental predictors of tricolored bat presence and abundance in Texas caves

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The identification of bat colonies is essential to conserve and manage these globally threatened mammals. Caves offer potential roosting locations (hibernacula) to hibernating bat species; however, identifying regions where bat-occupied caves exist can be time-consuming. In Texas, caves are often on privately owned land, creating difficulties for accessing and managing potential hibernacula. The tricolored bat (*Perimyotis subflavus*), a species susceptible to white-nose syndrome, hibernates in caves in the winter in Texas. We sought to identify and quantify site-specific structural and environmental features that influence the presence and abundance of overwintering tricolored bats. We surveyed caves for bats and recorded environmental and structural features of 116 caves January–February 2016, December–February 2016–2017, January–February 2018, and December–February 2018–2019. We used a zero-inflated Poisson regression to identify which features best explained the presence and abundance of tricolored bats. We found that bat presence increased as cave length decreased, and as Normalized Difference Vegetation Index (NDVI) and external vapor pressure deficit increased. Bat abundance increased as number of portals, cave length, NDVI, and external temperature increased. Combining surface data with subsurface features can assist with identifying specific karst regions and known caves within those regions for survey and management efforts.

Key words: caves, hibernacula, *Perimyotis subflavus*, tricolored bat, white-nose syndrome

La identificación de colonias de murciélagos es fundamental para la conservación y manejo de estos animales amenazados a nivel mundial. Las cuevas ofrecen abrigos potenciales para las especies de murciélagos que hibernan, sin embargo, identificar las regiones donde existen cuevas ocupadas por murciélagos requiere mucho tiempo. En Texas, las cuevas a menudo se encuentran en terrenos de propiedad privada, lo que crea dificultades para acceder y administrar estos sitios potenciales de hibernación. Esto es importante ya que el murciélago tricolor (*Perimyotis subflavus*), una especie susceptible al síndrome de la nariz blanca, hiberna en cuevas en Texas durante el invierno. Buscamos identificar y cuantificar las características ambientales y estructurales específicas que influyen en la presencia y abundancia de murciélagos tricolores que hibernan. Inspeccionamos las cuevas en busca de murciélagos y registramos las características ambientales y estructurales de 116 cuevas entre enero y febrero de 2016, de diciembre a febrero de 2016–2017, de enero a febrero de 2018 y de diciembre a febrero de 2018–2019. Usamos una regresión de Poisson inflada con ceros para identificar las características que mejor explican la presencia y abundancia de murciélagos tricolores. Encontramos que la presencia de murciélagos aumenta a medida que disminuye la longitud de la cueva y con el incremento del Índice de Vegetación de Diferencia Normalizada (IVDN) y del Déficit de Presión de Vapor (DPV). La abundancia de los murciélagos aumenta con el incremento en el número de portales, el largo de la cueva, el IVDN y de la temperatura externa. Con las amenazas actuales para los murciélagos tricolores, combinar datos de la superficie con características del subsuelo puede ayudar en la identificación de regiones kársticas específicas y reconocer cuevas dentro de esas regiones para los esfuerzos de muestreo y manejo.

Palabras clave: cuevas, *Perimyotis subflavus*, murciélago tricolor, síndrome de la nariz blanca, sítios de hibernación.

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Approximately 51 species of bats are found in North America north of Mexico (Bradley et al. 2014), with greatest species richness occurring in the Southwest United States. Many of these species choose hibernacula in which to enter a state of torpor, where body temperature and metabolic rates are reduced to conserve energy (Geiser 2004, 2013). Among the various roosts occupied by bats during the winter months, caves are commonly used by many species (Kunz 1982; Hill and Smith 1984; Harvey 1997). Selection of hibernacula by bats may be influenced by a number of factors, including roost dimensions, microclimate conditions, availability and abundance of alternative roosts, and surrounding landscape characteristics (Kunz 1982; Raesly and Gates 1987; Briggler and Prather 2003; Meierhofer et al 2019a).

Several North American hibernating bat species are at risk of exposure to the cold-tolerant fungus *Pseudogymnoascus destructans*, the causative agent of the often-fatal disease, white-nose syndrome (WNS; Blehert et al. 2009; Lorch et al. 2011; Warnecke et al. 2012). As a cold-tolerant fungus, *P. destructans* proliferates at temperatures <19.8 °C (Verant et al. 2012) and may prefer environments with high water vapor (Marroquin et al. 2017). The fungal spores infect dermal tissue of hibernating bats, which causes frequent arousals that deplete the host's fat reserves (Reeder et al. 2012) and contributes to evaporative water loss (EWL; Cryan et al. 2010; Willis et al. 2011), resulting in high mortality in bats afflicted with WNS. The disease is spreading steadily from its introduction in New York across North America, primarily along karst regions where caves can form (Langwig et al. 2015; Hoyt et al. 2021).

WNS was recently confirmed in the state of Texas in spring 2020, resulting in the deaths of cave myotis (*Myotis velifer*) in central Texas (TPWD 2020), which is one of several species that is susceptible to the disease. Another WNS-susceptible species found in Texas is the tricolored bat (*Perimyotis subflavus*). Once a common bat species in North America ranging from Central America to southern Canada (Fujita and Kunz 1984; Harvey et al. 2011), the tricolored bat has experienced severe population declines (>90%), primarily as a result of WNS (Cheng et al. 2021). As a result of these population declines, and other current threats to this species (e.g., wind energy; Mickleburgh et al. 2002; Hammerson et al. 2017), tricolored bats are undergoing a status review for listing under the Endangered Species Act by the United States Fish and Wildlife Service (USFWS 2017). Within Texas, tricolored bats were listed as a species of greatest conservation need (TPWD 2012), even prior to the invasion of *P. destructans*. In spring 2017, tricolored bats tested positive for the presence of *P. destructans* fungal spores in Texas (TPWD 2017), but no visible signs of WNS (e.g., wing membrane lesions, emaciation, unexplained mortality of bats in hibernacula; Cryan et al. 2010; Foley et al. 2011) were noted for this species. However, the presence of the fungus increases the potential for this species to become afflicted with WNS.

In light of the continued spread of *P. destructans* and documentation of WNS, it is important to allocate resources and efforts wisely when working to access and target caves for long-term effective monitoring and management efforts. This can be particularly challenging in a state such as Texas, where approximately 95% of land is privately owned. Indeed, identifying who owns the land and making contact can be difficult and time-consuming. Further, the Texas landscape is large, covering 695,662 km², furthering the challenges of resource allocation. Given the impending threat of WNS to tricolored bats in Texas, and understanding the complexities of gaining access to private lands, we sought to determine how surface and subsurface site-specific structural and environmental characteristics influence presence and abundance of tricolored bats during winter. This information can assist with identifying regions, and known caves within those regions, for targeted access and survey efforts. This information will help to better plan for, manage, and protect tricolored bats in Texas and other regions along their southern range.

Materials and Methods

Study area.—We conducted cave surveys for overwintering tricolored bats throughout their known range in Texas. We obtained information about cave locations from the Texas Speleological Society, state wildlife biologists, and the public. As approximately 95% of Texas is privately owned, access to caves is often restricted by private landowners and is primarily opportunistic, thus making it difficult to avoid sampling bias. Nevertheless, we were able to survey a total of 116 caves in 33 counties within five Level III ecoregions (Chihuahuan Deserts, Cross Timbers, Edwards Plateau, South Central Plains, and Southwestern Tablelands; Griffith et al. 2004, 2007; Fig. 1).

Bat surveys.—We surveyed caves once for overwintering bats during daylight hours January–February 2016, December–February 2016–2017, January–February 2018, and December–February 2018–2019. To increase the sample size of surveyed caves, we focused efforts on conducting surveys across caves rather than repeating cave surveys across years. During the times of survey, all bats had settled into hibernation and little if any relocation was expected. For our study, we conducted a census for each cave by visually surveying the cave for presence and abundance of tricolored bats. Two observers counted bats using clicker counters at each cave to reduce sampling error. At sites where we could not assure accurate counts (e.g., bats were in cracks or large clusters), we averaged the count between observers. We visually identified individuals to species without handling to minimize disturbance. We were confident in our ability to identify tricolored bats given their unique morphological features compared with other species within the state. We decontaminated all equipment and persons between surveys and sites following the most updated WNS decontamination protocol (http://whitenosesyndrome.org). Research on bats followed American Society of Mammalogists guidelines (Sikes et al. 2016) and was approved by the Texas A&M Institutional Animal Care and Use Committee (IACUC 2015-0296).

Although many factors may influence tricolored bat presence and abundance in caves, we chose to limit the number of independent variables in our analysis to prevent overfitting our data. After reviewing the literature, we chose to collect the

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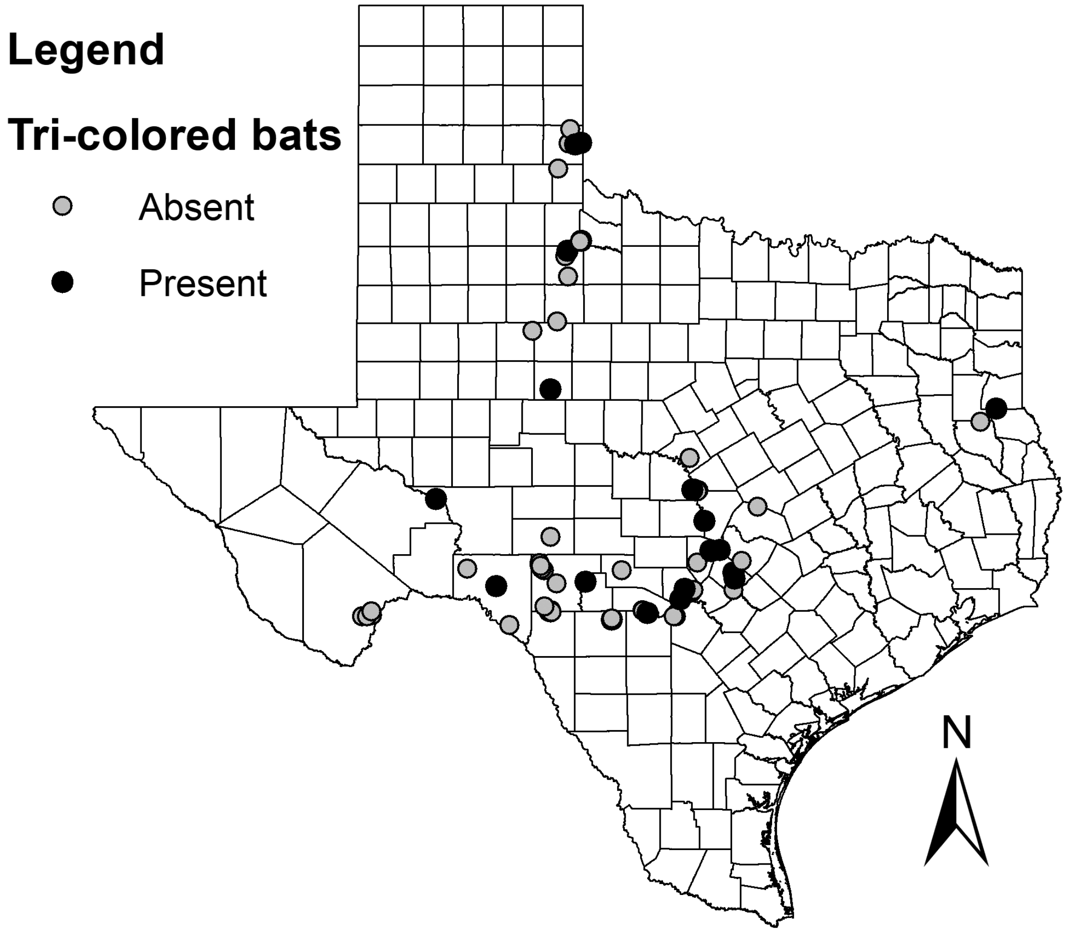

Fig. 1.—Locations of 116 caves surveyed for tricolored bat presence and abundance from January–February 2016, December–February 2016–2017, January–February 2018, and December–February 2018–2019 in Texas. Black circles indicate where at least one tricolored bat was present and grey circles indicate where tricolored bats were absent. Due to scale, some circles overlap.

following variables that have been previously reported as influential on tricolored bat presence or abundance: length of cave (Briggler and Prather 2003; Meierhofer et al. 2019a), external temperature (Meierhofer et al. 2019a), external vapor pressure deficit (VPD; Meierhofer et al. 2019a), Normalized Difference Vegetation Index (NDVI; Sandel et al. 2001; Meierhofer et al. 2019a), and number of cave portals. We recorded the total survey length (m) of caves using either a laser distance measurer (Tuirel T100; Tuirel Technology LLC, New York, New York, USA) or obtained it from cave maps or the Texas Speleological Survey when available. During each survey, we documented the number of portals for each cave and categorized them (1 = 1 portal, 2 = 2 portals, 3 = >2 portals). We used a Garmin GPS unit (Montana 680t; Garmin Ltd., Olathe, Kansas, USA) to record location (latitude, longitude) and elevation (m) of each site. We marked surveys as either complete surveys (we were confident that all areas of the cave were surveyed) or partial surveys (we could not be confident that we surveyed the entire cave system).

We used the NDVI as an indicator of vegetative canopy density of each sample location. NDVI is a spectral index derived from multispectral remote sensing imagery that is highly correlated with leaf area index and has been successfully used as a predictor of primary production (Tucker and Sellers 1986). We acquired NDVI datasets collected by the space-borne Moderate Resolution Imaging Spectroradiometer which were provided as a composite of images taken over a 16-day period at a spatial resolution of 250 m (Didan 2015). We downloaded a total of 18 NDVI composites required to provide geographic and temporal coverage of our study area, corresponding to sampling dates between 2016 and 2019. We produced NDVI measurements for each sample location by calculating the average NDVI value for each pixel using the raster math tool in ArcMap 10.5 (ESRI 2016) and extracting the values at each point. We chose to calculate the average rather than take the value corresponding to sampling date as sites were sampled within similar seasons, and to retain consistency with methodology used by Meierhofer et al. (2019a).

We acquired monthly mean external temperature and external VPD data with a spatial resolution of 4 km through the Parameter-Elevation Regressions on Independent Slopes Model (PRISM) Climate Group for all months in which sampling occurred when available (PRISM Climate Group 2019). We chose to use 4 km spatial resolution over more fine-scale resolutions due to our broad, state-wide modeling approach. Weather data from late 2018 (December) and early 2019 (January–February)

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were not yet available; therefore, we used data from previous years as an approximation for these survey dates. We calculated the mean external temperature and external VPD using the raster math tool in ArcMap 10.5 (ESRI 2016), and extracted the value for each corresponding sample location.

Statistical analysis.—We used R.3.4.1 (R Development Core Team 2018) to conduct all analyses. We did not include data for caves for which we only had partial surveys (n = 8) in our analysis, as we could not be sure of an accurate bat count. Due to the zero-inflated nature of our data (χ^2 = 1,325.38, $P < 0.05$), we chose to analyze tricolored bat abundance data using a zero-inflated Poisson regression, which provides a Poisson count model and a logit model. We standardized all predictor variables to z values prior to analysis and variance inflation factors (VIFs) showed that these variables were not multicollinear (all VIFs < 2).

We entered tricolored bat count data as the dependent variable to analyze both presence and abundance data, as the zero-inflated Poisson regression model produces model components that can be interpreted for variation in bat presence–absence, and variation in bat abundance. We ran all combinations of independent variables to produce 30 regression models, plus a null model (intercept only). We ranked models using AICc (Akaike's information criterion with correction for small sample sizes) and models are presented with associated AICc weights (relative likelihood of a model) and ΔAICc. To approximate the proportion of variance explained by each model, we calculated a pseudo R^2 value using the deviance of the null model minus the deviance of the candidate model divided by the deviance of the null model (Zurr et al. 2009).

Results

We analyzed data for 108 caves across Texas (Fig. 1). We found a total of 322 ($\bar{X}$ + SD = 3.07 ± 11.74, max = 91, min = 1) tricolored bats in 26 of these caves (23.9%). External temperature, NDVI, and external VPD from all caves surveyed for bats ranged from 4.86 to 12.92 °C, 0.21 to 0.69, and 5.14–12.19 kPa, for each of the three sampling periods, respectively. Number of portals for all caves surveyed for bats varied from 1 to 3, and the median number of portals was 1. Length of all caves surveyed ranged from 1.18 m to 5,725.20 m, and medians are reported in Table 1 due to the large variability in cave lengths. The external temperature, external VPD, number of portals, and NDVI were similar between caves with and without bats but caves with bats were considerably longer (Table 1).

Our top model contained all five independent variables and explained approximately 49% of the deviation in tricolored bat abundance (pseudo R^2 = 0.49, Table 2). All other models had AICc weights <10% of the AICc weight of the top model, thus we did not use model averaging and report the results of the top model. Our analysis suggested that cave length, external VPD, and NDVI were the main drivers explaining tricolored bat presence, while number of portals, cave length, external temperature, and NDVI were the main drivers of tricolored bat abundance (Table 3). Although the global model produced the lowest AICc value (Table 2), due to the comparatively small beta (β) coefficient weights (interpreted as the degree of change in the outcome variable for every 1 unit of change in the predictor variable) of some of the factors within the fitted model (Table 3), we interpreted associated P-values with caution and instead determined the importance of each factor within the model by comparing relative coefficient size. Relative coefficient sizes suggest that cave length and external VPD had the greatest influence on bat presence, with the likelihood of bat presence increasing with decreasing cave length and increasing external VPD. Coefficient sizes suggest that number of portals and external temperature had the greatest influence on bat abundance, with abundance increasing with increasing number of portals and increasing external temperature.

Discussion

We found that a combination of both environmental and structural site-specific landscape factors can assist with predicting presence and abundance of overwintering tricolored bats across the Texas landscape. Specifically, shorter caves, higher external VPD, and increasing NDVI were the greatest drivers in predicting tricolored bat presence. The greatest drivers in predicting tricolored bat abundance were a greater number of portals, longer caves, warmer external temperature, and increased NDVI. Although our data were predominantly opportunistically collected and may not adequately capture characteristics of cave environments in western Texas (much of the land in West Texas is owned by oil companies), we were able to broadly define characteristics of caves where tricolored

Table 1.—Descriptive statistics for all caves, caves with tricolored bats present, and caves with tricolored bats absent across Texas collected January–February 2016, December–February 2016–2017, January–February 2018, and December–February 2018–2019. Variables are: Length = length of cave, Portals = number of openings to cave (1 = 1 portal, 2 = 2 portals, 3 = > 2 portals), Temp = external ambient temperature (°C), NDVI = Normalized Difference Vegetation Index, and VPD = external vapor pressure deficit (kPa).

	All caves				Caves with bats present				Caves with bats absent			
	Min	Max	$\bar{X}$/Median	SD	Min	Max	$\bar{X}$/Median	SD	Min	Max	$\bar{X}$/Median	SD
Length (m)[a]	1.18	5725.20	25.70	—	3.90	5725.20	52.00	—	1.18	828.00	23.65	—
Portal[a]	1	3	1	—	1	3	1	—	1	3	1.41	—
Temp (°C)	4.86	12.92	10.13	1.98	4.86	12.92	10.07	1.99	4.86	12.92	10.08	2.01
NDVI	0.21	0.69	0.45	0.13	0.21	0.69	0.45	0.13	0.21	0.69	0.45	0.13
VPD (kPa)	5.14	12.19	7.41	1.39	5.14	12.19	7.38	1.33	5.14	12.19	7.42	1.41

[a]Medians are supplied for length and portal.

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Table 2.—The top five zero-inflated Poisson regression models (ranked using Akaike's Information Criterion with correction for small sample sizes (AICc)) plus the null model and associated parameters for predicting variance in tricolored bat presence and abundance in Texas caves based on data gathered January–February 2016, December–February 2016–2017, January–February 2018, and December–February 2018–2019. Variables are: Length = length of cave (m), Portals = number of openings to cave (1 = 1 portal, 2 = 2 portals, 3 = > 2 portals), Temp = external ambient temperature (°C), NDVI = Normalized Difference Vegetation Index, and VPD = external vapor pressure deficit (kPa).

Model	*K*	AICc	ΔAICc	AICc weight	Pseudo R^2
Length + Portals + Temp + NDVI + VPD	12	439.83	0	0.94	0.49
Length + Portals + Temp + VPD	10	446.08	6.25	0.04	0.47
Length + Portals + Temp	8	448.34	8.51	0.01	0.46
Length + Portals + Temp + NDVI	10	449.15	9.32	0.01	0.47
Length + Portals + NDVI + VPD	10	454.80	14.97	0	0.46
Null (intercept only)	2	807.27	367.44	0	-

Table 3.—Coefficients (β), standard errors (*SE*), *z* values, and associated *P*s as determined from a zero-inflated Poisson regression for independent variables predicting presence and abundance of tricolored bats in Texas caves based on data gathered January–February 2016, December–February 2016–2017, January–February 2018, and December–February 2018–2019. Variables are: Length = length of cave (m), Portals = number of portals (1 = 1 portal, 2 = 2 portals, 3 = > 2 portals), Temp = external ambient temperature (°C), NDVI = Normalized Difference Vegetation Index, and VPD = external vapor pressure deficit (kPa). Significant independent variables are in bold.

	Variable	β	*SE*	*z* value	*P*
Presence (zero-inflation model)	**Length**	**−2.19**	**0.93**	**-2.37**	**0.02**
	Portals	0.27	0.33	0.83	0.41
	Temp	−0.31	0.40	−0.77	0.44
	NDVI	**1.15**	**0.50**	**2.30**	**0.02**
	VPD	**1.71**	**0.57**	**3.02**	**<0.01**
	Intercept	1.35	0.34	3.98	<0.01
Abundance (count model)	**Length**	**−0.20**	**0.03**	**5.62**	**<0.01**
	Portals	**0.43**	**0.08**	**5.27**	**<0.01**
	Temp	**0.39**	**0.09**	**4.24**	**<0.01**
	NDVI	**−0.24**	**0.11**	**−2.30**	**0.02**
	VPD	−0.17	0.13	−1.31	0.19
	Intercept	1.86	0.10	19.33	<0.01

bats were found using information gathered across five Level III ecoregions. Our results indicate that differences existed in the factors predicting presence and abundance, suggesting the importance of combining remote-sensing data with cave-site characteristics to identify regions and caves for survey and management efforts.

Predictors of tricolored bat presence.—Several structural factors can influence the thermal properties of an individual cave thus affecting its use by bats (Tuttle and Stevenson 1978; Raesly and Gates 1987; Perry 2013). Our data showed that tricolored bats were more likely to be found in shorter caves. Although the raw statistics in Table 1 suggest that tricolored bats are more likely to be found in longer caves, there was larger variability in cave lengths with bats present than caves without. One plausible reason for tricolored bats to be more likely found in shorter caves is that the structure of these shorter caves may compensate for size, thereby providing greater thermal diversity to bats occupying these caves (Ransome 1990). However, these findings contrast by Briggler and Prather (2003) and Dixon (2011) who found that tricolored bats were more likely to be present in longer caves. However, Briggler and Prather (2003) categorized caves 80–150 m as long and cave lengths in the study by Dixon (2011) were <50 m, whereas mean and maximum length for our surveyed caves were 222 m and 5,725 m, respectively. Indeed, Perry (2013) considered caves of 80–150 m as relatively short, so whether tricolored bats are found in longer or shorter caves is contingent upon the variation in length of caves surveyed for that study.

Our model suggested that the probability of tricolored bat presence increased with increasing external VPD, signifying that bats were more likely to be found in locations with lower atmospheric water content. Tricolored bats are oftentimes found roosting in areas within hibernacula with high moisture content (Twente 1955; Cryan et al. 2010) as EWL (which is linked to VPD) leads to dehydration and increased rates of arousal during winter months (Thomas and Geiser 1997; Ben-Hamo et al. 2013). Thus, our result seems at odds with previous findings. However, this result supports findings from our previous research that suggested tricolored bats were more likely to be detected occupying artificial hibernacula (i.e., culverts) in regions of high VPD (Meierhofer et al. 2019a). One explanation for our finding is that external VPD is not an accurate proxy for internal VPD and thus provides little information about VPD within hibernacula (Meierhofer et al. 2019a). As such, it is difficult to speculate on the proliferation of *P. destructans* within these environments from external VPD measures.

Tricolored bat presence was positively related to NDVI, indicating that bats were more likely to be found in areas of increased vegetative density. Whereas most research on tricolored bat hibernation and winter activity has taken place in northern regions, research in warmer, southern regions has found that tricolored bats are active throughout the year and may engage in feeding behavior during the winter months (Grider et al. 2016). Indeed, NDVI has been directly linked to abundance in several insect species (Trierweiler et al. 2013; Cole et al. 2015; Dantur Juri et al. 2015), and therefore may provide important foraging areas. Should Texas tricolored bats show similar winter activity to those in North Carolina (Grider et al. 2016), bats may be more likely to be found in areas exhibiting high NDVI values as these areas have a higher abundance of prey than areas with less vegetation. Further research is required to fully understand the winter activity and hibernation behavior of tricolored bats in the most southern reaches of their range.

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Predictors of tricolored bat abundance.—Although we found that presence of tricolored bats was greater in shorter caves, abundance of tricolored bats increased with increasing cave length. Longer caves have higher surface area, and therefore may provide more area for roosting. Indeed, larger caves are occupied by more hibernating bats than are smaller caves (Briggler and Prather 2003; Kryštufek 2007). Further, longer caves may have more stable temperatures and humidity within the roost (Kunz 1982) and provide greater variability in available microclimates (Tuttle and Stevenson 1978; Ransome 1990).

Tricolored bat abundance increased as the number of portals increased. The number of cave openings affects temperatures within a cave (Tuttle and Stevenson 1978). More openings may increase airflow into the cave, thereby modifying cave air temperature and vapor content and creating greater variation in internal microclimates. Perry (2013) suggested that in regions where the mean ambient surface temperature is >10 °C, such as in Texas, bats may roost close to the entrance where colder external air mixes with warmer cave air during winter. Thus, multiple portals may allow for a greater abundance of bats to roost in more favorable thermal climates during winter.

Tricolored bat abundance also increased as external temperature increased. The relationship between external temperature and the internal temperature of caves is complicated and influenced by many factors such as cave complexity (Perry 2013). Although temperature profiles within caves follow a similar trend as external temperatures (Verant et al. 2012; Meierhofer et al. 2019b), caves are buffered from extremes in temperature (Speakman and Thomas 2003) and the amplitude in change of internal temperature is a fraction of external temperature variation (Perry 2013). Tricolored bats may be able to utilize caves in warm areas of the state due to their ability to roost across a broad temperature range (0–17.8 °C; Rabinowitz 1981; Raesly and Gates 1987; Webb et al. 1996; Briggler and Prather 2003; Meierhofer et al. 2019b). Unfortunately, the ambient external temperature of the caves surveyed ranged between approximately 5 and 13 °C, which is within the suitable growth range of *P. destructans* (Verant et al. 2012). Hourly temperature recordings from data loggers deployed for a year in two Texas caves (one in north Texas, one in central Texas) occupied by tricolored bats, as well as microclimate temperatures recorded from seven bat species (including the tricolored bat) indicate that internal cave temperatures likely fall within a range that is suitable or optimal for *P. destructans* growth (Meierhofer et al. 2019b); bat presence–abundance data used in this study were a subset of the same cave locations. Thus, temperatures in caves used by tricolored bats may put their populations in Texas at risk of developing WNS.

As with bat presence, NDVI was also found to be positively associated with bat abundance. As discussed above, increased NDVI may lead to increased winter foraging opportunities that may be able to sustain larger colonies of over-wintering bats should they engage in feeding bouts during hibernation.

Gaining access to caves for monitoring and management efforts in regions where land is predominantly privately owned is challenging, as access must be granted by the landowner. Due to the continued spread of *P. destructans* and recent documentation of WNS in Texas (TPWD 2020), identifying regions, and caves within those regions, most likely occupied by bats is important to allocate resources wisely for targeted management and monitoring efforts. Our study identified surface and subsurface site-specific landscape and environmental characteristics that influenced their presence and abundance. Although our external site-specific factors cannot speak to the complexity of the internal environments of caves, our findings can assist in identifying regions, and known caves within those regions, for more focused survey efforts in Texas and other regions covering the range of tricolored bats.

Acknowledgments

We thank J. Carey, K. Demere, S. Goree, L. Johnston, J. Kennedy, B. Kimbell, B. Stamps, E. Whittle, L. Wolf, B. Upton, and P. Bixler for their assistance in data collection. We appreciate the Texas Speleological Survey, Texas Cave Management Association, and Texas grottos for providing cave information and access. Thanks to Dr. C. Comer, J. Kennedy, Dr. W. Godwin, and D. Wright for facilitating access to private properties and data collection. We appreciate the access provided by all Texas landowners. Many thanks to Dr. J. French for his advice and assistance with data analysis. We thank the journal referees for their insightful and helpful review comments. This work was funded by the U.S. Fish and Wildlife Service's State Wildlife Grant Program (CFDA# 15.611) as administered by Texas Parks and Wildlife Department, and the U.S. Fish and Wildlife Service (CFDA# 15.657). Additional funding support was provided by the Fightwns "Micro Grants for Microbats", Texas Ecolab research grants, and the National Speleological Society WNS Rapid Response Grant and Research Grant.

Conflict of Interest

None declared.

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Submitted 08 January 2021. Accepted 08 November 2021.

Associate Editor was Susan Loeb.

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