

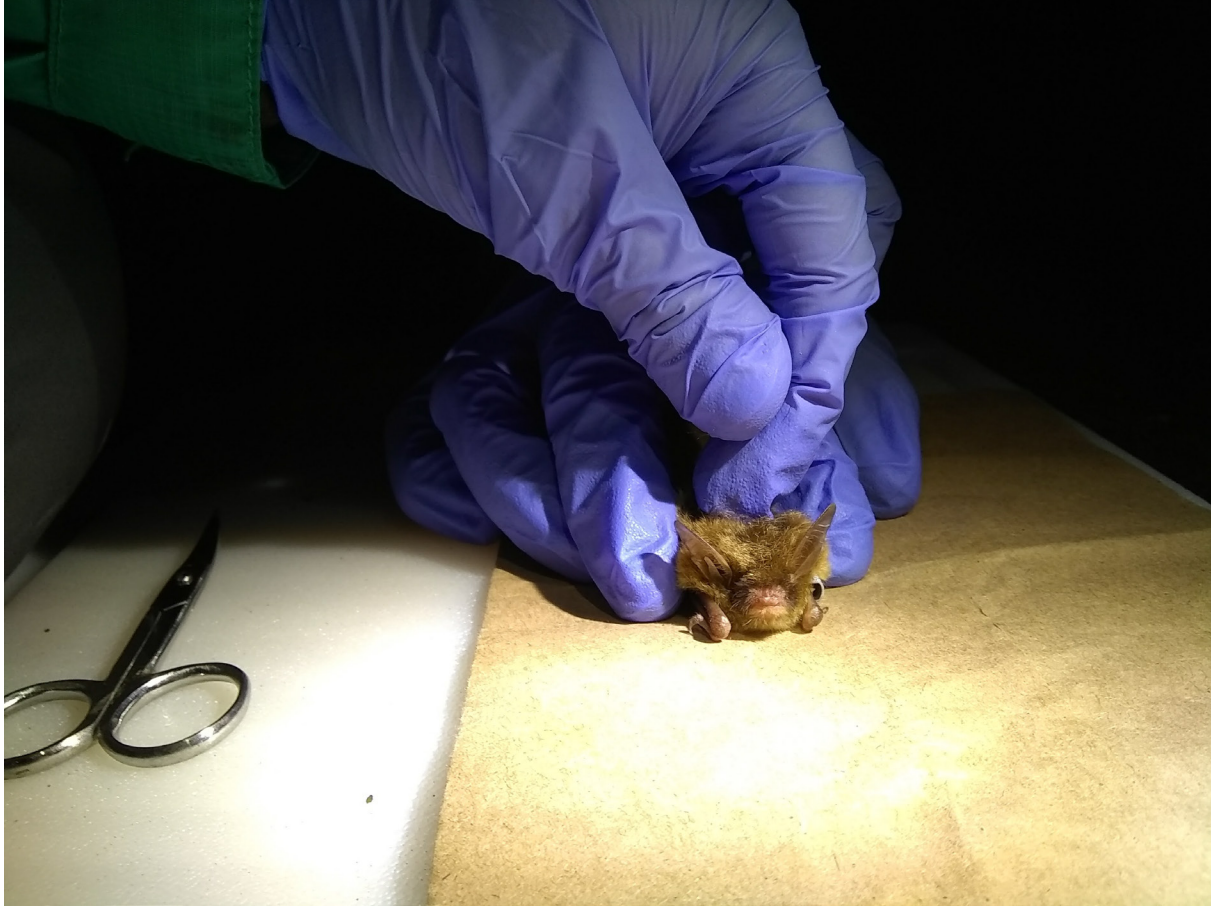


Post-White-nose Syndrome Bat Communities in the National Capital Region

Part 1—Final Report

Natural Resource Report NPS/NCRO/NRR—2021/2319





ON THIS PAGE

Northern long-eared bat captured by mist net in Rock Creek Park
NPS/SABRINA DEELEY

ON THE COVER

Big brown bat captured by mist net in Chesapeake and Ohio Canal National Historical Park
NPS/SABRINA DEELEY

Post-White-Nose Syndrome Bat Communities in the National Capital Region

Part I—Final Report

Natural Resource Report NPS/NCRO/NRR—2021/2319

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Preface

This final report has three parts. Part 1—Final Report of bat communities of the National Capital Region describes the background, methods, and general results. Detailed information about surveys, site locations, and results are divided into Parts 2A-F provides acoustic call data, and Parts 3A-C supply capture and effort data.

Executive Summary

White-nose syndrome (WNS) has caused large population decreases for several hibernating species in eastern North America. Our objectives were to document the existing bat communities, determine how bat communities have changed since the onset of WNS, document migration activity, document hibernacula use, identify day-roosting habits of WNS-impacted species, and provide ongoing monitoring recommendations within the National Park Service (NPS) National Capital Region (NCR). We surveyed the region between 2016 and 2018 using active acoustic recording, passive acoustic recording, mist netting, crevice searches, and radio-telemetry tracking. Using passive acoustic monitoring, software identified calls and nights with presence (based on United States Fish and Wildlife Service standards) from all species for which we surveyed, including the Federally Endangered Indiana (*Myotis sodalis*) and Threatened northern long-eared (*Myotis septentrionalis*) bats.

Our active acoustic methods duplicated sampling techniques and locations previously surveyed 2003 – 2004. Comparing the two datasets, we determined that the bat communities have significantly changed since WNS. There were significant decreases in the number of echolocation calls recorded for the WNS-impacted Indiana bat, little brown bat (*Myotis lucifugus*), and tri-colored bat (*Perimyotis subflavus*). We also documented an increase in the number of echolocation calls for the big brown bat (*Eptesicus fuscus*).

With passive acoustic sampling, we identified the presence of 12 bat species within the NCR: big brown, eastern red (*Lasiurus borealis*), eastern small-footed (*Myotis leibii*), evening (*Nycticeius humeralis*), hoary bat (*Lasiurus cinereus*), little brown, Mexican free-tailed (*Tadarida brasiliensis*), northern long-eared, silver-haired (*Lasionycteris noctivagans*), southeastern myotis (*Myotis austroriparius*), and tri-colored bats. We documented presence relative to sampling intensity at each sample site, identifying that the western end of the Chesapeake and Ohio Canal National Historical Park (CHOH) had the highest recorded bat diversity and numbers of occupied nights for species highly-impacted by WNS.

Our netting surveys verified the continued presence of species highly-impacted by WNS: eastern small-footed bat, little brown bat, northern long-eared bat, and tri-colored bat. However, compared to pre-WNS surveys in the NCR units, we documented a significant reduction in distribution and abundance, measured by both acoustic monitoring and physical capture, of the little brown, northern long-eared, and tricolored bats. Within Rock Creek Park (ROCR) and Prince William Forest Park (PRWI), the northern long-eared bat populations appear to be persisting. Their day-roosting ecology appears relatively unchanged in terms of forest type/condition and day-roost type/condition post-WNS when compared to pre-WNS observations in the mid-Atlantic region. Additionally, we documented a potential tri-colored bat maternity colony location within private property adjacent to CHOH.

Acknowledgments

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Special thanks goes to J. Johnson, J. Gates, and W. Ford for providing access to the 2003 – 2004 pre-WNS data from the National Park Service units. Fieldwork was provided by T. Calhoun, E. Barr, S. Dermody, R. Lesagonicz, G. Mosley, A. Morrison, A. Silvis, H. Taylor, and V. Wolfgang.

Glossary

Active acoustic sampling: bat site surveys that occur for less than one night when a human is present actively orienting a detector microphone.

Acoustic recorders: hardware used to record and store bat echolocation calls.

Detection probability (p): The ability for a survey to detect the presence of a species when it is present.

Kaleidoscope 4.5.0 Bats of North America 4.2.0 classifier (Wildlife Acoustics, Inc., Concord, MA, USA): Software for automatically identifying bats to species, approved by United States Fish and Wildlife Service (United States Fish and Wildlife Service 2019).

Maximum Likelihood Estimator (MLE): statistic to estimate species presence or absence on a site-night based on bat calls recorded over that time utilizing known misclassification rates among all combinations of bat species present (U.S. Fish and Wildlife Service Midwest Region 2019). Presence is defined as $MLE < 0.05$.

Mist netting: bat capture method based on deploying nylon or polyester nets between poles; pole height ranges from 2.6 to 7.8 m.

National Land Cover Dataset (NLCD): Spatially-explicate, long-term data on the physical material on the earth's surface developed by the United States Geological Survey.

North American Bat Monitoring Program (NABat): Continent-wide bat monitoring program (Loeb et al. 2015). The program has developed 10x10 km grid cells for the continent that are intended to be the sample unit for long-term, broad-scale bat assessments.

Occupancy probability (Ψ): The likelihood that a site is occupied by a species.

Passive acoustic sampling: when acoustic sampling occurs for more than 12 hours overnight without being actively monitored by a human

Shannon-Wiener Index: Method for calculating species diversity, taking into account species richness and abundance (Shannon 1948).

Single-season occupancy model: Analytical method of determining the probability of occupancy at a sample site by conducting repeat samples at each site within a period of time during which occupancy does not change.

Species richness: Number of species within a sample.

Summer survey period: United States Fish and Wildlife Service approved acoustic and mist netting sampling period (15 May – 15 August) to determine summer presence of Indiana bat (*Myotis sodalis*) and northern long eared bat (*Myotis septentrionalis*).

Introduction

White-nose syndrome (WNS), caused by the fungi *Pseudogymnoascus destructans*, increases overwinter arousal and/or dehydration in hibernating bats, leading to a depletion of fat reserves often followed by mortality from starvation/exposure or shifts in reproductive time and lowered recruitment in overwinter survivors (Franci et al. 2012; Reeder et al. 2012; Reynolds et al. 2016; Muthersbaugh 2018; Nocera 2018). Since 2007, WNS has caused large population decreases for several hibernating species in eastern North America, i.e., eastern small-footed (*Myotis leibii*), little brown (*Myotis lucifugus*), northern long-eared bat (*Myotis septentrionalis*), Indiana bat (*Myotis sodalis*) and tri-colored bat (*Perimyotis subflavus*) in affected areas (Alves et al. 2014). Despite high mortality rates, some WNS-impacted species are persisting in localized area within the WNS-affected region (Dobony et al. 2011, Pettit and O’Keefe 2017, De La Cruz et al. 2018).

Prior to the onset of WNS, the impetus for most bat survey work on federal and state agency lands in the mid-Atlantic region was to determine the local presence or absence of the endangered Indiana bat on the landscape during maternity season or within caves/mines/tunnels during the winter hibernating season. Approximately 30 winter hibernacula in the surrounding Maryland, Pennsylvania, Virginia and West Virginia region that historically overwintered Indiana bat are within the plausible migration distance to National Capital Region (NCR) units (Powers et al. 2015). Though the previous survey of these units found no evidence of Indiana bat presence on NCR units (Gates and Johnson 2005), maternity activity in the summer was detected in surrounding portions of the mid-Atlantic: Carroll County, Maryland; Caroline County, Virginia; and Tucker County, West Virginia (Johnson et al. 2010; Germain et al. 2017). Pre-WNS, bat species in the NCR units were influenced by landscape habitat configuration, i.e., forested land versus urbanized or agricultural matrices and/or for some species, distances to putative winter hibernacula (Johnson et al. 2008). Migratory species such as the eastern red bat (*Lasiurus borealis*) or the day-roost and winter hibernacula generalist big brown bat (*Eptesicus fuscus*) were ubiquitous in distribution regionally from the Ridge and Valley east through the Blue Ridge and Piedmont to the Coastal Plain, whereas species such as the northern long-eared bat were largely confined to forested units in the upper Piedmont, Blue Ridge and Ridge and Valley in closer proximity to karst formations or the presence of mines and tunnels (Johnson et al. 2008).

Post-WNS, from Northeast through the mid-Atlantic and west to the Ohio River Valley, bat communities have substantially changed in terms of species presence, relative abundances, inter-species relationships and habitat use during the non-hibernation season when bats are physical present on the landscape (Johnson et al. 2013; Silvis et al. 2014). For example, Jachowski et al. (2014) observed that the functional extirpation of little brown bats in the Northeast resulted in a competitive release and niche expansion of the eastern red bat and big brown bat that are not affected or less affected, respectively, by WNS. Similarly, recent analyses of hibernacula in the mid-Atlantic have documented population declines of 75%-95% for Indiana bats, northern long-eared bats, little brown bats and the tri-colored bat (Powers et al. 2015).

Northern long-eared bats, little brown bats and tri-colored bats are now species of high conservation concern. A proposed rule by the U.S. Fish and Wildlife Service to list the northern long-eared bat as

threatened (Federal Register § 78:61045-61080) was adopted as regulation in April 2015, and the little brown bat and tri-colored bat currently are undergoing status reviews that might also lead to listing proposals. Additionally, the Chesapeake and Ohio Canal National Historical Park (CHOH) contains a tunnel that serves as an important hibernacula sites for the small-footed bat in Maryland, and other colluvial boulderfield/talus slopes along with Catoctin Mountain Park (CATO) and Harper's Ferry National Historical Park (HAFE) harbor active summer maternity colonies of the species (Johnson et al. 2009; D. Feller, Maryland Division of Natural Resources [DNR], unpublished data). In the Appalachian Mountains, Johnson et al. (2011) found small-footed bats in emergent rock roosts on steep slopes with high solar exposure with proximity to vegetation cover and water. While the small-footed bat has also experienced WNS-associated declines and was proposed for Federal status but dismissed for insufficient data, remains a sensitive species in Maryland, Virginia and West Virginia (Moosman et al. 2013; Huth et al. 2015; Powers et al. 2015).

Individual bats and/or bat species are not equally vulnerable to capture on a given night, producing considerable bias associated with netting, even in a pre-WNS context. For example, in WNS-affected regions, mist-netting efforts required to adequately determine species absence of Indiana bats now exceeds 100 net-nights per survey site – an effort that would be logistically and fiscally prohibitive for land managers seeking to use netting for regulatory clearance of land management activities that might cause “take”, i.e., prescribed burning or hazard tree removal during the maternity season (Coleman 2013; Niver et al. 2014). As WNS continues to spread and bat populations decline further, biologists invariably will rely more on acoustic detection, as the primary method of monitoring bat presence on the landscape (Coleman et al 2014). Moreover, short-term active acoustic sampling as conducted previously in the NCR (Gates and Johnson 2005) also is no longer considered a viable post-WNS monitoring technique with relative nightly activity levels > 90% reduced from pre-WNS years (Ford et al. 2011; Coleman et al. 2014). Current U.S. Fish and Wildlife Service monitoring guidelines for regulatory approval prior to Federal actions encourages use of passive fixed site acoustic monitoring as opposed to mist-netting (United States Fish and Wildlife Service 2018). Additionally, targeted mist-netting based on relative acoustic activity can improve capture success (Coleman 2013). In the post-WNS environment, documentation of threatened northern long-eared bat maternity colony day-roost tree or snag use still requires radio-tracking of tagged individuals (Silvis et al. 2012, 2014).

Objectives

- 1) Continue to document the post-WNS bat assemblage and general foraging habitat associations and compare current conditions with pre-WNS observations provided by Gates and Johnson (2005), with particular emphasis on the northern long-eared, Indiana, little brown, eastern small-footed and tri-colored bat during the spring arrival and summer maternity season.
- 2) Determine the mid- to late-fall migratory staging use and possible overwinter use of D.C.-area units for eastern red bats, hoary bats and silver-haired bats (*Lasionycteris noctivagans*).
- 3) Continue to survey known and potential winter hibernacula for the presence of overwintering bats.

- 4) Determine the efficacy of establishing a subset of acoustic sites for permanent inclusion into the North American Bat Monitoring Program (NABat; Loeb et al. 2015), depending on proximity to high- or medium-value sample grids. Additionally, identify portions of units suitable for inclusion into local NABat acoustic driving transect effort.
- 5) Within the NCR, determine day-roost tree or snag use by northern long-eared bats (or opportunistically, other high conservation concern species) and eastern small footed bats colluvial rock use by rock search protocols (emphasis on CATO, CHOH, and HAFE).
- 6) Incorporate NCR units' bat species presence/absence data into a larger multi-partner (e.g., Fort A.P. Hill, Fort Pickett, Marine Corps Base-Quantico, National Aeronautics and Space Administration Wallops Flight Facility, George Washington and Jefferson National Forest, Shenandoah National Park, Great Dismal Swamp National Wildlife Refuge, James River National Wildlife Refuge, and various Virginia wildlife management areas, state forests and state preserves) mid-Atlantic landscape- and smaller forest stand-level predictive modeling effort of potential maternity season foraging and day-roosting habitat across various ecological conditions, spatial extents and temporal scales and to identify data "gaps" that can be resolved in the current post-WNS conditions for the northern long-eared bat.
- 7) Provide NCR- and unit-specific monitoring and management recommendations for future NPS bat conservation efforts.

Methods

The NCR study area consisted of Prince William Forest Park (PRWI) and the 11 NPS units that Gates and Johnson (2005) surveyed 2003–2004: Antietam National Battlefield (ANTI), CATO, CHOH, GWMP, HAFE, MANA, Monocacy National Battlefield (MONO), National Capital Parks-Central (now National Mall and Memorial Parks [NAMA]), National Capital Parks-East (NACE), Rock Creek Park (ROCR), and Wolf Trap National Park for the Performing Arts (WOTR; Figure 1). The region includes a mix of forests, agricultural areas, and degrees of urban development from lightly impacted to heavily urbanized. The most forested units include CATO, PRWI, and northwestern portions of CHOH in central and western Maryland. Running along the DC and Maryland border with Virginia and West Virginia from downtown D.C., CHOH is surrounded by all NCR habitat types. The battlefield units (ANTI, MANA, MONO) consist mainly of agricultural fields and small forest stands. HAFE is a mixture of rural mountainous forest and open battlefields. As a performing arts center, WOTR contains cleared land with small forest fragments surrounded by a suburban landscape. Units most proximal to D.C. include ROCR, NAMA, GWMP and NACE. Following the Virginia border and Potomac River near D.C., GWMP primarily consists of thin linear forest and a few larger forest stands. ROCR contains several small parks and two large, mostly-contiguous forests. Though containing some small, open forest patches, NAMA is mostly groomed grass and developed land. NACE has several small parks along the Anacostia River, thin linear forests, and Greenbelt Park.

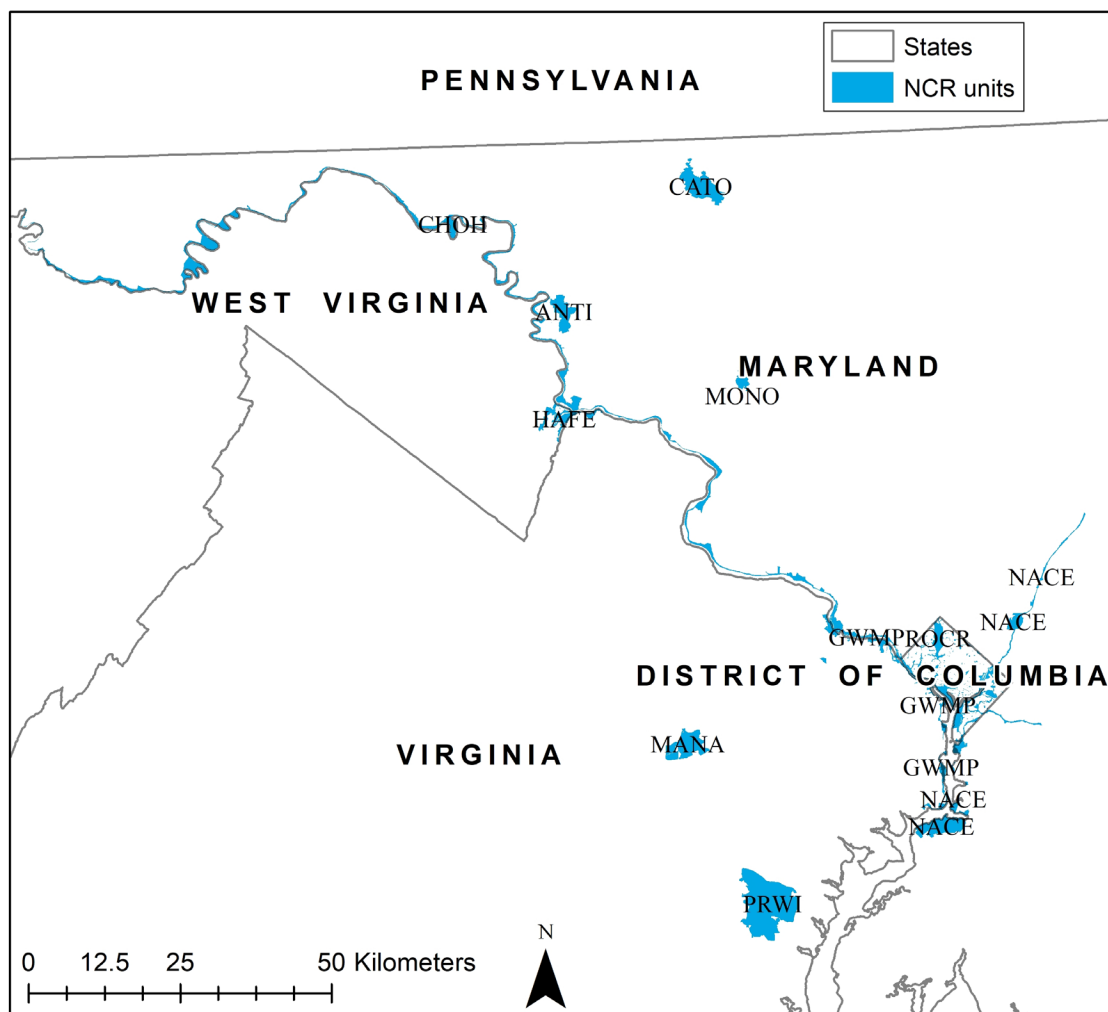


Figure 1. NPS National Capital Region (NCR) national parks: Antietam National Battlefield (ANTI), Catoclin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield Park (MANA), Monocacy National Battlefield (MONO), National Mall and Memorial Parks (NAMA), National Capital Parks-East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap National Park for the Performing Arts (WOTR).

Objective 1

We used a mixture of active acoustic sampling, passive acoustic sampling, and mist netting capture methods to document the post-WNS NCR bat communities. For pre-WNS survey efforts, Gates and Johnson (2005) used active acoustic sampling and netting to document presence throughout the region. However, active monitoring has greater spatial-temporal bias in data collection, lower detection probabilities, and higher costs per hour of data (Coleman et al. 2014). Therefore, we only resampled a portion of pre-WNS sites to compare to pre-WNS results using active sampling; our larger effort to document presence and absence of bat species was with passive acoustic sampling, in accordance with USFWS and NABat standards (United States Fish and Wildlife Service 2018). We used mist netting captures to verify presence of species and document bat population information.

Active Acoustic Surveys

Following the methods of Johnson et al. (2008), we used ANABat II (Titley Electronics, Ballina, Australia¹) zero-crossing, frequency-division to actively survey sites at each unit for one 20-minute period between sunset and 0200. If a bat was “observed,” as evidenced by audible echolocation sound from the detector or visual identification, we attempted to follow its direction with the detector microphone for a few seconds to record a complete, high quality call sequence (Ford et al. 2005). Historic call files (Gates and Johnson 2005) and call files collected in this effort were identified to species using Kaleidoscope 4.5.0 Bats of North America 4.2.0 classifier (Wildlife Acoustics, Inc., Concord, MA, USA) with the following species considered as known or possibly extant in the NCR: big brown, eastern red, hoary (*Lasiurus cinereus*), Indiana, eastern small-footed, evening (*Nycticeius humeralis*), silver-haired, little brown, northern long-eared, and tricolored bats. Echolocation calls identified to species were used for analyses of echolocation call data. Using program R, we used paired *t*-tests to compare active acoustic calls between pre-and post-WNS periods (Student 1908; Zimmerman 1997; R Core Team 2017).

Passive Acoustic Surveys

During the USFWS summer periods, we used Song Meter acoustic recorders (Wildlife Acoustics, Inc., Concord, MA, USA) to conduct passive acoustic sampling at both stratified pseudo-random locations and a selection of pre-WNS active sampling sites (Gates and Johnson 2005). For the random sampling, we used the North American Bat (NABat) Monitoring Program’s 100 km² grid cells to spatially balance sampling across the NCR (Loeb et al. 2015). We used ArcMap 10.3 to generate random points within developed, forest, open, and wetland areas. These categories were based on data from 2011 National Land Cover Dataset (NLCD) classified coverages from 30 m x 30 m Landsat imagery (Homer et al. 2015). We attempted to sample each land cover category once within each NABat grid cell, where that land cover type represented at least 10% of the total area. Each random point was at least 200 m away from any other to prevent incidental clustering of random points within a grid cell. We sampled each grid cell with over 2 km² of NPS land with at least four sites. To balance effort among units, we initially allocated 300 sites proportional to total unit area, and then randomly and non-randomly added additional sites proportional to each cell’s land cover types and total area.

In 2017 and 2018 in PRWI, we used a stratified pseudo-random sampling design to select forested sites that represented upland, flat or mid-slope, and bottomland topographic classes and fire histories within the unit. Each randomly-generated point was at least 150 m away from other points to ensure that an even distribution was achieved across the park. Points were sampled for approximately 30 nights.

We used a hand-held GPS unit to locate sites in the field. However, since poor acoustic site selection can impact the detectability (Britzke et al. 2013), we allowed the actual sample site to be placed

¹ Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S Government

within a 200 m buffer of a random point. This buffer allowed us to place detectors in locations better able to detect bats, but also to prevent preferential selection of specific habitat type. The buffer also allowed for correct NLCD land cover adjustments or logistics issues, e.g., no location to secure the detector, excessive vegetative clutter, presence of interfering structures or an insecure location. If the first location was inappropriate for sampling, we proceeded to the next random point within that type until an appropriate location is located. When possible, each passive detector was placed > 3 m from the bole of a tree (Loeb et al. 2015) and 3.66 m off the ground on telescoping poles (Figure 2). Raising the microphone off the ground can increase the number of calls recorded (Weller and Zabel 2002; Fischer et al. 2009). We activated each detector at least 15 minutes prior to sunset and deactivated 15 minutes after sunrise (Loeb et al. 2015).



Figure 2. Typical passive acoustic detector attached to a tree (orange circle) with microphone (yellow circle) on the top of the corresponding pole in Chesapeake and Ohio Canal National Historical Park (NPS/SABRINA DEELEY)

In summer 2016, we sampled a minimum of one random sample location per NABat grid cell from the dominant land cover type within the cell. We sampled for at least nine nights before and after 1 July 2016 (the midpoint in USFWS summer period) to improve detection of rare species throughout the possible maternity period. We based sampling length on 2015 field surveys in CATO, HAFE, MANA, and PRWI where the northern long-eared bat were detected with 95% confidence after 9

nights (Kalen et al. 2015). In 2017, we resampled sites from summer 2016 and at least three additional random sampling locations per grid cell for at least 9 nights.

In 2018, we maintained an equal passive acoustic monitoring effort in PRWI but selected only a few acoustic sites in MANA and ROCR for continued monitoring. Additionally, we conducted a fine-scale passive acoustic assessment of an area in ROCR where we had previously captured female and juvenile northern long-eared bats and identified several day roosts. To examine fine-scale northern long-eared bat activity within a possible maternity colony area, we deployed 98 passive acoustic detectors in concentric circles approximately 60 m apart, though actual distance varied based on the landscape. These detectors recorded data between April and August 2018. We determined the number of nights where presence was documented at each site versus sampled nights and activity patterns across the sample period.

For all passive acoustics, we selected the same species as the active acoustic surveys in the Kaleidoscope classifier for all units, except MANA and PRWI. We included the Mexican free-tailed bat and southeastern myotis in parks where these species may have extended their range (MANA = Mexican free-tailed bats; PRWI = Mexican free-tailed bat and southeastern myotis). Both species have been expanding north over the past decade into the mid-Atlantic region (McCracken et al. 2018; M St. Germain, Virginia Tech, unpublished data). We excluded the eastern small footed bat from PRWI as no suitable roost habitat occurred there or within close proximity. Following USFWS recommendation for Indiana bat and northern long-eared bat acoustic monitoring, we used Kaleidoscope maximum-likelihood estimators ($MLE < 0.05$) to determine presence or absence values for all bat species for each site-night as a standardized metric (United States Fish and Wildlife Service 2018).

We used nightly presence and call values to calculate the total number of presence nights and calls at each site for each species during the USFWS period of 15 May – 15 Aug. We used site-night presence and absence values to run two single-season occupancy models (2016 and 2017) for the northern-long eared bat in unmarked within program R (Fiske and Chandler 2011). We used the sample Julian day and amount of precipitation on the sample night (PRISM Climate Group 2019) as detection covariates. We then associated each site with the amount of developed area within 100 m and 1 km using NLCD land cover data from 2011 (Homer et al. 2015); a fractal dimension index (measure of the complexity of forest stand shape) for the area within 500 m of the site, using the R package SDMTools and NLCD land cover data (VanDerWal et al. 2014; Homer et al. 2015); latitude; and longitude.

Mist-netting Surveys

Between 2016 and 2018, we conducted mist-netting from late-April to mid-August. We selected netting locations to provide a general survey of the region and to capture species heavily-impacted by WNS. We used Gates and Johnson (2005) and our previous netting captures and 2016–2017 passive acoustic activity of Indiana, little brown, northern long-eared, and tricolored bats as the basis for site selection. We placed nets along possible flight corridors and avoided netting during poor weather conditions, as these can reduce bat activity (Loeb et al. 2015). We identified species using a dichotomous key (Menzel et al. 2002), and recorded sex, age (adult or juvenile), weight, forearm

length, reproductive condition, and whether a bat was a recaptured bat (Francel et al. 2012). We banded all bat species highly-impacted by WNS, as well as a subset of big brown bats for an ancillary region-wide study. The Virginia Tech Institutional Animal Care protocol 16-240 approved all bat handling procedures, and our collection efforts were permitted under USFWS #TE34778A-2, Maryland Department of Natural Resources #56152, Virginia Department of Game and Inland Fisheries #061519, and West Virginia Division of Natural Resources #2018.180 scientific collecting permits, as well as individual park permits for each survey year.

Objective 2

Fall, winter, and spring activity in the D.C. area

To determine migration patterns and overwinter activity, we deployed acoustic detectors in GWMP, MANA, NACE, PRWI, and ROCR between August and May 2016–2018. We combined these data with data from the summer acoustic surveys to compare activity levels. We used the same processing methods used with summer survey efforts. However, we excluded Mexican free-tailed bats and southeastern myotis, as they were unlikely to overwinter in the NCR. We identified the proportion of nights with presence for each overwinter month for each site.

Objective 3

Survey winter hibernacula

We determined that Maryland DNR were already conducting regular, ongoing surveys of CHOH hibernacula (D. Feller, Maryland DNR, unpublished data). In order to avoid duplicate surveys that could cause unnecessary stress to any hibernating bats, and with approval of the CHOH Natural Resources Program Manager, we supplemented Maryland DNR hibernacula surveys with passive acoustic detectors at known/possible hibernacula entrances from August through April in 2016–2017 and 2017–2018. Survey effort in 2017–2018 was higher than in 2016–2017, and not all sites were surveyed for the same periods due to equipment and logistics issues. We used the same processing methods used with other passive survey efforts. We identified activity for each species at each sample site for the recording period.

Objective 4

Priority sites for NABat inclusion

We associated all passive acoustics sites with NABat grids, which were designed to structure long-term, continent-wide bat monitoring efforts (Loeb et al. 2015). Using the nightly presence data, we calculated the Shannon-Wiener Index and the proportion of sample nights with presence for all 2016 – 2018 samples within the USFWS summer sampling period, using package *vegan* in program R (Magurran 1988; Oksanen et al. 2015). Within each NABat grid, we calculated the mean sample nights with presence of all sites and mean Shannon-Wiener Index. To determine the number of sample nights required to document presence for the species highly impacted by WNS, we calculated the probability of occupancy and detection for the equation using the null models of all species using unmarked in program R (Fiske and Chandler 2011). We then used these values to calculate the level of effort required to determine true absence at a site, as provided by Wintle et al. (2012), for our four species heavily-impacted by WNS.

Objective 5

Day roosts for species of interest

When we captured a species of interest, we affixed a unique identification tag and LB-2X radio transmitter (0.27-0.31 g: Holohil Systems Ltd. Woodlawn, ON, Canada) to the bat. Subsequent days, we tracked the bats using TRX-2000WR receivers and folding three-element antennas (Wildlife Materials Inc., Carbondale, IL, USA) to their day roosting locations for the life of the transmitter. For each roost tree, we recorded tree decay class, species, possible roosting location, and diameter at breast height. If possible, we netted identified day roosts to capture additional females to determine maternity activity and roost network dynamics.

Eastern small-footed bat crevice searches

To determine small-footed bat survey locations, we documented possible roosts (e.g. rocky slopes and man-made structures) while in the field in 2016 and 2017 and reviewed Google Earth satellite imagery of the units. We focused on colluvial rock formations and rock walls with crevices in CATO, CHOH, and HAFE. We also identified areas near higher small-footed bat 2016 passive acoustic activity. Following the small-footed bat day-roost search protocols established by Moosman et al. (2015), we surveyed potentially occupied talus slopes, other colluvium and rock crevices for bat at CATO, CHOH, HAFE, GWMP, and ROCR.

Objective 6

Multi-partner data integration

Mist-net capture records of northern-long eared bats within the NCR have been incorporated in an assessment of occupancy and detection throughout the northeast U.S. provided to the U.S. Fish and Wildlife Service (De La Cruz et al. 2019). Additionally, data collected from this survey are currently being integrated into several landscape-level bat community assessments. We expect that analysis and interpretation of much of this work will be completed in 2021. Presently, we are combining NCR bat acoustic, mist netting capture, and day-roost data with similar data from surrounding NPS units in the northeastern region, i.e., Appomattox Court House National Historical Park, Booker T. Washington National Monument, Gettysburg National Battlefield (GETT), Richmond National Park, Shenandoah National Park, Petersburg National Battlefield, Colonial National Historical Park, as well as Back Bay National Wildlife Refuge, Great Dismal Swamp National Wildlife Refuge, James River National Wildlife Refuge, George Washington and Jefferson National Forest, Department of Defense installations, various Virginia state lands (state forests, parks and wildlife management areas) and non-governmental/private lands. Current in-work or planned analysis include:

- 1) Migration and overwintering patterns within the mid-Atlantic, with a focus on determining coastal migration and non-traditional hibernacula for the northern long-eared bat
- 2) Reproductive patterns for bats within the mid-Atlantic and how they relate to environmental characteristics and nearby acoustic data.
- 3) Acoustic standards for determining presence for all mid-Atlantic species
- 4) Variation in big brown bat diet along an urban-to-rural gradient

- 5) Roost tree selection of northern long-eared bats
- 6) Fine-scale (temporal and spatial) habitat use, with a focus on the northern long-eared bat
- 7) Occupancy and use of topographic classes (e.g., upland, flat or midslope, and bottomland) and fire histories

Results

Objective 1

Post-WNS bat communities

Active Acoustic Surveys

In 2017, we revisited 164 of the 362 sites surveyed by Johnson et al. (2008) in 2003 – 2004 (Figure 3); 147 of those sites (40.6%) were revisited in non-precipitation conditions similar to the original survey (Deeley et al. 2020a). Kaleidoscope software identified calls and night-level presence ($MLE < 0.05$) of 10 species (Deeley et al. 2020a). The total recorded calls were from big brown ($n = 690$), eastern red ($n = 124$), hoary ($n = 89$), Indiana ($n = 9$), eastern small-footed ($n = 1$), evening ($n = 103$), little brown ($n = 72$), northern long-eared ($n = 13$), silver-haired ($n = 259$), and tricolored ($n = 39$) bats. There were 102 samples with calls: big brown ($n = 60$), eastern red ($n = 39$), hoary ($n = 35$), Indiana ($n = 8$), eastern small-footed ($n = 1$), evening ($n = 34$), little brown ($n = 29$), northern long-eared ($n = 1$), silver-haired ($n = 55$), and tricolored ($n = 14$) bats. Post-WNS, we had a lower proportion of samples with calls (2003 = 80.0%, 2004 = 82.9%, 2017 = 69.4%). We determined that there were significant decreases ($P < 0.05$) in the number of Indiana, little brown and tri-colored bat calls and significant increases in the number of big brown bat calls between pre- and post-WNS samples (Table 1). Unit-level species richness declined due to little brown and tri-colored bats, though northern long-eared bat distribution also declined throughout the study area (Table 2).

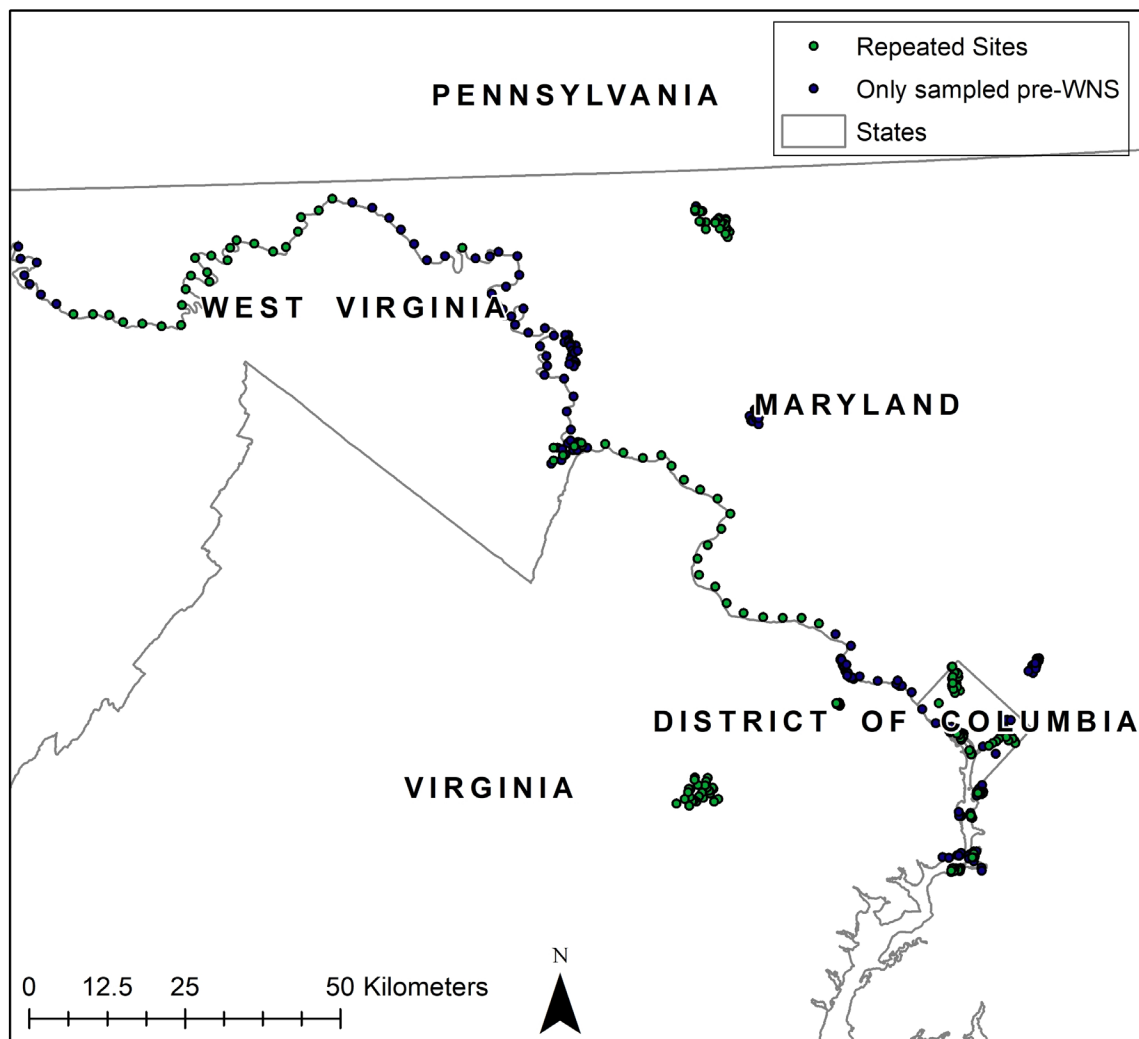


Figure 3. Locations within the National Capital Region using the same active echolocation recording methods. Green dots represent sites sampled both in 2003 – 2004 and 2017 and blue dots those sites sampled just 2003 – 2004.

Table 1. Number and sample mean of active acoustic calls recorded within the National Capital Region from 2003 – 2004 and 2017 based on Kaleidoscope. Species abbreviations include: big brown (*Eptesicus fuscus*; EPFU), eastern red (*Lasiurus borealis*; LABO), evening (*Nycticeius humeralis*; NYHU), hoary bat (*Lasiurus cinereus*; LACI), Indiana (*Myotis sodalis*; MYSO), eastern small-footed (*Myotis leibii*; MYLE), little brown (*Myotis lucifugus*; MYLU), northern long-eared (*Myotis septentrionalis*; MYSE), silver-haired (*Lasionycteris noctivagans*; LANO), and tri-colored bat (*Perimyotis subflavus*; PESU).

Species	2003–2004		2017		Mean change	P-value
	Total	Mean (SE)	Total	Mean (SE)		
EPFU	889	2.46 (0.40)	679	4.62 (0.96)	2.16	0.01
LABO	151	0.42 (0.06)	104	0.71 (0.17)	0.29	0.07
LACI	496	1.37 (0.21)	85	0.58 (0.13)	-0.79	0.07
LANO	878	2.43 (0.34)	251	1.71 (0.32)	-0.72	0.86
MYLE	23	0.06 (0.02)	1	0.01 (0.01)	-0.05	0.05
MYLU	573	1.58 (0.33)	66	0.44 (.09)	-1.14	0.00
MYSE	48	0.13 (0.03)	13	0.09 (0.08)	-0.04	0.33
MYSO	77	0.21 (0.05)	9	0.06 (0.02)	-0.15	0.01
NYHU	108	0.30 (0.52)	94	0.64 (0.18)	0.34	0.13
PESU	394	1.09 (0.21)	28	0.19 (0.07)	-0.9	0.01

Table 2. Species documented through active acoustics (based on call data) and mist-netting captures in NPS National Capital Region from 2003 – 2004 (Gates and Johnson 2005) and 2016 – 2018 (including District of Columbia Department of Energy and Environment 2017 summer collaboration). Species lost indicate species that were documented 2003 – 2004, but not 2016 – 2018, and species gained are those species documented 2016 – 2018, but not 2003 – 2004. Note that sample effort by unit was not equal between 2003–2004 and 2016–2018. Park abbreviations are defined in Figure 1. Species abbreviations are defined in Table 1.

Sample Method	Park	2003 – 2004 species	2016 – 2018 species	Species lost since WNS	Species gained since WNS
Acoustics	ANTI	9	N/A	N/A	N/A
	CATO	10	8	MYLE, MYSE	–
	CHOH	10	8	MYLE, MYSE	–
	GWMP	10	N/A	N/A	N/A
	HAFE	8	2	EPFU, LACI, LANO, MYLU, MYSO, PESU	–
	MANA	10	8	MYSE, MYSO	–
	MONO	7	N/A	N/A	N/A
	NAMA	6	5	PESU	–
	NACE	8	8	MYSO	MYSE
	ROCR	8	7	MYSE	–
	WOTR	8	1	EPFU, LABO, LANO, MYLU, MYSE, NYHU, PESU	–
Netting	ANTI	3	2	MYLU	–
	CATO	4	3	MYLU	–
	CHOH	6	7	LACI, MYSE	LANO, MYLE, NYHU,
	GWMP	4	4	MYLU, PESU	LANO, NYHU
	HAFE	3	3	MYSE	LACI
	MANA	3	2	PESU	–
	MONO	4	2	MYLU, PESU	–
	NAMA	1	1	LABO	EPFU
	PRWI	N/A	6	N/A	EPFU, LABO, LACI, LANO, MYSE, NYHU
	NACE	2	2	–	–
	ROCR	6	5	LACI, MYLU	LANO

Passive Acoustic Surveys

Between 15 May 2016 and 15 August 2018, we recorded data from 562 sites on 35,717 site-nights (ANTI= 250; CATO= 565; CHOH = 5,519; GWMP = 2,850; HAFE = 265; MANA= 1,688; MONO = 265; NACE = 5,297; NAMA = 168; PRWI = 4,926; ROCR = 13,750; WOTR = 174; Deeley et al. 2020a). During the USFWS summer periods, we sampled 546 sites for 17,572 nights (ANTI= 250;

CATO= 565; CHOH = 2,335; GWMP = 495; HAFE = 265; MANA= 313; MONO = 265; NACE = 1,209; NAMA = 168; PRWI = 2,595; ROCR = 8,938; WOTR = 174; Deeley et al. 2020a).

Kaleidoscope software identified calls and nights with presence ($MLE < 0.05$) for all 12 species (Table 3; Deeley et al. 2020a). Big brown and eastern red bats had the highest number of total and mean calls (Figure 4). The total recorded calls were big brown ($n = 626,810$), eastern red ($n = 88,767$), eastern small-footed ($n = 2,014$), evening ($n = 85,933$), hoary ($n = 179,116$), Indiana ($n = 8,352$), little brown ($n = 57,370$), northern long-eared ($n = 8,596$), silver-haired ($n = 279,306$), tricolored ($n = 47,122$), Mexican free-tailed ($n = 4,426$), and southeastern myotis ($n = 1,107$) bats. We noted that the proportion of nights with presence within our 2018 ROCR concentric circles was low and identified no central area of highest detections which may indicate a maternity colony (Figure 5), despite overlapping known capture and roost sites. However, we will conduct future analysis of nightly and within-night activity.

We used 59 sites from 2016 and 428 sites from 2017 to develop northern long-eared bat occupancy models. In 2016, the null model was a competing model, indicating that the measured variables did not explain a large portion of detection or occupancy (Table 4). In 2017, the amount of developed area (within 100 m) and latitude impacted occupancy, and Julian day impacted detection (Table 4). The amount of precipitation within a sample night did not appear to have a significant effect on detection for either year.

Table 3. Mean echolocation calls per site-night for all species surveyed during the USFWS survey period within each National Capital Region unit. Unit abbreviations are in Figure 1. Species abbreviations are defined in Table 1.

Unit	EPFU	LABO	LACI	LANO	MYAU ¹	MYLE	MYLU	MYSE	MYSO	NYHU	PESU	TABR ¹
ANTI	14.224	3.024	16.104	9.120	–	0.016	0.988	0.036	0.280	1.780	0.488	–
CATO	19.694	3.487	4.943	5.358	–	0.096	1.919	0.324	0.237	2.161	0.635	–
CHOH	26.592	8.702	9.460	8.306	–	0.072	7.409	0.201	0.934	10.190	3.723	–
GWMP	44.141	3.386	13.612	26.754	–	0.059	2.283	0.089	0.370	3.149	2.101	–
HAFE	12.249	4.374	10.196	5.196	–	0.057	3.113	0.702	0.566	6.445	1.317	–
MANA	35.984	7.869	12.428	19.243	–	0.022	2.447	0.077	0.313	4.990	0.933	6.047
MONO	7.049	3.223	11.770	12.585	–	0.011	1.728	0.011	0.068	2.528	0.521	–
NACE	45.014	3.926	6.254	19.430	–	0.023	2.071	0.079	0.121	2.395	1.342	–
NAMA	37.976	3.940	39.274	89.655	–	0.000	1.619	0.018	0.036	6.042	1.619	–
PRWI	8.148	6.389	7.175	4.567	0.406	–	3.008	0.316	0.293	5.783	2.313	1.033
ROCR	25.855	1.377	3.194	6.030	–	0.012	0.746	0.267	0.079	1.939	0.875	–
WOTR	42.540	2.149	9.828	16.580	–	0.029	2.207	0.086	0.161	2.069	1.368	–

¹Outside species' known distribution

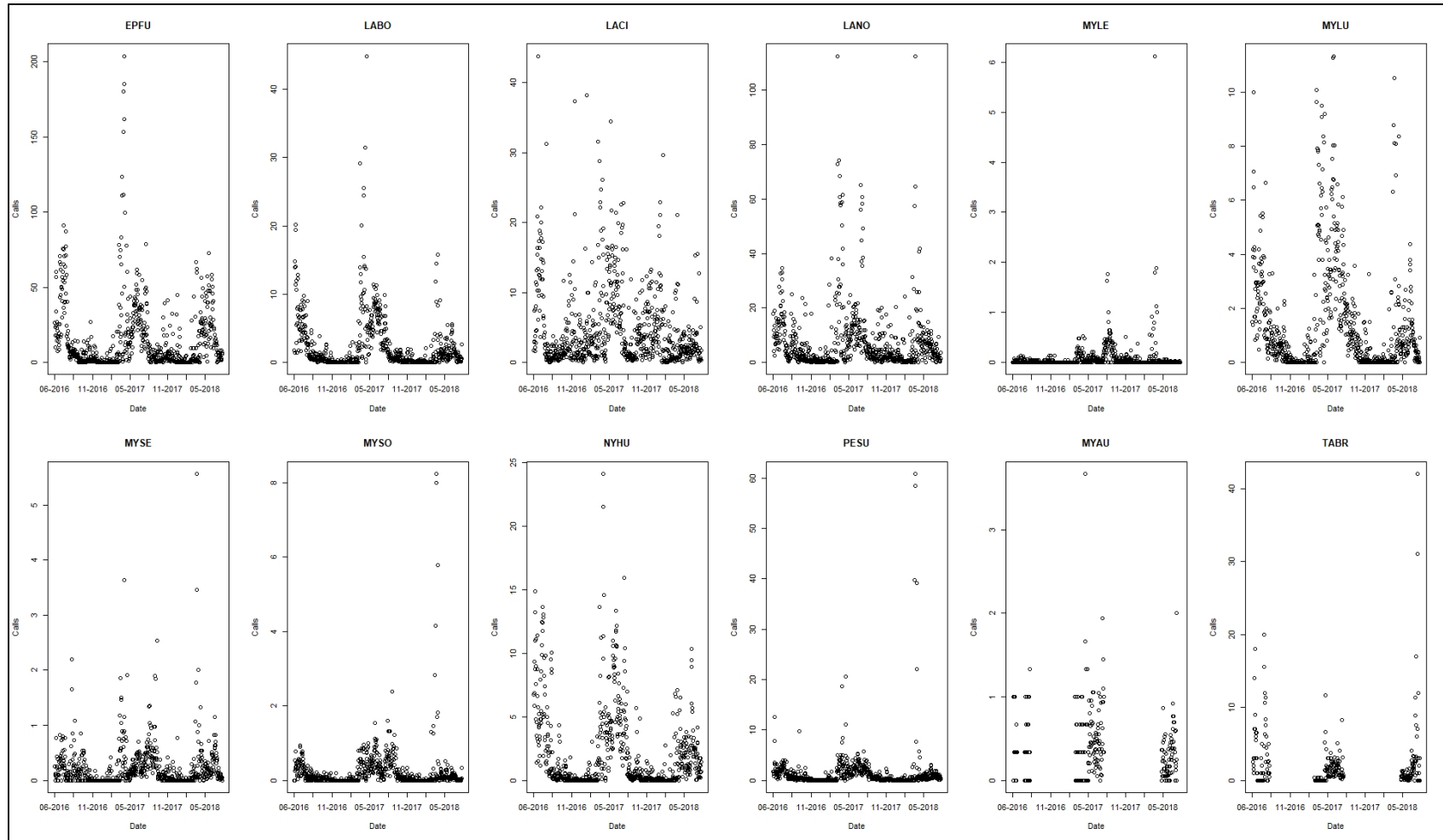


Figure 4. Mean echolocation calls per night for all species surveyed within the National Capital Region from June 2016 – August 2018. Hash marks on the x axis are at 90 day points over the survey duration. Species abbreviations are defined in Figure 1.

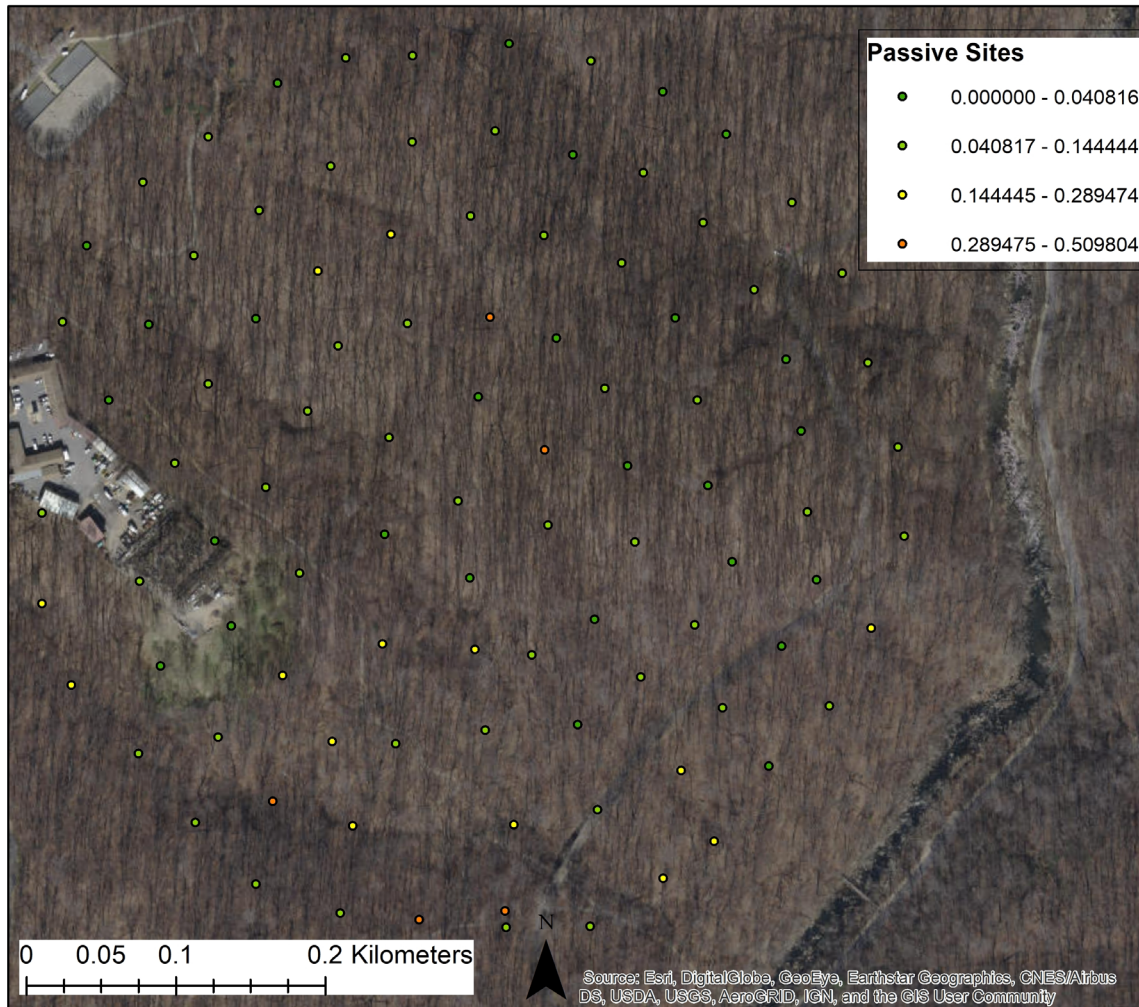


Figure 5. Passive acoustic recording sites from Rock Creek Park's fine-scale habitat use assessment from sample nights between 15 May and 14 August 2018. Colors indicate the proportion of sample nights with northern long-eared bat (*Myotis septentrionalis*) presence throughout the sampling period. Note that due to deployment dates and equipment failure, not all sites sampled for the same period.

Table 4. Top occupancy models ($\Delta AIC < 2$) for northern long-eared bat (*Myotis septentrionalis*). Abbreviations include: FDI = fractal dimension index, Precip = amount of precipitation on acoustic night.

Year	Detection	Occupancy	AIC	ΔAIC	AIC weight
2016	NULL	Latitude	685.30	0	0.08
	NULL	Developed area (100 m) + Latitude	686.33	1.03	0.05
	Precip	Latitude	686.65	1.36	0.04
	Julian	Latitude	686.82	1.52	0.04
	NULL	NULL	686.85	1.56	0.04
	NULL	Forest FDI (500 m) + Latitude	686.95	1.65	0.03
	NULL	Developed area (1 km) + Latitude	687.28	1.98	0.03
	NULL	Longitude	687.28	1.99	0.03
2017	Julian	Developed area (100 m) + Latitude	2212.48	0	0.32
	Julian	Developed area (100 m) + Forest FDI (500 m) + Latitude	2214.48	2.00	0.12

Netting Surveys

We had 222 netting sample nights across all units (ANTI = 5, CATO = 11, CHOH = 28, GWMP = 22, HAFE = 11, MANA = 4, MONO = 4, NACE = 10, NAMA = 1, PRWI = 33, ROCR = 88, WOTR = 4; Figure 6; Deeley et al. 2020b). We captured 1,394 bats (including recaptures): big brown = 1,162; eastern red = 165; eastern small-footed = 1; evening = 5; hoary = 3; little brown = 3; northern long-eared = 37; silver-haired = 16; and tri-colored bats = 2 (Appendix A). We documented three species highly-impacted by WNS: northern long-eared bats (CATO = 1, ROCR = 29, PRWI = 5), little brown bats (CHOH = 3), and tri-colored bats (CHOH = 1, ROCR = 1; Figure 7; Deeley et al. 2020b). We captured all species captured pre-WNS and 3 species that were not captured during pre-WNS sampling: eastern small-footed, evening, and silver-haired bats. Similar to our active acoustic results, unit-level netting species richness was negatively impacted due to the absence of little brown, northern long-eared, and tri-colored bats (Table 2).

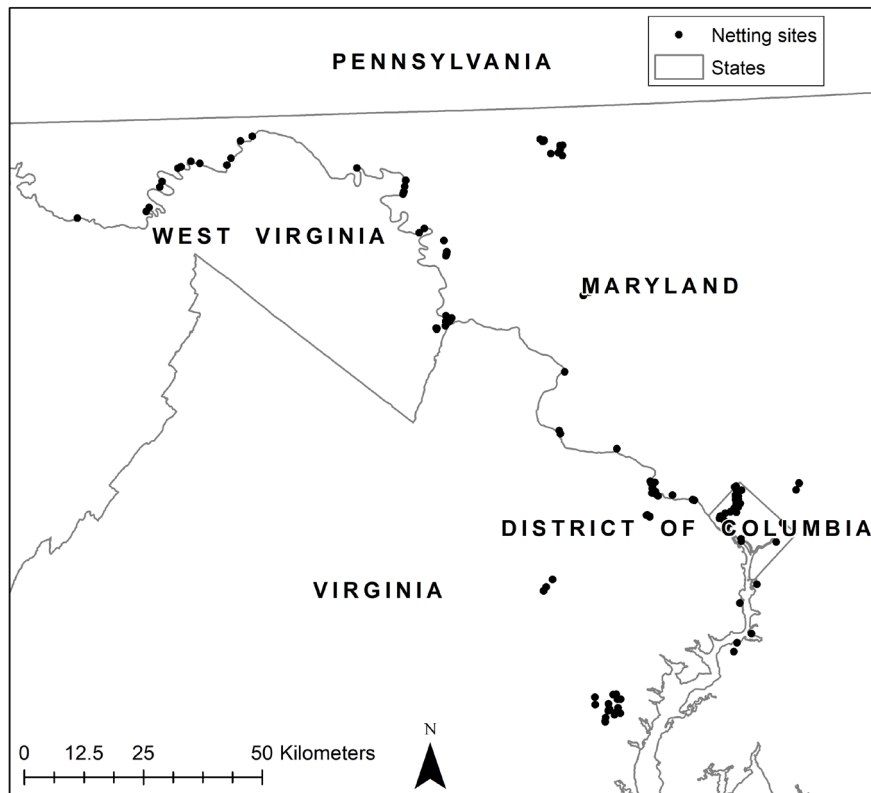


Figure 6. Locations of mist netting 2016 – 2018 National Capital Region. (District of Columbia Department of Energy and Environment netting locations not shown).

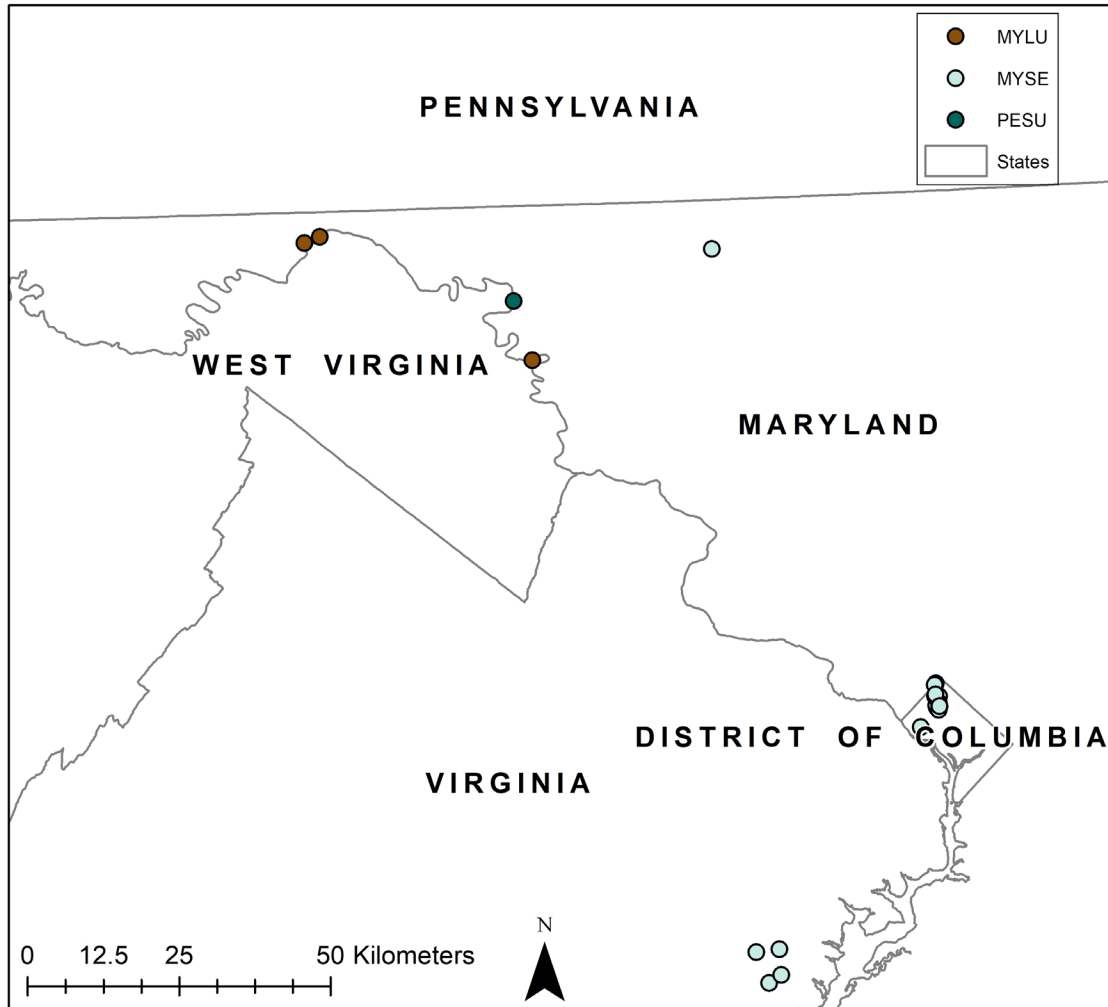


Figure 7. Mist netting capture locations 2016 – 2018 of little brown (*Myotis lucifugus*; MYLU), northern long-eared (*Myotis septentrionalis*; MYSE), and tri-colored bat (*Perimyotis subflavus*; PESU) within the National Capital Region.

Objectives 2 and 3

We surveyed 174 sites in CHOH, GWMP, MANA, NACE, PRWI, and ROCR for 18,288 nights from 15 August 2016 – 14 May 2017 and 15 August 2017 – 14 May 2018. We documented calls from big brown ($n = 191,366$), eastern red ($n = 24,900$), eastern small-footed ($n = 1,598$), evening ($n = 18,363$), hoary ($n = 70,725$), Indiana ($n = 3,872$), little brown ($n = 17,929$), Mexican free-tailed ($n = 4,426$), northern long-eared ($n = 4,360$), silver-haired ($n = 122,439$), southeastern myotis ($n = 1,107$), and tricolored ($n = 20,172$) bats. More eastern small footed echolocation calls were recorded in this period than in the USFWS summer survey period. Big brown, hoary, and silver haired bats had the highest mean echolocation calls across all the units (Table 5). CHOH had the highest mean echolocation calls for northern long-eared, Indiana bats, little brown, and tricolored bats. Though most activity occurred during the fall and winter period surrounding the USFWS periods, we did document year-round activity for all 6 units (Appendix B; Deeley et al. 2020a). All species had nights with presence within the non-summer months (Appendix B).

Table 5. Mean echolocation calls per site-night for all bat species surveyed within each NPS National Capital Region park 15 August 2016–14 May 2017 and 15 August 2017 – 14 May 2018. Unit abbreviations are in Figure 1. Species abbreviations are defined in Table 1.

Unit	EPFU	LABO	LACI	LANO	MYLE	MYLU	MYSE	MYSO	NYHU	PESU
CHOH	25.274	2.476	4.152	9.814	0.478	2.660	0.712	0.979	2.116	4.156
GWMP	2.848	0.414	8.638	7.894	0.004	0.158	0.024	0.021	0.315	0.166
MANA	9.542	2.015	3.509	7.645	0.009	0.897	0.017	0.072	1.160	0.365
NACE	7.126	1.302	1.001	3.011	0.003	0.546	0.014	0.044	0.403	0.165
PRWI	0.694	1.820	1.535	4.364	–	1.332	0.354	0.093	1.132	0.961
ROCR	12.536	0.770	5.126	8.231	0.009	0.524	0.235	0.044	1.039	0.650

Fall, winter, and spring activity of migratory bats

All D.C.-area units were monitored for two overwinter periods, although not every park was sampled equally for each period (Deeley et al. 2020a). Activity within each surveyed unit indicated evidence of some migration activity (Appendix B; Deeley et al. 2020a). Straddling the Piedmont and Coastal Plain, PRWI has the lowest amount of forest fragmentation compared to other Coastal Plain areas, which may explain the low big brown bat fall and spring activity.

Survey winter hibernacula

We passively sampled 25 CHOH sites during portions of the overwinter periods, 14 of which were near potential hibernacula. Near some of these potential hibernacula, we recorded echolocation calls indicating overwinter arousal, especially for big brown, hoary, and silver-haired bats (Appendix C). Though eastern small-footed bat calls occurred at multiple sites, IN-NR1-ACT trends indicate that multiple bats may be using the tunnel and emerging throughout the winter. We also noted differences in activity on opposite ends of CHOH railroad tunnels (e.g., IN-NR1-ACT and IN-NR2-ACT), though some variation may be due to detector placement.

Objective 4

NABat inclusion

We used summer passive acoustic sites to evaluate NCR NABat grid cells for future monitoring. Shannon-Wiener indices were highly site and grid specific: proximal locations did not always have similar indices (Figure 8; Appendix D). Western CHOH had the highest density of high-value index grids and grid-level mean proportion of nights with presence for Indiana, little brown, northern-long eared, and tricolored bats (Figure 8; Appendices D and E).

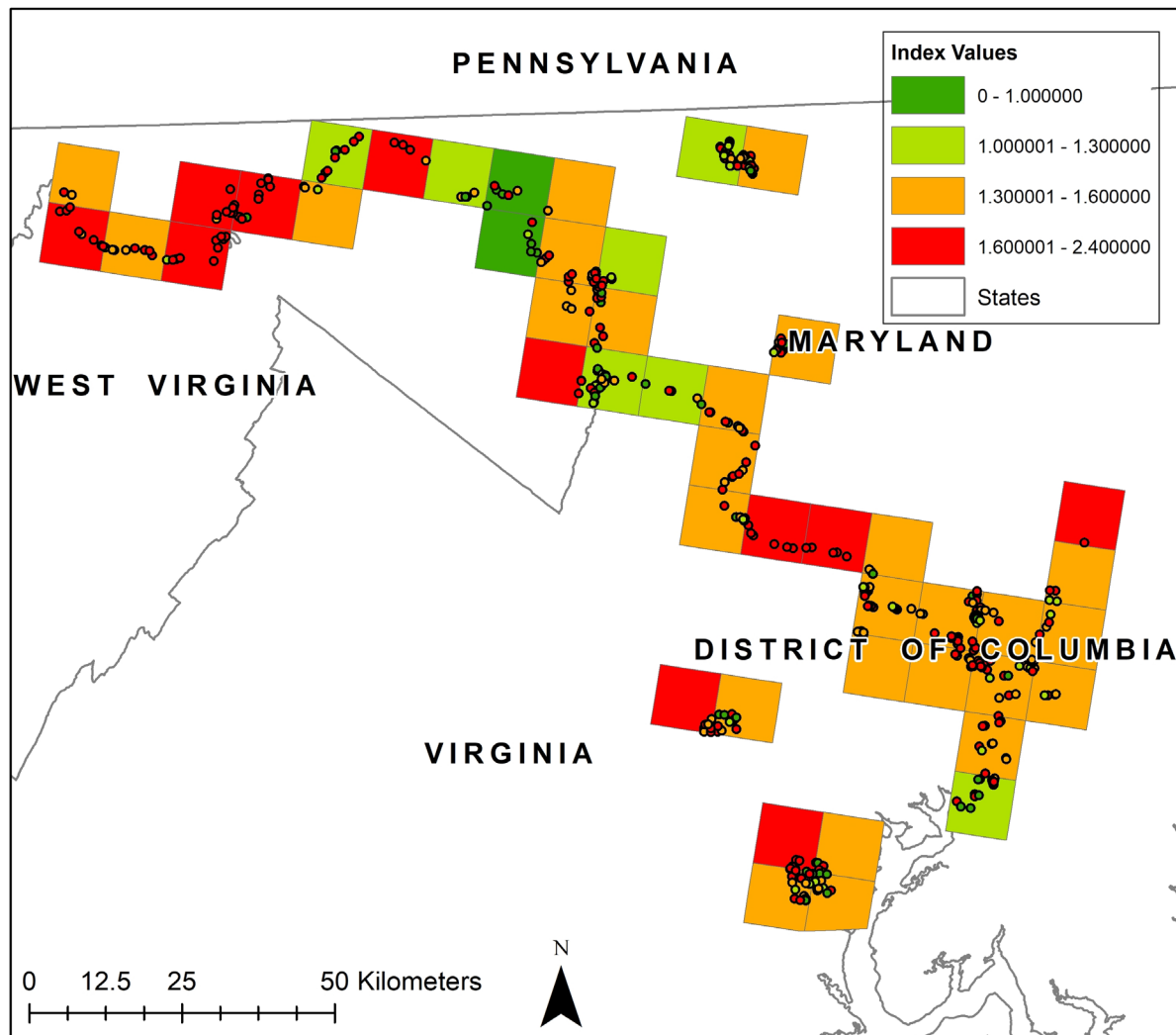


Figure 8. Passive acoustic sites (dots) and North American Bat (NABat) grid cells (squares) with associated Shannon-Weiner Index for biodiversity based on echolocation calls from 15 May – 14 August 2016 – 2018 within the National Capital Region.

The level of effort required to document the presence or absence of species highly-impacted by WNS were higher for our 2016 data set than our 2017 data set (Table 6). Since we sampled fewer sites for longer in 2016 than 2017 with correspondingly higher detection opportunity at a site, the 2016 probability of detection (p) was lower and probability of occupancy higher (Ψ) than the 2017 values. Regardless of year, the minimum effort to detect any of these species at 95% confidence was over 8 nights.

Table 6. Level of Effort (LOE) required to detect 4 bat species: little brown (*Myotis lucifugus*; MYLU), Indiana (*Myotis sodalis*; MYSO), northern long-eared (*Myotis septentrionalis*; MYSE), and tri-colored bat (*Perimyotis subflavus*; PESU). We calculated the probability of detection (p) and occupancy (Ψ) using the null models in package *vegan* in program R (Oksanen et al. 2015); those values were used to determine level of effort, as provided by Wintle et al. (2012). Nightly presence was based on $MLE < 0.05$. The LOE (0.05) indicates effort required to detect species at 95%, and the LOE (0.10) indicates effort required to detect species at 90% confidence.

Species	Year	LOE (0.05)	LOE (0.10)	p	Ψ
MYLU	2016	16.51	13.00	0.19	0.64
	2017	8.10	6.09	0.31	0.52
MYSE	2016	26.51	19.95	0.11	0.52
	2017	14.12	9.18	0.14	0.31
MYSO	2016	22.01	14.43	0.09	0.32
	2017	8.52	4.71	0.18	0.22
PESU	2016	12.11	9.74	0.27	0.71
	2017	10.53	8.42	0.30	0.69

Objective 5

Day roosts for species of interest

Due to timing of captures, signal interference, and transmitter loss in the ROCR landscape, we were not able to fully document maternity colony dynamics. However, we did document 30 northern long-eared bat roost tree locations and conduct 24 exit counts (Appendix F). In 2016, we were able to track two females with one overlapping roost location, and document 8 bats emerging from a roost used by one of the bats. We calculated a minimum convex polygon in ArcGIS 10.5 for all four roosts; the total day-roost area was 1.85 ha (Figure 9).

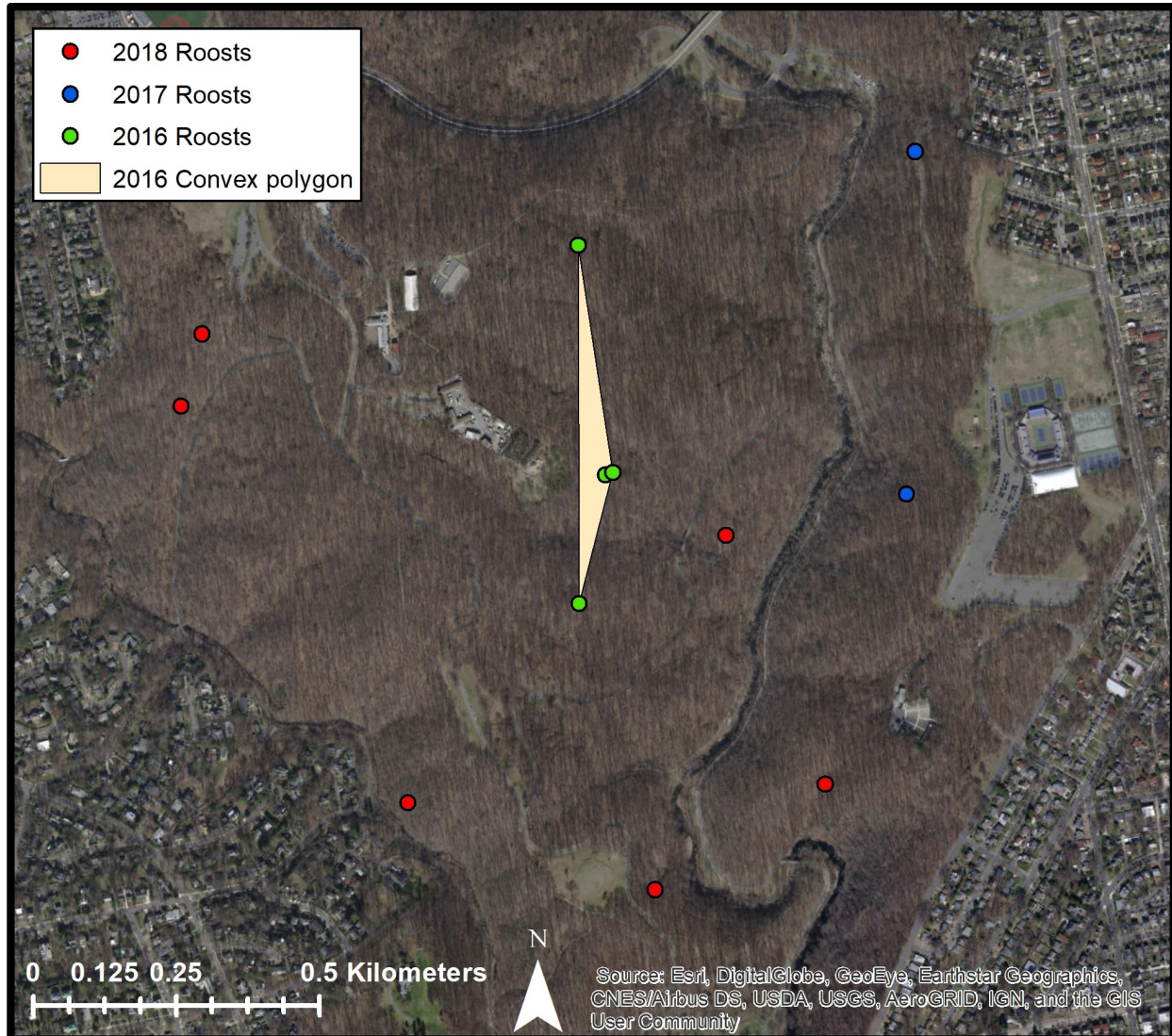


Figure 9. Minimum convex polygon (light brown triangle) for four roosts (green circles) used by two female northern long-eared bat (*Myotis septentrionalis*) in 2016. One 2016 roost tree was within the polygon. Nearby roost locations are red (2018) and blue (2017) circles.

Observed roosts appeared to be used for short periods, and most often the observed bats were roosting alone. Despite low numbers of roosts, our capture of juvenile northern long-eared bats throughout ROCR and PRWI indicate that they are successfully reproducing within or in proximity to those parks. Almost all roosts were within trees, though there was at least one instance of two bats roosting together within a Maryland house (Appendix F). Typical of the generalized day-roost habits of northern long-eared bats, roosts had no uniform characteristics: the bats used trees and snags (large and small boles of each), bark and crevices, and multiple tree species (Appendix F). Additionally, we tracked a tri-colored bat captured in CHOH to a roosting area on private land adjacent to CHOH (Appendix F). Though we were unable to identify the exact roost tree, we documented several bats leaving trees within the roosting area within the same period as the bat with the transmitter, indicating the possibility of a maternity colony.

Eastern small-footed bat crevice searches

We documented eastern small-footed bats throughout the region with passive acoustics (Deeley et al. 2020a) but only captured one eastern small-footed bat at the Stickpile Tunnel (CHOH; Deeley et al. 2020b). We conducted crevice surveys across 25 days in CATO, CHOH, HAFE, GWMP, and ROCR. We observed no eastern small-footed bats therein (Deeley et al. 2020b).

Objective 6

Multi-partner data integration

Capture information from northern-long eared bats from this survey were incorporated in an assessment of presence and detection throughout the mid-Atlantic and Northeast (De La Cruz et al. 2019). The survey determined that northern long-eared bat day-roosts were isolated, and that surviving reproducing populations may be persisting in areas with higher fragmentation relative to colonies in pre-WNS environments, due to higher likelihood of encounters (De La Cruz et al. 2019).

Discussion

Big brown bats

Big brown bats are distributed from southern Canada through northern South America, and are often found in both natural and anthropogenically-altered habitats, including urbanized areas (Kurta and Baker 1990). They overwinter in groups or singly in man-made structures and caves, sometimes arousing from hibernation throughout the winter (Kurta and Baker 1990). These bats consume a range of insects, though based on their powerful jaw structure and diet studies, they are believed to prefer beetle species (Agosta 2002). Their total length ranges from 87 to 138 mm, and they can weigh 11 – 23 g (Kurta and Baker 1990). During the non-hibernating season, big brown bats can day-roost in tree cavities, under exfoliating bark and a wide array of anthropogenic structures (Beer 1955; Whitaker and Gummer 1992).

We documented their presence with passive acoustics and mist netting within every park. With passive acoustics, we recorded the highest numbers of big brown bat calls in our most fragmented units near D.C. and the least number of calls in MONO and PRWI. We captured more big brown bats than any other bat, both within the region and every unit. Big brown bats were common throughout the study area, and we documented reproduction within every unit except NAMA. Our comparison of pre- and post-WNS active acoustics indicate that these populations may be increasing throughout the region, as has been noted in other post-WNS landscapes in eastern North America (Frank et al. 2014; Pettit and O’Keefe 2017).

Eastern red bats

Eastern red bats occur from southern Canada through South America and, rather than hibernate, typically they migrate to overwintering areas south of the Ohio River Valley (Shump and Shump 1982a). Eastern red bats typically weigh 7–13 g and are 77–117 mm long, and their body form allows them to fly fast with moderate maneuverability (Shump and Shump 1982a; Menzel et al. 2003). They largely day-roost in deciduous tree foliage (Barbour and Davis 1969; Shump and Shump 1982a; Menzel et al. 2003).

We documented eastern red bats presence with passive acoustics within every unit. They were most common in CHOH and least common in ROCR. Eastern red bats were the second-most captured bat within all units except NACE and WOTR. We documented reproduction in all units except CATO. Their distribution and populations do not appear to have changed since the previous survey. Our fall passive acoustics did not indicate strong migration patterns within the NCR, though the number of nights with presence decreased after August and increased in early spring.

Eastern small-footed bats

The eastern small footed bats typically occupy mountainous or hilly areas with emergent rock features from southeastern Canada through north Georgia, and west to Oklahoma (Best and Jennings 1997). Regionally, they roost within rock crevices in summer and caves and mines in winter (Johnson et al. 2009), though it appears some individuals overwinter in large talus slopes in nearby Shenandoah National Park and George Washington National Forest, Virginia (Mooseman et al. 2020;

N. Kalen, Virginia Tech, personal communications). They are the smallest bat in the area, with a total length of approximately 83 mm and weight of 3–6 g (Best and Jennings 1997).

The rarest species recorded with passive acoustic monitoring, eastern small-footed bats were recorded in all sites except NAMA (and PRWI, where we did not survey for them). Unsurprisingly, call activity was highest in units with many potential rock crevices: CATO, CHOH, HAFE, and GWMP. We had no evidence of reproduction within the area based on our single capture (CHOH). As we documented eastern small-footed bats within the study area through acoustics and mist netting but not rock surveys, we recommend that further surveys be conducted with acoustics or mist-netting within likely habitat, especially at CATO, northern CHOH and HAFE.

Evening bats

Evening bats can occur from southeastern Pennsylvania to Florida and west to Texas and northern Mexico (Watkins 1972). They typically day-roost in trees (cavities or exfoliating bark) as well as anthropogenic structures (Menzel et al. 2000). Evening bats body size typically ranges between 88 and 105 mm and weigh approximately 8 g (Watkins 1972; Menzel et al. 2003).

Passive acoustic results indicate that evening bats are most common within CHOH. Based on condition of individuals captured, reproduction is likely within both CHOH and GWMP, the only two locations they were captured. These bats had been recorded with active acoustics pre-WNS, but not captured. We also had low post-WNS capture rates: we netted heavily within GWMP and along the CHOH and only captured the species on one night within each unit. Though it is unclear whether evening bats' populations have increased within the NCR, the region is within the northern edge of the species' range and should be monitored for future distribution changes.

Hoary bats

Hoary bats can occur from northern Canada through South America and Hawaii, though there are more common west of the NCR (Shump and Shump 1982b). They are fast flyers which engage in long-distance migration, often in groups (Shump and Shump 1982b). In the summer and in overwintering areas, they often roost alone in tree foliage (Shump and Shump 1982b; Menzel et al. 2003; Jorge et al. 2020). Hoary bats are the largest species within the NCR: their body length can exceed 134 mm, and they can weigh 20–35 g (Shump and Shump 1982b).

We acoustically documented hoary bats at every unit, though the highest summer mean echolocation calls were in NAMA. Highest passive acoustic activity occurred in the spring and summer periods, and passive acoustics indicate that increased presence within PRWI in October. Similar to the pre-WNS survey, our captures were low.

Indiana bat

Indiana bats are typically found in areas with large limestone caves, but can occur within the northeast and Mid-Atlantic, west to Missouri (Thomson 1982). Their body size is around 85 mm, weighing approximately 7 g (Glass and Ward 1959; Thomson 1982). They usually overwinter in small to large numbers within caves and mines and day-roost in the summer in trees or snags,

typically under exfoliating bark and in trees with high solar exposure (Silvis et al. 2016). Their roosts are often within trees with high solar exposure (Britzke et al. 2003; Silvis et al. 2016).

Similar to the pre-WNS survey, we acoustically detected Indiana bats but failed to capture them. The passive acoustic data indicate that their calls were often recorded within CHOH. It is important to note that the area is bracketed by documented pre-WNS Indiana bat maternity colonies to the northeast in Carroll County, Maryland and then post-WNS in Caroline County, Virginia (Germain et al. 2017). Though greatly reduced by WNS impacts, continued surveys for their summer presence in the area should be a priority.

Little brown bats

Little brown bats are distributed throughout North America. They typically range from 4 to 9 g and 80 – 95 mm in length (Menzel et al. 2003). In summer, they roost in buildings, trees, snags, emergent rock and caves, and in winter, they mostly use caves and mines (Fenton and Barclay 1980). Passive acoustic results indicate that little brown bats are most likely to reside in CHOH, and the highest means of the proportion of nights with presence at the NABat grid-level were in the western CHOH, where we also captured them. Though our netting failed to provide evidence of successful little brown bat reproduction, the presence of two females within a small area may indicate colonies within foraging range of CHOH. Additionally, though not captured there, the NABat-level grids indicate relatively high acoustic presence in the northern portions of PRWI. Future little brown bat research should focus on these portions of the NCR and adjacent state and private lands to determine whether they are forming maternity colonies.

Little brown bat abundance and distribution throughout the NCR has decreased significantly since WNS: once the second-most commonly captured bat within the region, it is now the sixth most commonly captured species. We caught < 2% of the number captured pre-WNS with more netting events and higher average number of nets per event. Equivalent decreases are found throughout the Northeast (Dzal et al. 2011; Moosman et al. 2013; Nocera 2018), and therefore the capture of females (even non-reproductive) within the CHOH is noteworthy not just within the NCR units, but within the entire mid-Atlantic and Northeast.

Mexican free-tailed bats

Mexican free-tailed bats reside from central Virginia through South America and can range from 90 to 102 mm in length and weigh 9–15 g (Wilkins 1989). They typically roost in man-made structures or within large caves (Wilkins 1989). Mexican free-tailed bats are fast fliers that can migrate over the winter, rather than hibernating (Wilkins 1989).

Mean Mexican free-tailed bat calls were higher in MANA than PRWI, though numbers of calls and nights with presence were low within both units. Despite evidence of northern expansion within Virginia (McCracken et al. 2018; R. Reynolds, Virginia Department of Game and Inland Fisheries, personal communications; M. St Germain, Virginia Polytechnic Institute and State University, personal communications), we did not capture any of these species in our mist-netting effort. The NCR is likely north of most of the recently expanded distribution of these species, though continued monitoring seems warranted.

Silver-haired bats

Silver-haired bats occur from southeastern Alaska to California and from southern Canada through Georgia, and into the northern portions of Mexico (Kunz 1982). They range in size from 92 to 155 mm and weigh 8–11 g (Kunz 1982). Often roosting alone in the summer and the winter, they typically summer in trees and overwinter in caves, mines, trees, rock crevices, and buildings (Kunz 1982).

With passive acoustics, we documented silver-haired bats within all units. We were also able to capture them in CHOH, GWMP, PRWI, and ROCR, where pre-WNS they were only able to document acoustically (Gates and Johnson 2005). However, we did not document any evidence of reproduction, and most of the ROCR and PRWI captures were early in the summer season and therefore represent migratory populations. This capture pattern is similar to that found at Fort A.P. Hill, southeast of D.C. (M. St Germain, Virginia Polytechnic Institute and State University, personal communications). Though most silver-haired bats were captured in ROCR, overall there were relatively low mean numbers of calls. Fragmented and open units had the highest mean echolocation calls, with the highest number of calls in NAMA. Fall passive acoustics indicated relatively higher presence within the D.C. area in August than in the western portions of the study area; in October, western locations began to have similar relative presence.

Northern-long eared bats

Northern long-eared bats can occur from northern Canada to Florida and west to Wyoming (Caceres and Barclay 2000). They typically spend the summer in trees and snags and occasionally man-made structures, and they overwinter with other bats in caves or mines or trees and snags in the South where temperatures permit (Silvis et al. 2016). The body length of northern long-eared bats is typically less than 95 mm, and they weigh 5–9 g (Caceres and Barclay 2000). Their body form makes them one of the most maneuverable bats and enables gleaning prey off of vegetation (Caceres and Barclay 2000).

Based on mist-net captures, we determined that this species occurs throughout most of ROCR and PRWI, and we found evidence of successful reproduction across multiple summers. All our ROCR northern-long eared captures were within NABat grid cells with relatively high mean proportions of nights with presence, as was our CATO capture. However, we captured them throughout PRWI, despite lower grid values in the southern portions of the unit. Though we captured most of our northern long-eared bats in ROCR, the unit had a low mean echolocation call value, potentially a reflection of reduced post-WNS numbers as well as their low amplitude echolocation characteristics which biases acoustic sampling (Silvis et al. 2016). These results may also be due to our acoustic sampling of small, fragmented parks and urban sites within ROCR, areas we typically did not mist net.

Recent winter northern long-eared bat captures in eastern coastal areas (Ecological Engineering 2016; Grider et al. 2016; Hawkings et al. 2017; North Carolina Division of Parks and Recreation 2019), identifying that not all northern long-eared bats in the lower mid-Atlantic migrate hibernacula to the west to traditional hibernacula in the Appalachians Mountains. Our passive acoustic results indicate possible overwinter presence within PRWI and ROCR, and we did not document evidence

of WNS wing-scarring on northern long eared bats indicative of previous winter infection, indicating that individuals may be residing in the ROCR area or migrating to non-traditional hibernacula. Our capture of a northern long-eared bat 1 November 2019 lends additional evidence to this supposition.

Due to successful reproduction within PRWI and the larger contiguous areas of ROCR, any tree clearing activities during the maternity season should be closely reviewed to prevent harm to maternity colonies. We documented captures and day roosts throughout the units, especially within ROCR. In both units, we documented juveniles without identifying their originating maternity colonies. Therefore, though the USFWS 4(d) rule addresses placing buffers around known maternity roosts (Department of the Interior: Fish and Wildlife Serv 2015), we suggest assuming that maternity colonies may be present at any location within the PRWI and ROCR. Additionally, due to possible hibernation within the units, we suggest caution in overwinter tree removal and that anthropogenic structures such as cisterns, culverts and basements be examined before any management action proceed during that time.

Tri-colored bats

Tricolored bats occur from Kansas east throughout Canada, United States, and Mexico (Fujita and Kunz 1984). They are typically 77–89 mm, weighing approximately 4–8 g (Fujita and Kunz 1984). In the summer, tricolored bats day-roost in trees, caves, rock crevices and man-made structures (Fujita and Kunz 1984, Silvis et al. 2016). Overwinter, they typically roost in small groups in caves, mines, culverts, and other man-made structures similar to myotis in this region (Menzel et al. 2002) as well as in trees in the South (Silvis et al. 2016).

Mean echolocation calls for tricolored bats were highest in CHOH, followed by PRWI and GWMP. Mean echolocation calls were low in ROCR, though we captured them within the unit and have no evidence of reproduction. We documented evidence of reproduction near CHOH. Though this capture was within a NABat grid with a relatively-low mean proportions of nights with presence, it was adjacent to a relatively-high grid cell. We also note that a male tricolored bat was captured in Marine Corps Base Quantico, which borders PRWI (S. Freeze, Virginia Tech, unpublished data). We documented 6% of the number of individuals that were captured pre-WNS, therefore the identification of potential maternity colony adjacent to CHOH is of interest and importance to future conservation efforts. Future tri-colored bat research should focus on these CHOH, and adjacent state and private lands, to find and track maternity colonies.

Southeastern myotis

Southeastern myotis bats are distributed throughout the Southeast, primarily in the Coastal Plain and the Mississippi River Valley (Menzel et al. 2002). They are typically 77–97 mm and weigh 5.2–8.1 g (Jones and Manning 1989). Both in summer and winter, they often roost in caves, mines, buildings and trees, and they are sometimes found roosting with other species (Jones and Manning 1989; Carver and Ashley 2008). Overall, we recorded low numbers of echolocation calls within PRWI, therefore the NCR is likely still largely out of the southeastern myotis distribution, though continued monitoring should continue.

Conclusions

Our acoustic and mist netting results indicate that the bat species documented pre-WNS are still present today. However, the numbers and distributions of little brown, northern long-eared and tri-colored bats have declined throughout the region. Once found throughout the study area, these species were captured in localized areas and only after much higher mist-netting efforts.

Additionally, though we captured little brown and tri-colored bats, we documented no evidence of successful reproduction (i.e., juveniles) of either WNS-impact species. We documented successful northern long-eared bat reproduction, but only within ROCR and PRWI. These locations are significant, as within the Mid-Atlantic, reproduction has rarely been documented in recent years, especially over multiple years (Ecological Engineering 2016; Deeley and Gorman 2018; Dowling and O'Dell 2018).

We documented the highest species richness in western CHOH both with netting and NABat-grid level acoustic presence. Overall, NCR units lost species richness due to the absence of little brown and tricolored bats. We documented those species and northern long-eared bats in fewer units with active acoustics and mist netting results. To a lesser extent, a reduction in the distribution of northern long-eared bats decreased unit-level active acoustic and mist netting richness. Though the distribution of big brown bats does not appear to have changed, we note that there may be an increase in their regional numbers.

Our passive acoustics have indicated the presence of all 12 species within the units for which they were sampled, except eastern small-footed bats in NAMA. However, nightly presence based on MLE does not necessarily mean that the bats are residing within the unit nor reproducing. When trying to determine which sites to sample for ongoing monitoring (whether NABat or otherwise), units should take into account sampling effort within each sample site, grid, and the unit. Moreover, our LOEs for passive sites were high, indicating that passive acoustic monitoring should occur for longer periods than the current USFWS and NABat guidelines suggest, and that driving transects will likely be unsuccessful in documenting the full bat communities of an area. Site-level Shannon-Weiner Diversity indices and total nights with presence verses sampling effort for each species can be used to determine long-term NABat site-selection. Additionally, based on monitoring objectives, species presence and reproductive status from netting may provide managers insight into possible new sites.

Literature Cited

- Agosta, S. J. 2002. Habitat use, diet and roost selection by the big brown bat (*Eptesicus fuscus*) in North America: a case for conserving an abundant species. *Mammal Review* 32:179-198.
- Alves, D. M. C. C., L. C. Terribile, and D. Brito. 2014. The potential impact of White-nose syndrome on the conservation status of North American bats. *PLoS ONE* 9:e107395.
- Barbour, R. W., and W. H. Davis. 1969. *Bats of America* (Vol. 7). University Press of Kentucky Lexington.
- Beer, J. R. 1955. Survival and movements of banded big brown bats. *Journal of Mammalogy* 36:242–248.
- Best, T. L., and J. B. Jennings. 1997. *Myotis leibii*. *Mammalian Species* 1–6.
- Britzke, E. R., E. H. Gillam, and K. L. Murray. 2013. Current state of understanding of ultrasonic detectors for the study of bat ecology. *Acta Theriologica* 58:109–117.
- Britzke, E. R., M. J. Harvey, and S. C. Loeb. 2003. Indiana bat, *Myotis sodalis*, maternity roosts in the southern United States. *Southeastern Naturalist* 2:235–242.
- Caceres, M. C., and R. M. R. Barclay. 2000. *Myotis septentrionalis*. *Mammalian Species* 1–4.
- Carver, B. D., and N. Ashley. 2008. Roost tree use by sympatric Rafinesque's big-eared bats (*Corynorhinus Rafinesquii*) and Southeastern Myotis (*Myotis austroriparius*). *The American Midland Naturalist* 160:364–373.
- Coleman, L. S. 2013. Assessing the impacts of White-nose syndrome induced mortality on the monitoring of a bat community at Fort Drum Military Installation (M.S. Thesis). Virginia Polytechnic Institute and State University, Blacksburg, VA, USA.
- Coleman, L. S., W. M. Ford, C. A. Dobony, and E. R. Britzke. 2014. A comparison of passive and active acoustic sampling for a bat community impacted by White-nose syndrome. *Journal of Fish and Wildlife Management* 5:217–226.
- De La Cruz, J. L., S. Deeley, M. S. Muthersbaugh, S. Freeze, and Silvis, Alexander. 2019. Occupancy and detection probability of northern long-eared bats and other WNS-impacted species in the northeastern United States. U.S. Fish and Wildlife Service, Hadley, MA.
- De La Cruz, J. L., R. L. Ward, and E. S. Schroder. 2018. Landscape characteristics related to use of artificial roosts by northern long-eared bats in north-central West Virginia. *Northeastern Naturalist* 25:487–501.
- Deeley, S., and K. Gorman. 2018. 2018 Post-WNS Bat Surveys in Gettysburg National Military Park Interim Report, Contract # P17AC01524 (Interim).

- Deeley, S., S. Freeze, and L. Rohrbaugh. 2020a. Part 1. Post-White-nose syndrome bat communities in the national capital region. Natural Resource Report, National Park Service, Fort Collins, Colorado
- Deeley, S., S. Freeze, and L. Rohrbaugh. 2020b. Part 2. Post-White-nose syndrome bat communities in the national capital region. Natural Resource Report, National Park Service, Fort Collins, Colorado
- Department of the Interior: Fish and Wildlife Serv. 2015. Listing the northern long-eared bat with a rule under section 4(d) of the Act. Federal Register.
- Dobony, C. A., A. C. Hicks, K. E. Langwig, R. I. von Linden, J. C. Okoniewski, and R. E. Rainbolt. 2011. Little brown myotis persist despite exposure to White-nose syndrome. *Journal of Fish and Wildlife Management* 2:190–195.
- Dowling, Z. R., and D. I. O'Dell. 2018. Bat use of an island off the coast of Massachusetts. *Northeastern Naturalist* 25:362–382.
- Dzal, Y., L. P. McGuire, N. Veselka, and M. B. Fenton. 2011. Going, going, gone: The impact of White-nose syndrome on the summer activity of the little brown bat (*Myotis lucifugus*). *Biology Letters* 7:392–394.
- Ecological Engineering. 2016. Protected bat species survey report: Northern long-eared bat research project eastern North Carolina survey phase 1, sessions 1 & 2: fall 2015 and winter 2016 (TIP No. R-9999 WBS No. 34634.1.4). Cary, North Carolina.
- Fenton, M. B., and R. M. R. Barclay. 1980. *Myotis lucifugus*. *Mammalian Species* 1–8.
- Fischer, J., J. Stott, B. S. Law, M. D. Adams, and R. I. Forrester. 2009. Designing effective habitat studies: Quantifying multiple sources of variability in bat activity. *Acta Chiropterologica* 11:127–137.
- Fiske, I., and R. Chandler. 2011. unmarked: An R package for fitting hierarchical models of wildlife occurrence and abundance. *Journal of Statistical Software* 43:1–23.
- Ford, W. M., E. R. Britzke, C. A. Dobony, J. L. Rodrigue, and J. B. Johnson. 2011. Patterns of acoustical activity of bats prior to and following White-nose syndrome occurrence. *Journal of Fish and Wildlife Management* 2:125–134.
- Ford, W. M., M. A. Menzel, J. L. Rodrigue, J. M. Menzel, and J. B. Johnson. 2005. Relating bat species presence to simple habitat measures in a central Appalachian forest. *Biological Conservation* 126:528–539.
- Francel, K. E., W. M. Ford, D. W. Sparks, and V. Brack. 2012. Capture and reproductive trends in summer bat communities in West Virginia: Assessing the impact of White-nose syndrome. *Journal of Fish and Wildlife Management* 3:33–42.

- Frank, C. L., A. Michalski, A. A. McDonough, M. Rahimian, R. J. Rudd, and C. Herzog. 2014. The Resistance of a North American Bat Species (*Eptesicus fuscus*) to White-nose syndrome (WNS). (M. L. Baker, ed.) PLoS ONE 9:e113958.
- Fujita, M. S., and T. H. Kunz. 1984. *Pipistrellus subflavus*. Mammalian Species Archive 228:1–6.
- Gates, J. E., and J. B. Johnson. 2005. Bat inventories of the national capital region parks (Final Report No. TIC#: D–59). University of Maryland Center for Environmental Sciences, Frostburg, Maryland.
- Germain, M. J. St., A. B. Kniewski, A. Silvis, and W. M. Ford. 2017. Who Knew? First *Myotis sodalis* (Indiana bat) maternity colony in the coastal plain of Virginia. *Northeastern Naturalist* 24.
- Glass, B.P. and Ward, C.M., 1959. Bats of the genus *Myotis* from Oklahoma. *Journal of Mammalogy*, 40(2):194-201
- Grider, J. F., A. L. Larsen, J. A. Homyack, and M. C. Kalcounis-Rueppell. 2016. Winter activity of coastal plain populations of bat species affected by White-nose syndrome and wind energy facilities. (H. Rebelo, ed.) PLOS ONE 11:e0166512.
- Hawkings, J. A., M. K. Gooden, and P. L. Sewell. 2017. Final report: Fall 2016/Winter 2017 NCDOT northern long-eared bat research project, Bertie, Bladen, Hyde, Martin, and Tyrrell Counties, North Carolina (No. TIP No. R-9999 WBS No. 34634.1.4). Cooperhead Environmental Consulting, Inc., Paint Lick, Kentucky.
- Homer, C. G., J. A. Dewitz, L. Yang, S. Jin, P. Danielson, G. Xian, J. Coulston, et al. 2015. Completion of the 2011 National Land Cover Database for the conterminous United States- Representing a decade of land cover change information. *Photogrammetric Engineering and Remote Sensing* 81:345–354.
- Huth, J. K., A. Silvis, P. R. Moosman, M. Ford, and S. Sweeten. 2015. A comparison of survey methods for documenting presence of *Myotis leibii* (Eastern small-footed bats) at roosting areas in Western Virginia. *Virginia Journal of Science* 66:13.
- Jachowski, D. S., C. A. Dobony, L. S. Coleman, W. M. Ford, E. R. Britzke, and J. L. Rodrigue. 2014. Disease and community structure: White-nose syndrome alters spatial and temporal niche partitioning in sympatric bat species. *Diversity and Distributions* 20:1002–1015.
- Johnson, J. B., W. M. Ford, J. L. Rodrigue, J. W. Edwards, and C. M. Johnson. 2010. Roost selection by male Indiana myotis following forest fires in central Appalachian hardwoods forests. *Journal of Fish and Wildlife Management* 1:111–121.
- Johnson, J. B., J. E. Gates, and W. M. Ford. 2008. Distribution and activity of bats at local and landscape scales within a rural–urban gradient. *Urban Ecosystems* 11:227–242.

- Johnson, J. B., J. E. Gates, and W. M. Ford. 2009. Notes on foraging activity of female *Myotis leibii* in Maryland.
- Johnson, J. B., J. L. Rodrigue, and W. M. Ford. 2013. Nightly and yearly bat activity before and after White-nose syndrome on the Fernow Experimental Forest in West Virginia (Res. Pap. No. NRS-24).
- Johnson, J. S., J. D. Kiser, K. S. Watrous, and T. S. Peterson. 2011. Day-Roosts of *Myotis leibii* in the Appalachian Ridge and Valley of West Virginia. *Northeastern Naturalist* 18:95–106.
- Jones, C., and R. W. Manning. 1989. *Myotis austroriparius*. *Mammalian Species* 1–3.
- Jorge, M., S.R. Freeze, S.E. Sweeten, M.C. True, H. Taylor, K. Gorman, M. St. Germain, E.P. Garrison and M.J. Cherry. 2020. Dormant season burning impacts to migratory bats. Department of Defense Legacy Resource Management Program Final Report HQ0034-18-2-0012. Arlington, VA 65p.
- Kalen, N., W. M. Ford, A. Silvis, K. E. Powers, and T. Keifer. 2015. Post-White-nose syndrome assessment of bat species occupancy at Catoctin Mountain Park and Harper’s Ferry National Historical Park – Interim Report.
- Kunz, T. H. 1982. *Lasionycteris noctivagans*. *Mammalian Species* 1–5.
- Kurta, A., and R. H. Baker. 1990. *Eptesicus fuscus*. *Mammalian Species* 1–10.
- Loeb, S. C., T. J. Rodhouse, L. E. Ellison, C. L. Lausen, J. D. Reichard, K. M. Irvine, J. T. H. Coleman, et al. 2015. A plan for the North American Bat Monitoring Program (NABat) (No. Gen. Tech. Rep. SRS-208). USDA Forest Service, Southern Research Station, Ashville, NC.
- Magurran, A. E. 1988. Ecological diversity and its measurement. Princeton university press.
- McCracken, G. F., R. F. Bernard, M. Gamba-Rios, R. Wolfe, J. J. Krauel, D. N. Jones, A. L. Russell, et al. 2018. Rapid range expansion of the Brazilian free-tailed bat in the southeastern United States, 2008–2016. *Journal of Mammalogy* 99:312–320.
- Menzel, M. A., T. C. Carter, W. M. Ford, B. R. Chapman, and J. Ozier. 2000. Roost-tree characteristics of evening bat, red bat, and Seminole bat roosts in the Upper Coastal Plain. Pages 304–313 in *Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies* (Vol. 54).
- Menzel, M. A., J. M. Menzel, S. B. Castleberry, J. Ozier, W. M. Ford, and J. W. Edwards. 2002. Illustrated key to skins and skulls of bats in the southeastern and mid-Atlantic states (No. Research Note NE-376). USDA Forest Service, Northeastern Research Station, Newton Square, PA.
- Menzel, M. A., J. M. Menzel, J. C. Kilgo, W. M. Ford, T. C. Carter, and J. W. Edwards. 2003. Bats of the Savannah River Site and vicinity 80.

- Moosman, P. R., J. P. Veilleux, G. W. Pelton, and H. H. Thomas. 2013. Changes in capture rates in a community of bats in New Hampshire during the progression of White-nose syndrome. *Northeastern Naturalist* 20:552–558.
- Moosman, P.R., P.R. Anderson, and M.G. Frasier. 2020. Use of rock-crevices in winter by big bow bats and Eastern small-footed bats in the Appalachian Ridge and Valley of Virginia. *Banisteria* 58: 9-13.
- Muthersbaugh, M. S. 2018. Seasonal activity patterns of bats in the central Appalachians (M.S. Thesis). Virginia Polytechnic Institute and State University, Blacksburg, Blacksburg, VA, USA.
- Niver, R. A., R. A. King, M. P. Armstrong, and W. M. Ford. 2014. Methods to evaluate and develop minimum recommended summer survey effort for Indiana bats: White paper.
- Nocera, T. 2018. Assessing the long-term impacts of White-nose syndrome on bat communities using acoustic surveys at Fort Drum Military Installation (M.S. Thesis). Virginia Polytechnic Institute and State University, Blacksburg, VA, USA.
- North Carolina Division of Parks and Recreation. 2019. Mammals of North Carolina: their distribution and abundance.
- Oksanen, J., F. G. Blanchet, R. Kindt, P. Legendre, P. R. Minchin, R. B. O’Hara, G. L. Simpson, et al. 2015. *vegan*: community ecology package. R package version 2.2-1.
- Pettit, J. L., and J. M. O’Keefe. 2017. Impacts of White-nose syndrome observed during long-term monitoring of a midwestern bat community. *Journal of Fish and Wildlife Management* 8:69–78.
- Powers, K. E., R. J. Reynolds, W. Orndorff, W. M. Ford, and C. S. Hobson. 2015. Post-White-nose syndrome trends in Virginias cave bats, 2008 – 2013. *Journal of Ecology and the Natural Environment* 7:113–123.
- PRISM Climate Group. 2019. PRISM spatial climate datasets. Oregon State University, Covallis.
- R Core Team. 2017. R: A language and environment for statistical computing. Vienna, Austria.
- Reeder, D. M., C. L. Frank, G. G. Turner, C. U. Meteyer, A. Kurta, E. R. Britzke, M. E. Vodzak, et al. 2012. Frequent arousal from hibernation linked to severity of infection and mortality in bats with White-nose syndrome. *PLoS ONE* 7:e38920.
- Reynolds, R. J., K. E. Powers, W. Orndorff, W. M. Ford, and C. S. Hobson. 2016. Changes in rates of capture and demographics of *Myotis septentrionalis* (northern long-eared bat) in Western Virginia before and after onset of White-nose syndrome. *Northeastern Naturalist* 23:195–204.
- Shannon, C. E. 1948. A mathematical theory of communication. *Bell System Technical Journal* 27:379–423.
- Shump, K. A., and A. U. Shump. 1982a. *Lasiurus borealis*. *Mammalian Species* 1–6.

- . 1982*b*. *Lasiurus cinereus*. Mammalian Species 1.
- Silvis, A., W. M. Ford, E. R. Britzke, N. R. Beane, and J. B. Johnson. 2012. Forest succession and maternity day roost selection by *Myotis septentrionalis* in a mesophytic hardwood forest. International Journal of Forestry Research 2012:e148106.
- Silvis, A., W. M. Ford, E. R. Britzke, and J. B. Johnson. 2014. Association, roost use and simulated disruption of *Myotis septentrionalis* maternity colonies. Behavioural Processes 103:283–290.
- Silvis, A., R. W. Perry, and W. M. Ford. 2016. Relationships of three species of White-nose syndrome-impacted bats to forest condition and management (General Technical Report No. SRS-214). US Forest Service Southern Research Station, Asheville, NC, USA.
- Student, W. S. G. 1908. The probable error of a mean. Biometrika 6:1–25.
- Thomson, C. E. 1982. *Myotis sodalis*. Mammalian Species 1–5.
- United States Fish and Wildlife Service. 2018. 2018 range-wide Indian bat survey guidelines.
- . 2019. Indiana Bat Summer Survey Guidance - Automated Acoustic Bat ID Software Programs.
- U.S. Fish and Wildlife Service Midwest Region. 2019. Glossary of Acoustic Bat Survey Terms. Midwest Region Endangered Species.
- VanDerWal, J., L. Falconi, S. Januchowski, L. Shoo, and C. Storlie. 2014. SDMTools: Species distribution modelling tools: Tools for processing data associated with species distribution modelling exercises.
- Watkins, L. C. 1972. *Nycticeius humeralis*. Mammalian Species 1–4.
- Weller, T. J., and C. J. Zabel. 2002. Variation in bat detections due to detector orientation in a forest. Wildlife Society Bulletin 30:922–930.
- Whitaker, J. O., Jr., and S. L. Gummer. 1992. Hibernation of the big brown bat, *Eptesicus fuscus*, in buildings. Journal of Mammalogy 73:312–316.
- Wilkins, K. T. 1989. *Tadarida brasiliensis*. Mammalian Species 1–10.
- Wintle, B. A., T. V. Walshe, K. M. Parris, and M. A. McCarthy. 2012. Designing occupancy surveys and interpreting non-detection when observations are imperfect: Interpreting non-detections in occupancy surveys. Diversity and Distributions 18:417–424.
- Zimmerman, D. W. 1997. Teacher's corner: A note on interpretation of the paired-samples t test. Journal of Educational and Behavioral Statistics 22:349–360.

Appendix A. Total mist-net captures for National Capital Region Units

Total bat captures from mist netting within National Park Service, National Capital Region units from 2016–2018 can be found in Table A1. Unit abbreviations are: Antietam National Battlefield (ANTI), Catoctin Mountain Park (CATO), Chesapeake and Ohio Canal National Historical Park (CHOH), George Washington Memorial Parkway (GWMP), Harpers Ferry National Historical Park (HAFE), Manassas National Battlefield Park (MANA), Monocacy National Battlefield (MONO), National Mall and Memorial Parks (NAMA), National Capital Parks-East (NACE), Prince William Forest Park (PRWI), Rock Creek Park (ROCR), and Wolf Trap National Park for the Performing Arts (WOTR). Species abbreviations are: *Eptesicus fuscus* (Big Brown bat; EPFU), *Lasiurus borealis* (Eastern Red bat; LABO), *Lasiurus cinereus* (Hoary bat; LACI), *Lasionycteris noctivagans* (Silver-haired bat; LANO), *Myotis leibii* (Eastern small-footed bat; MYLE), *Myotis lucifugus* (Little Brown bat; MYLU), *Myotis septentrionalis* (Northern long-eared bat; MYSE), *Nycticeius humeralis* (Evening bat; NYHU), and *Perimyotis subflavus* (Tri-colored bat; PESU).

Table A1. Total bat captures from mist netting in National Capital Region units (2016–2018).

Unit	Species	Year			
		2016	2017	2018	2016 – 2018
ANTI	EPFU	0	0	5	5
	LABO	0	1	3	4
	LACI	0	0	0	0
	LANO	0	0	0	0
	MYLE	0	0	0	0
	MYLU	0	0	0	0
	MYSE	0	0	0	0
	NYHU	0	0	0	0
	PESU	0	0	0	0
CATO	EPFU	0	2	12	14
	LABO	0	0	1	1
	LACI	0	0	0	0
	LANO	0	0	0	0
	MYLE	0	0	0	0
	MYLU	0	0	0	0
	MYSE	0	0	1	1
	NYHU	0	0	0	0
	PESU	0	0	0	0

Table A1 (continued). Total bat captures from mist netting in National Capital Region units (2016–2018).

Unit	Species	Year			
		2016	2017	2018	2016 – 2018
ANTI	EPFU	0	0	5	5
	LABO	0	1	3	4
	LACI	0	0	0	0
	LANO	0	0	0	0
	MYLE	0	0	0	0
	MYLU	0	0	0	0
	MYSE	0	0	0	0
	NYHU	0	0	0	0
	PESU	0	0	0	0
CATO	EPFU	0	2	12	14
	LABO	0	0	1	1
	LACI	0	0	0	0
	LANO	0	0	0	0
	MYLE	0	0	0	0
	MYLU	0	0	0	0
	MYSE	0	0	1	1
	NYHU	0	0	0	0
	PESU	0	0	0	0
CHOH	EPFU	0	72	128	200
	LABO	0	30	18	48
	LACI	0	0	0	0
	LANO	0	0	2	2
	MYLE	0	1	0	1
	MYLU	0	3	0	3
	MYSE	0	0	0	0
	NYHU	0	0	1	1
	PESU	0	0	1	1

Table A1 (continued). Total bat captures from mist netting in National Capital Region units (2016–2018).

Unit	Species	Year			
		2016	2017	2018	2016 – 2018
GWMP	EPFU	7	112	14	133
	LABO	0	15	5	20
	LACI	0	0	0	0
	LANO	0	1	0	1
	MYLE	0	0	0	0
	MYLU	0	0	0	0
	MYSE	0	0	0	0
	NYHU	0	3	0	3
	PESU	0	0	0	0
HAFE	EPFU	0	27	23	50
	LABO	0	4	4	8
	LACI	0	1	0	1
	LANO	0	0	0	0
	MYLE	0	0	0	0
	MYLU	0	0	0	0
	MYSE	0	0	0	0
	NYHU	0	0	0	0
	PESU	0	0	0	0
MANA	EPFU	0	17	3	20
	LABO	0	1	3	4
	LACI	0	0	0	0
	LANO	0	0	0	0
	MYLE	0	0	0	0
	MYLU	0	0	0	0
	MYSE	0	0	0	0
	NYHU	0	0	0	0
	PESU	0	0	0	0

Table A1 (continued). Total bat captures from mist netting in National Capital Region units (2016–2018).

Unit	Species	Year			
		2016	2017	2018	2016 – 2018
MONO	EPFU	0	5	4	9
	LABO	0	0	2	2
	LACI	0	0	0	0
	LANO	0	0	0	0
	MYLE	0	0	0	0
	MYLU	0	0	0	0
	MYSE	0	0	0	0
	NYHU	0	0	0	0
	PESU	0	0	0	0
NACE	EPFU	0	47	10	57
	LABO	0	3	0	3
	LACI	0	0	0	0
	LANO	0	0	0	0
	MYLE	0	0	0	0
	MYLU	0	0	0	0
	MYSE	0	0	0	0
	NYHU	0	0	0	0
	PESU	0	0	0	0
NAMA	EPFU	0	2	0	2
	LABO	0	0	0	0
	LACI	0	0	0	0
	LANO	0	0	0	0
	MYLE	0	0	0	0
	MYLU	0	0	0	0
	MYSE	0	0	0	0
	NYHU	0	0	0	0
	PESU	0	0	0	0

Table A1 (continued). Total bat captures from mist netting in National Capital Region units (2016–2018).

Unit	Species	Year			
		2016	2017	2018	2016 – 2018
PRWI	EPFU	1	78	113	192
	LABO	0	21	12	33
	LACI	0	2	0	2
	LANO	0	0	2	2
	MYLE	0	0	0	0
	MYLU	0	0	0	0
	MYSE	1	3	1	5
	NYHU	0	1	0	1
	PESU	0	0	0	0
ROCR	EPFU	57	126	288	471
	LABO	7	9	26	42
	LACI	0	0	0	0
	LANO	2	1	8	11
	MYLE	0	0	0	0
	MYLU	0	0	0	0
	MYSE	7	9	15	31
	NYHU	0	0	0	0
	PESU	0	1	0	1
WOTR	EPFU	0	8	1	9
	LABO	0	0	0	0
	LACI	0	0	0	0
	LANO	0	0	0	0
	MYLE	0	0	0	0
	MYLU	0	0	0	0
	MYSE	0	0	0	0
	NYHU	0	0	0	0
	PESU	0	0	0	0
TOTAL		83	606	706	1394

Appendix B. Overwinter mean echolocation calls in National Capital Region Units

Figures B1–B6 show mean echolocation calls recorded for NPS National Capital Region units 15 August 2016 – 14 May 2017 and 15 August 2017 – 14 May 2018 by unit. All calls were identified to species based on Kaleidoscope Bats of North America 4.2.0 classifier. Calls (y-axes) are the mean calls for each date within the unit, and date (x-axes) are the sample nights. X-axis marks are at 180 days. Nights with no calls appear with a dot on zero and nights that were not sampled do not have a dot. Species abbreviations are: big brown (*Eptesicus fuscus*; EPFU), eastern red (*Lasiurus borealis*; LABO), hoary bat (*Lasiurus cinereus*; LACI), silver-haired (*Lasionycteris noctivagans*; LANO), eastern small-footed (*Myotis leibii*; MYLE), little brown (*Myotis lucifugus*; MYLU), northern long-eared (*Myotis septentrionalis*; MYSE), Indiana (*Myotis sodalis*; MYSO), evening (*Nycticeius humeralis*; NYHU), Mexican free-tailed (*Tadarida brasiliensis*; TABR), southeastern myotis (*Myotis austroriparius*; MYAU), and tri-colored bat (*Perimyotis subflavus*; PESU).

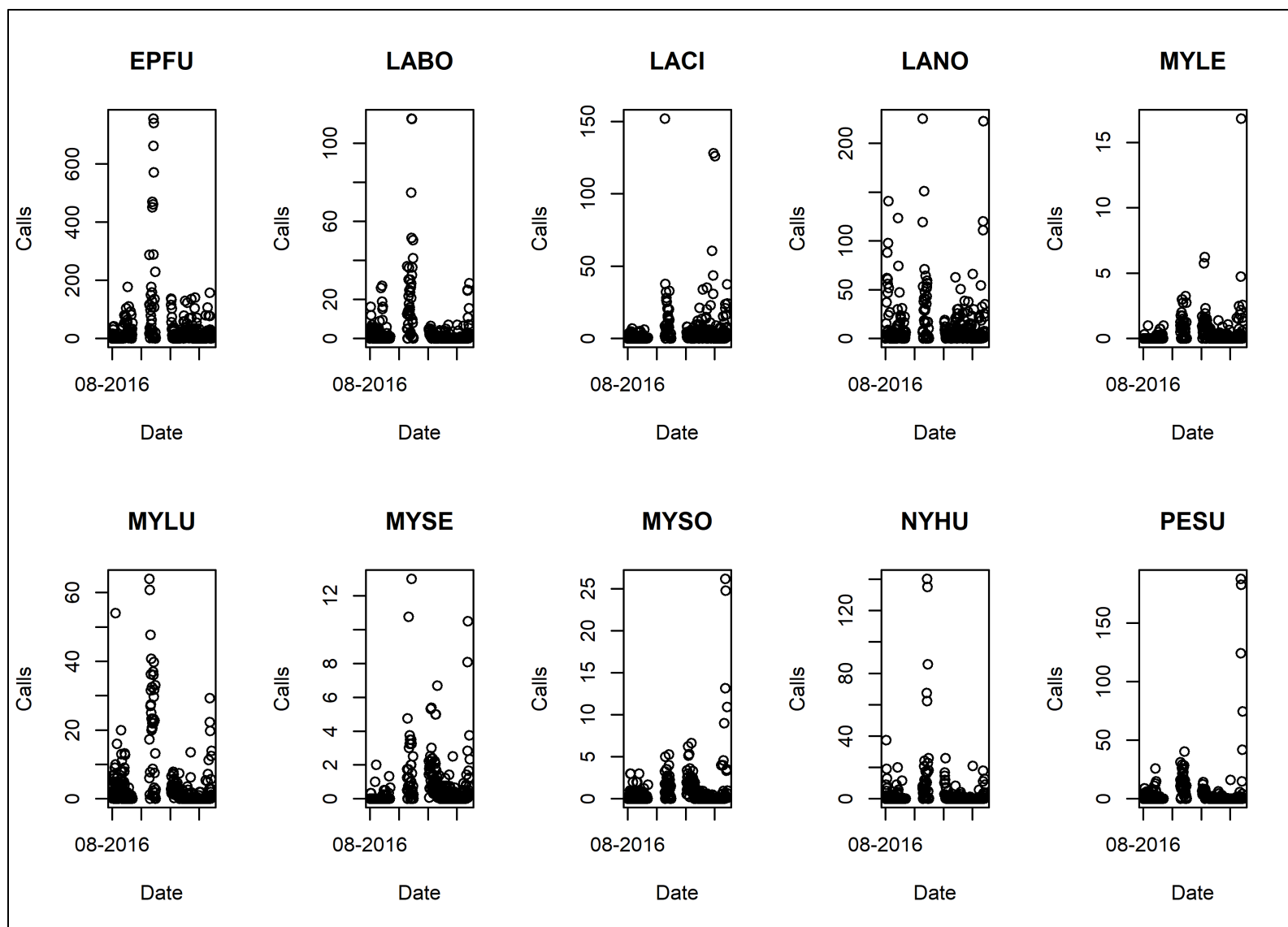


Figure B1. Mean echolocation calls recorded at Chesapeake and Ohio Canal National Historical Park.

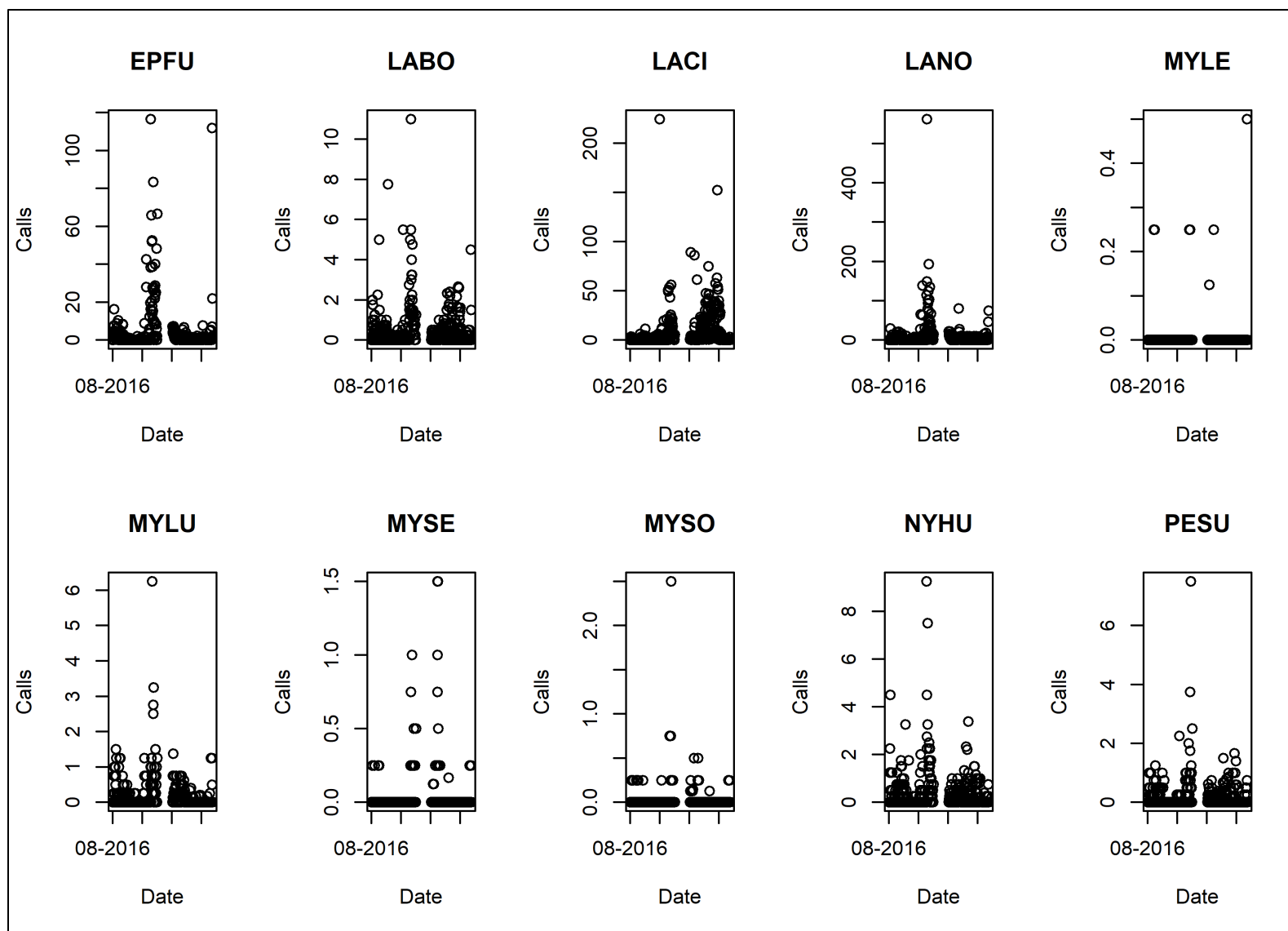


Figure B2. Mean echolocation calls recorded at George Washington Memorial Parkway.

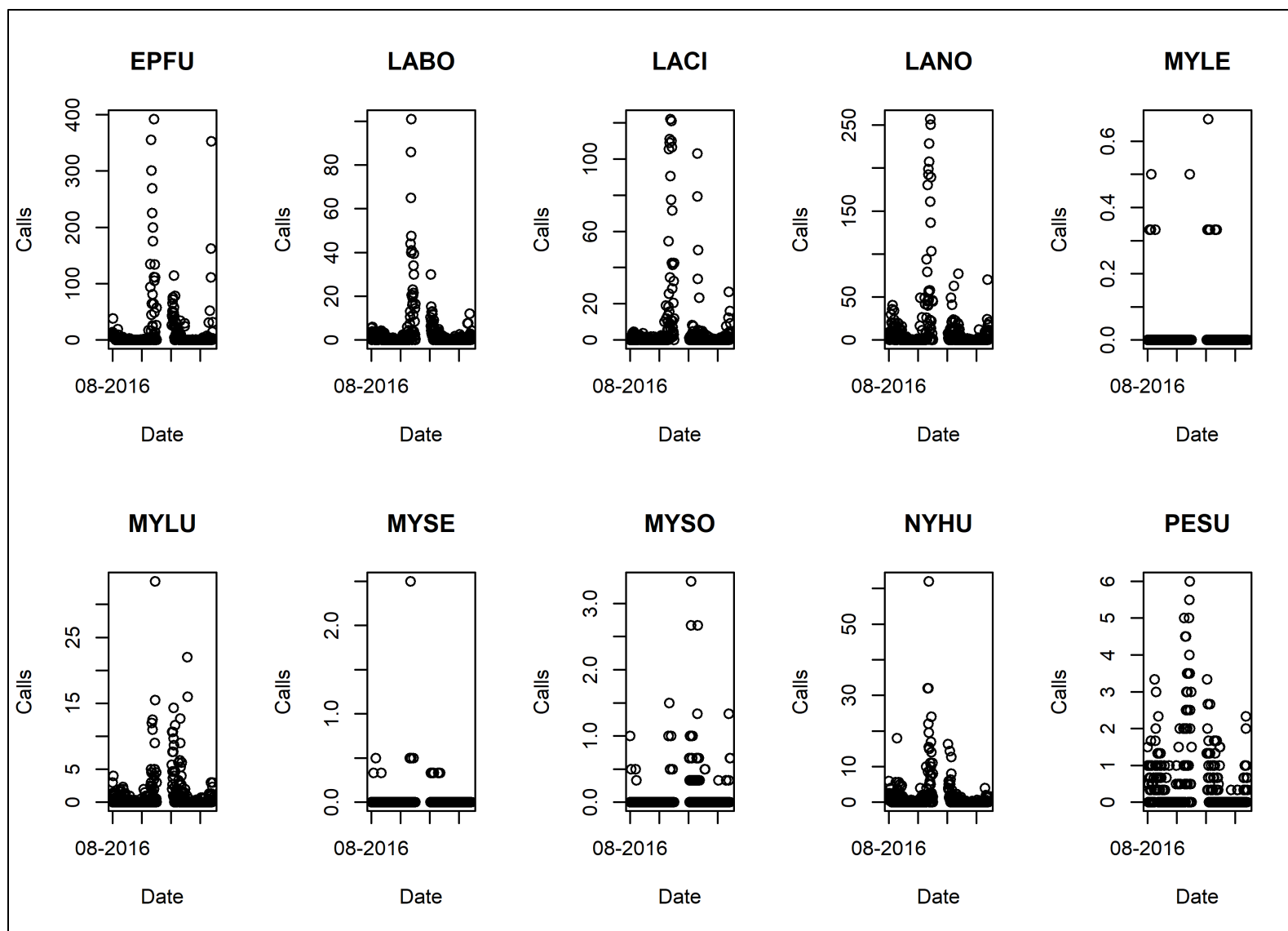


Figure B3. Mean echolocation calls recorded at Manassas National Battlefield Park.

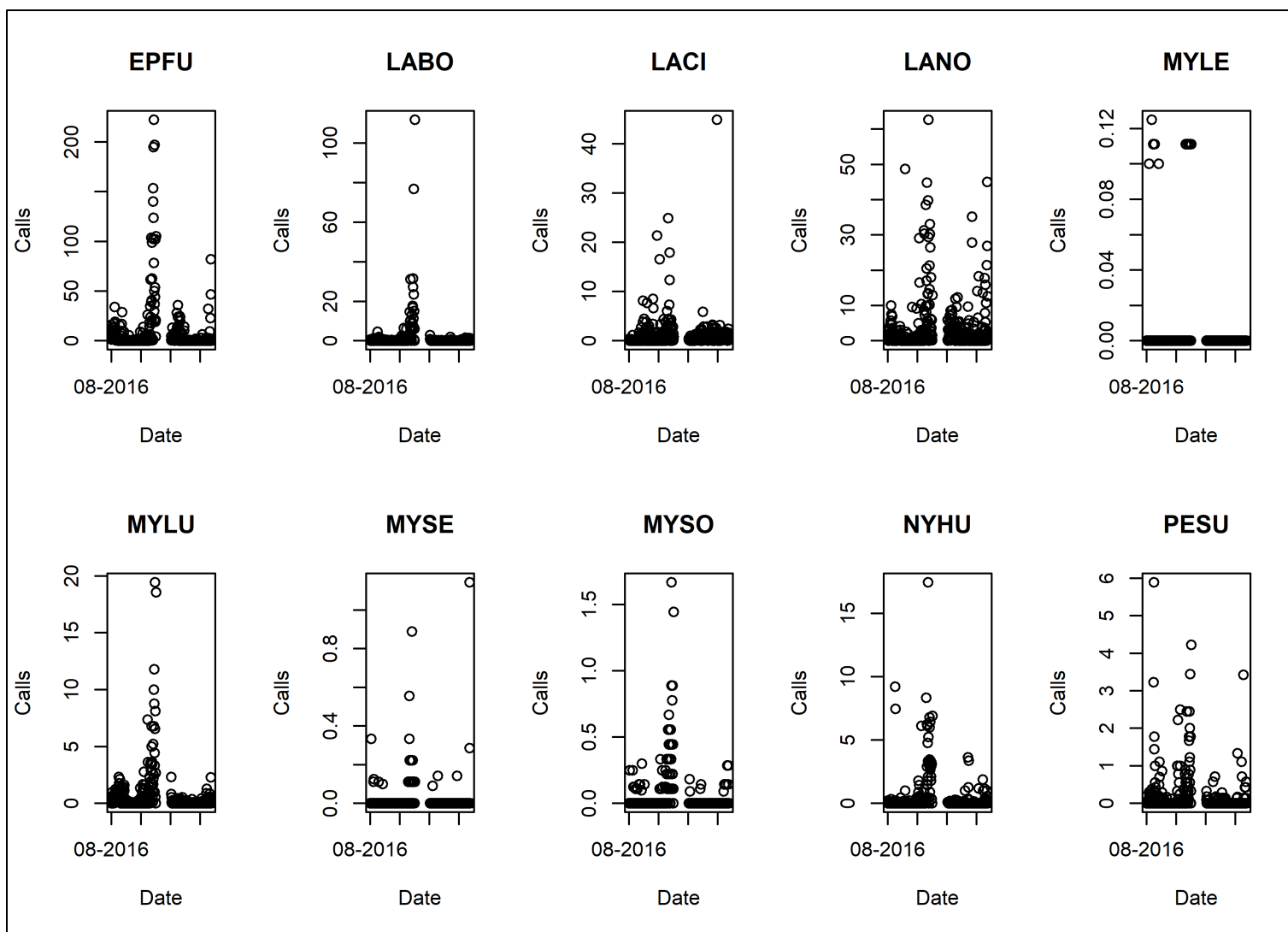


Figure B4. Mean echolocation calls recorded at National Capital Parks-East.

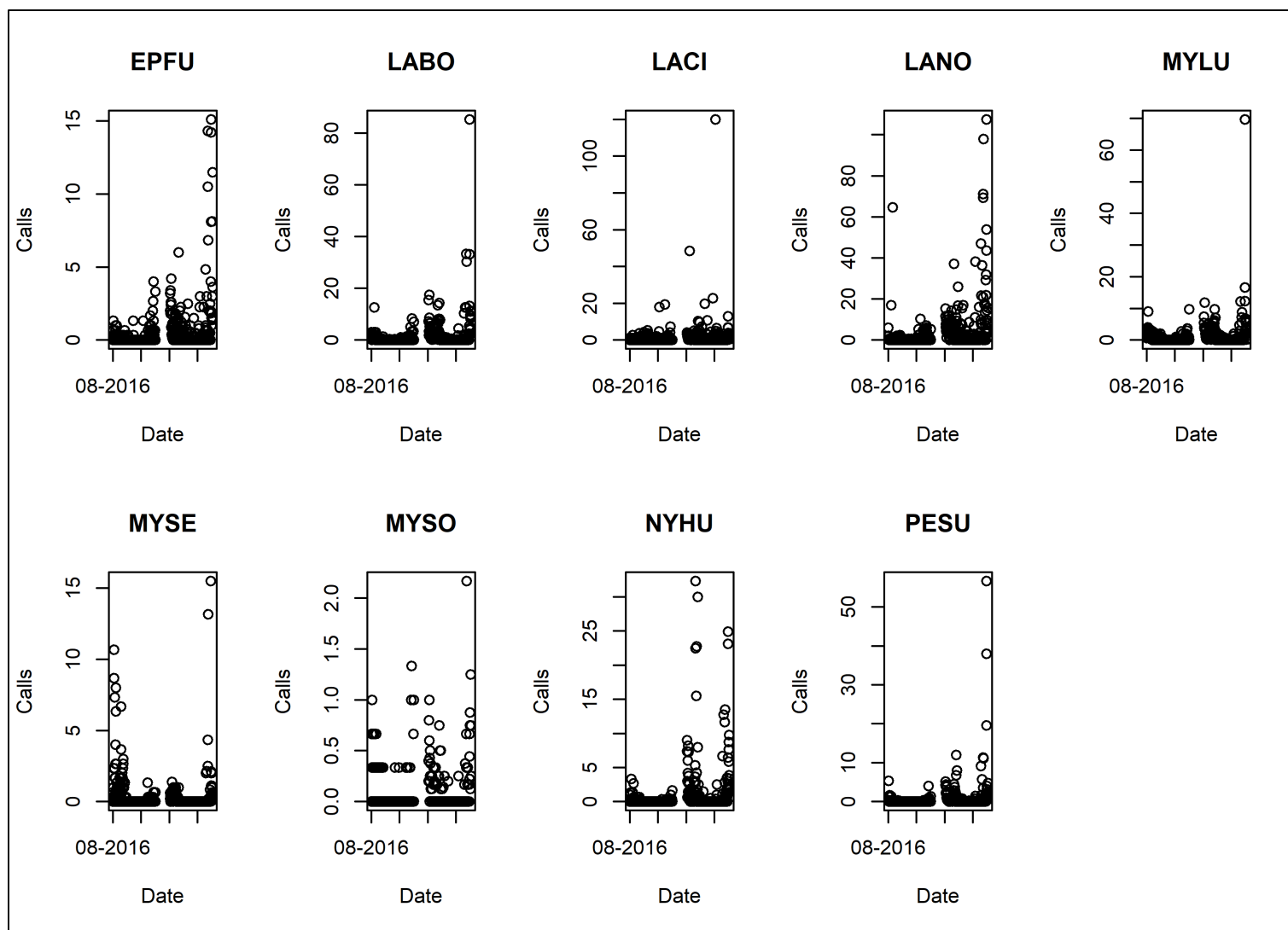


Figure B5. Mean echolocation calls recorded at Prince William Forest Park.

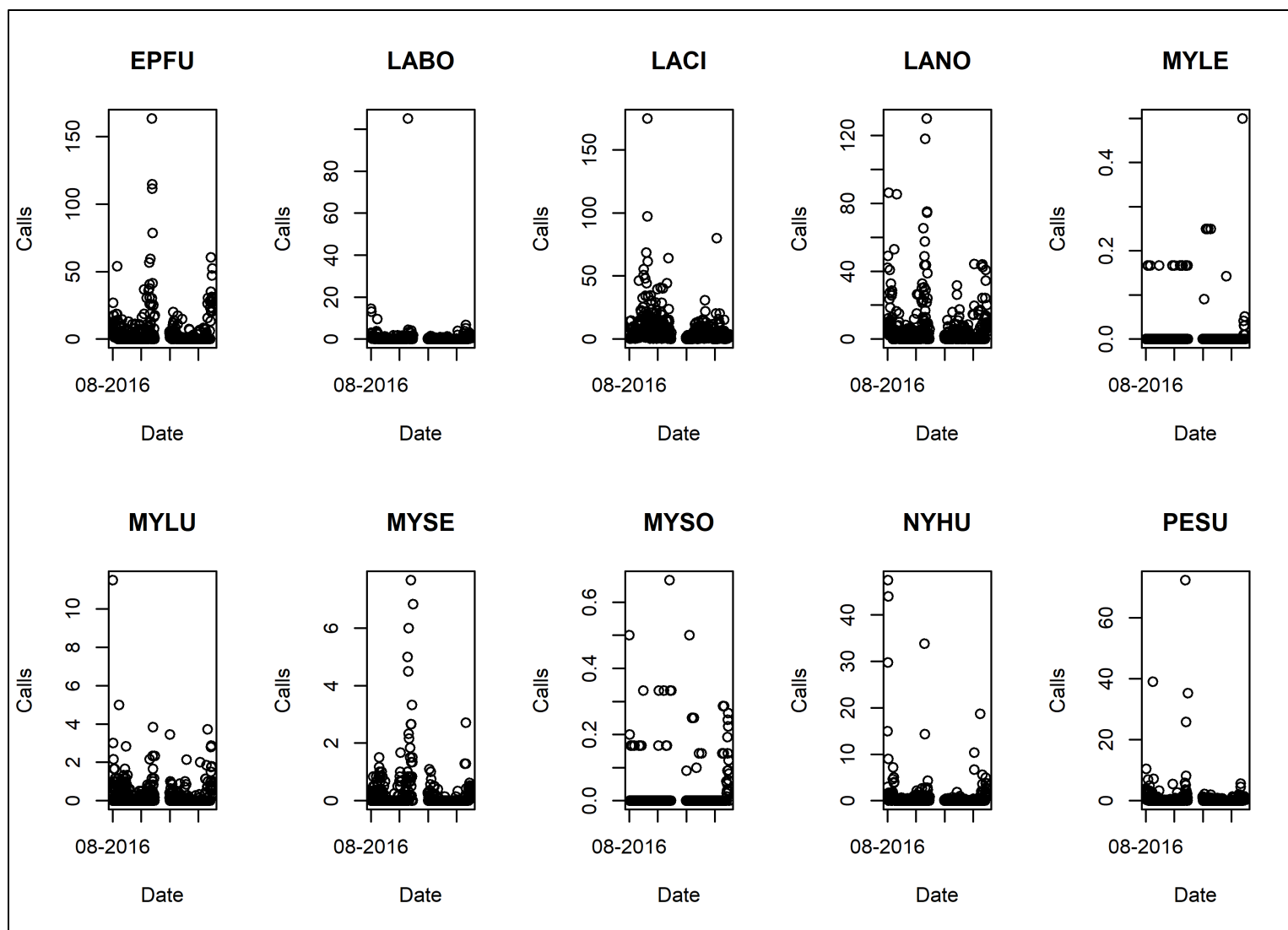
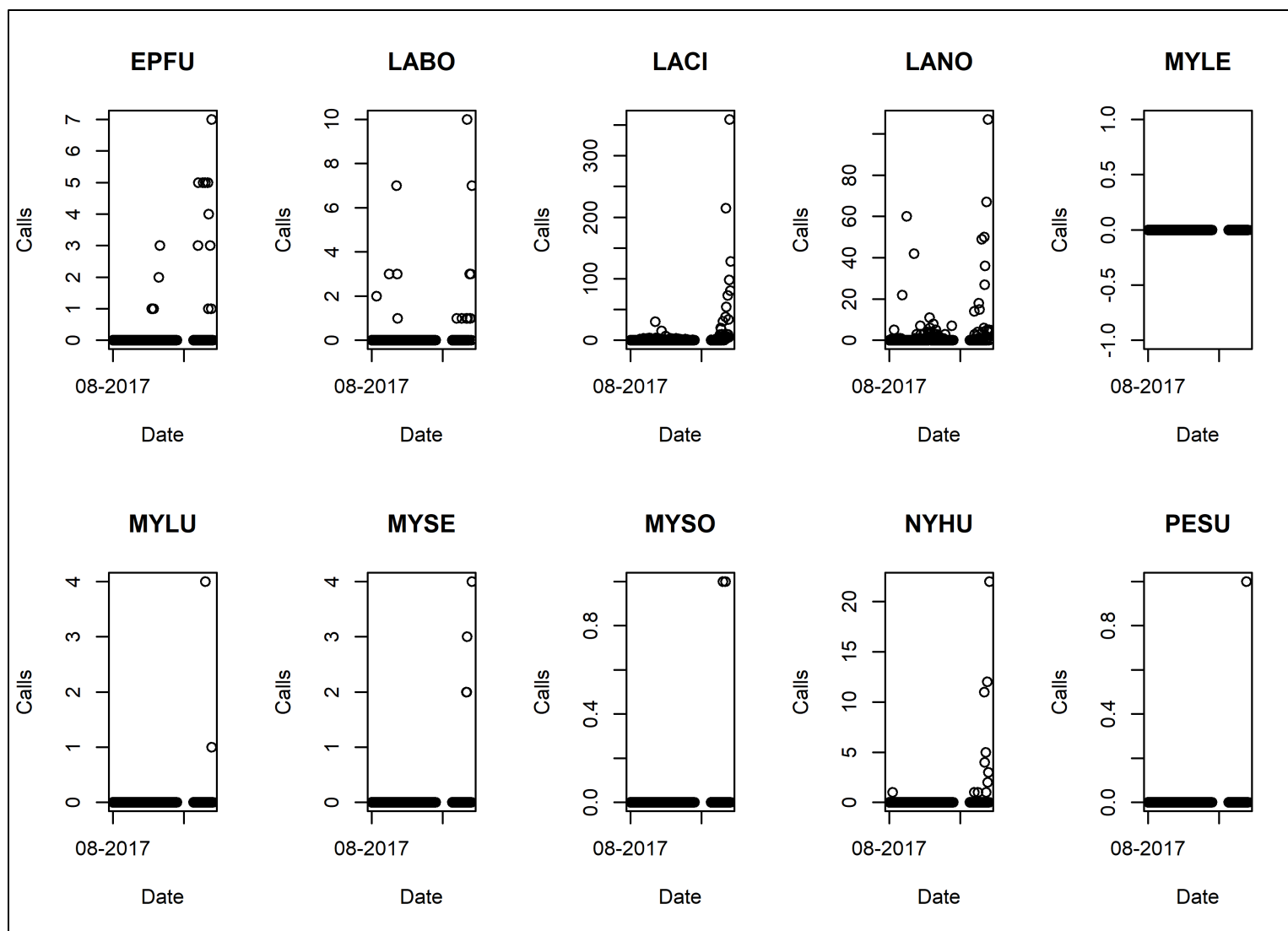


Figure B6. Mean echolocation calls recorded at Rock Creek Park.

Appendix C. Fall acoustics for Chesapeake & Ohio Canal National Historical Park.

Figures C1–C14 show the number of echolocation calls for 14 sites sampled along the Chesapeake and Ohio Canal National Historical Park 15 August 2016 – 14 May 2017 and 15 August 2017 – 14 May 2018 in proximity to caves and railroad tunnels (Deeley et al. 2020b). All calls were identified to species based on Kaleidoscope Bats of North America 4.2.0 classifier. Calls (y-axes) are the mean calls for each date within the unit, and date (x-axes) are the sample nights. Nights with no calls appear with a dot on zero and nights that were not sampled do not have a dot. Not all sites were sampled for the same periods. Species abbreviations are: big brown (*Eptesicus fuscus*; EPFU), eastern red (*Lasiurus borealis*; LABO), hoary bat (*Lasiurus cinereus*; LACI), silver-haired (*Lasionycteris noctivagans*; LANO), eastern small-footed (*Myotis leibii*; MYLE), little brown (*Myotis lucifugus*; MYLU), northern long-eared (*Myotis septentrionalis*; MYSE), Indiana (*Myotis sodalis*; MYSO), evening (*Nycticeius humeralis*; NYHU), Mexican free-tailed (*Tadarida brasiliensis*; TABR), southeastern myotis (*Myotis austroriparius*; MYAU), and tri-colored bat (*Perimyotis subflavus*; PESU).



Appendix C1. Echolocation calls recorded at 2LCAVE-ACT.

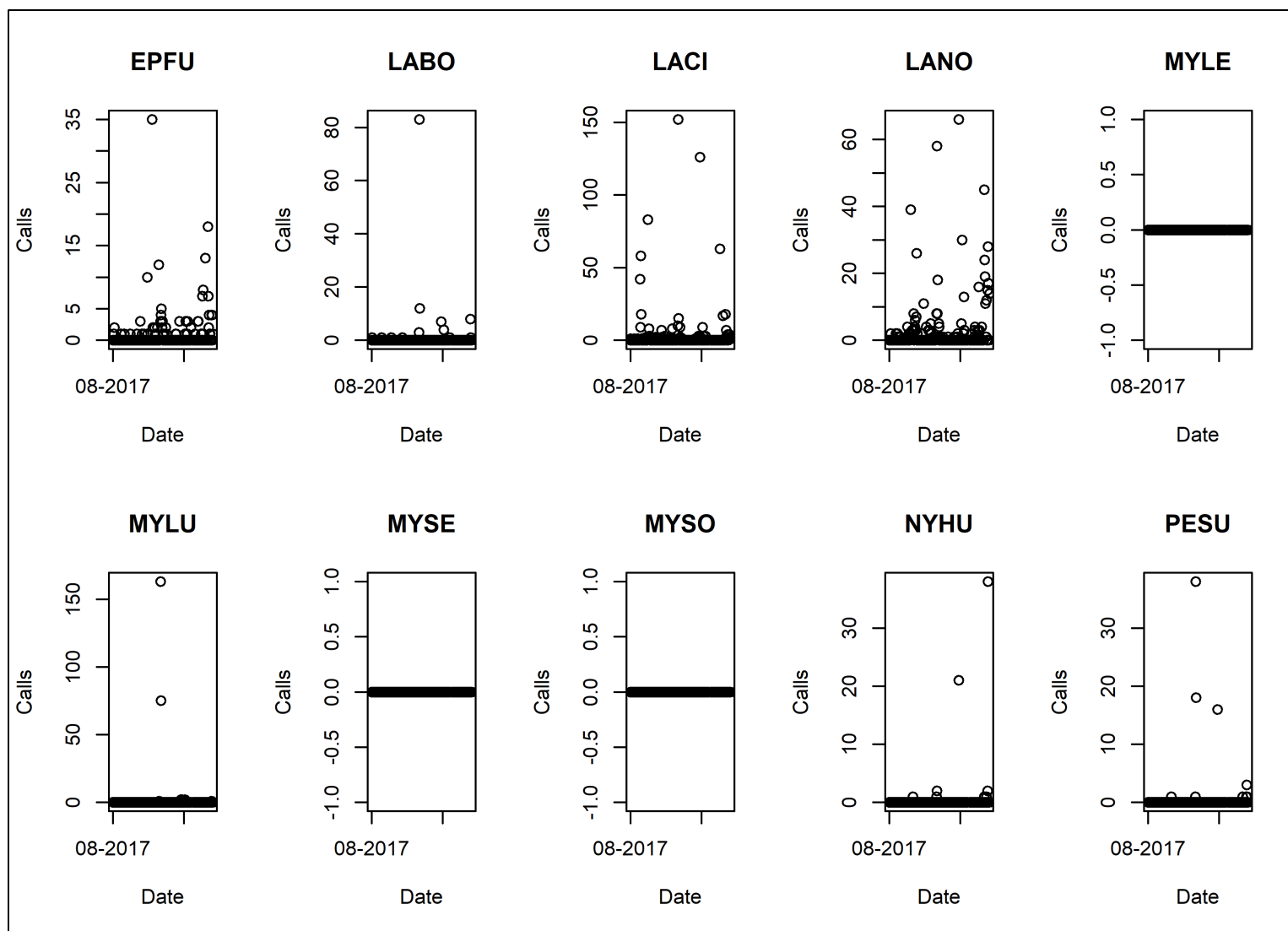


Figure C2 Echolocation calls recorded at DCAVE-ACT.

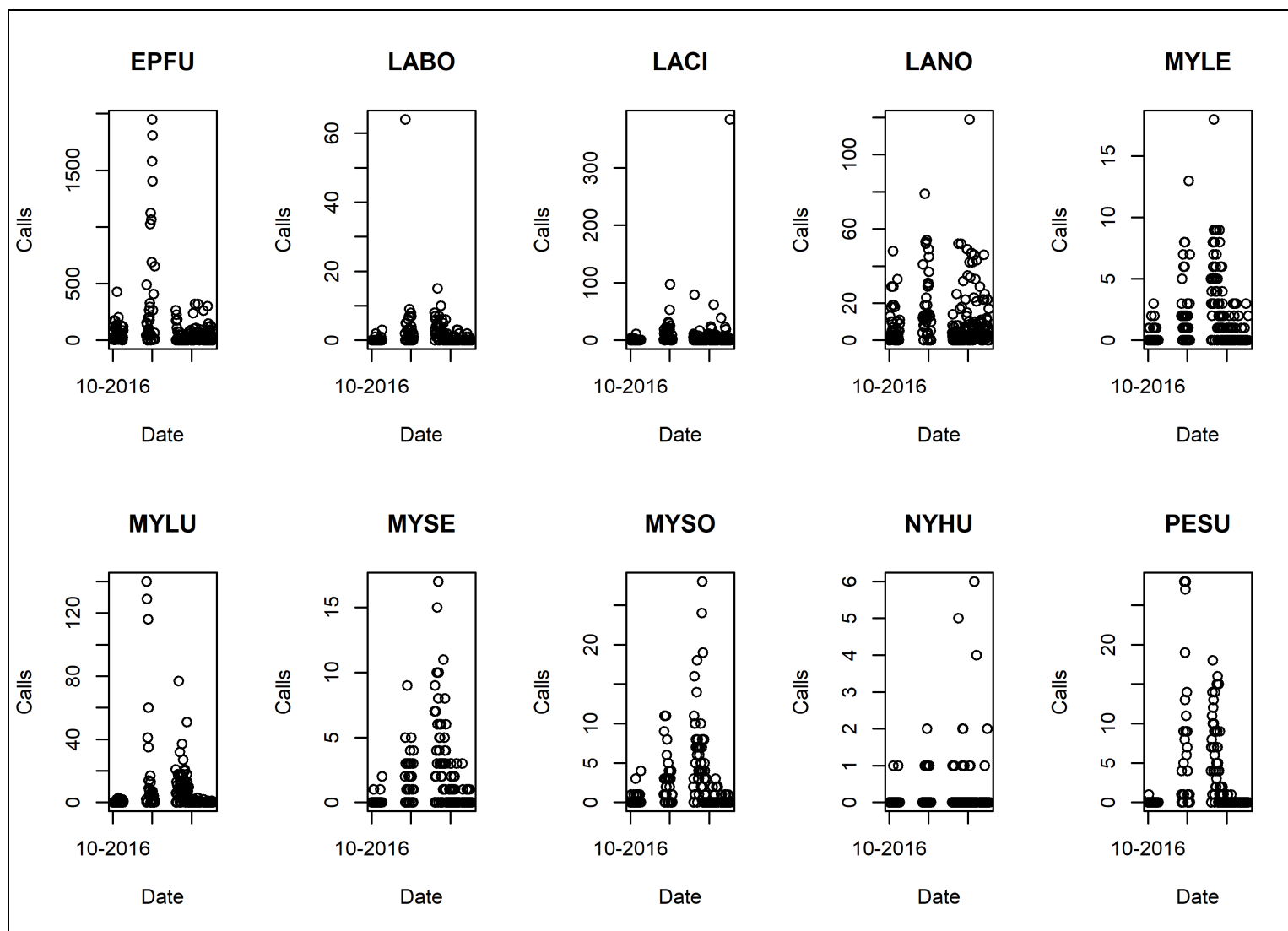


Figure C3. Echolocation calls recorded at IN-NR1-ACT.

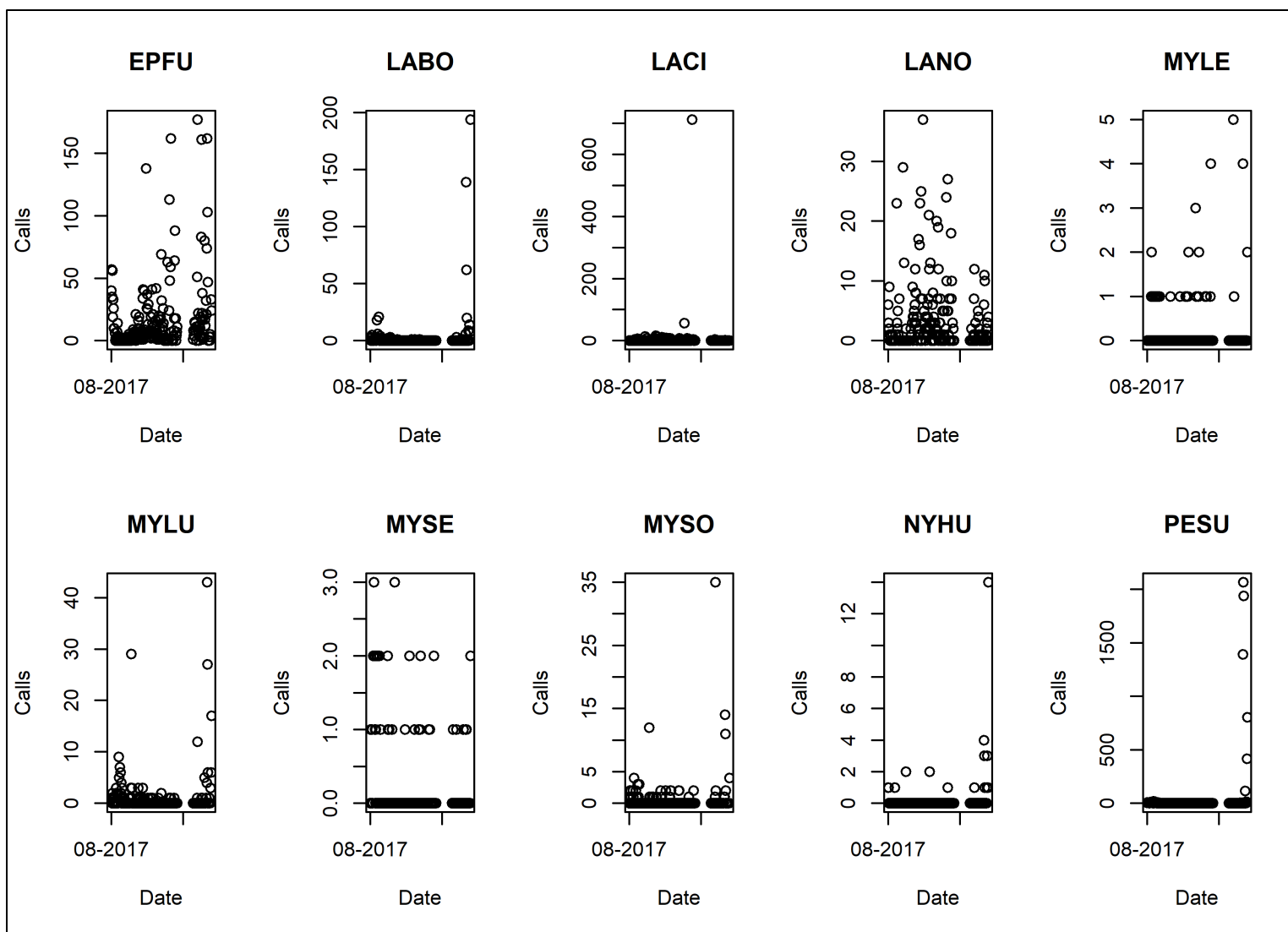


Figure C4. Echolocation calls recorded at IN-NR2-ACT.

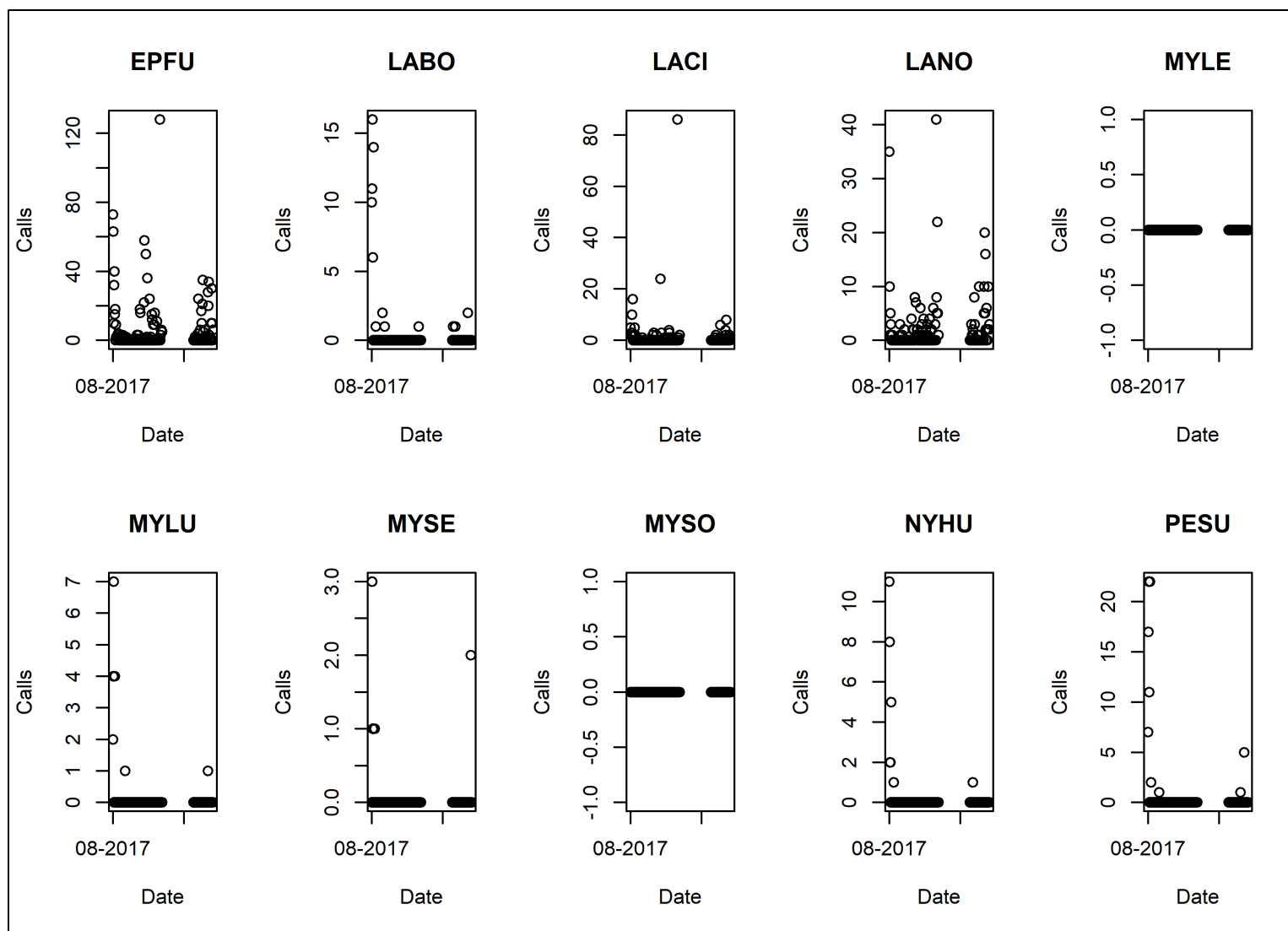


Figure C5. Echolocation calls recorded at KCAVE- ACT.

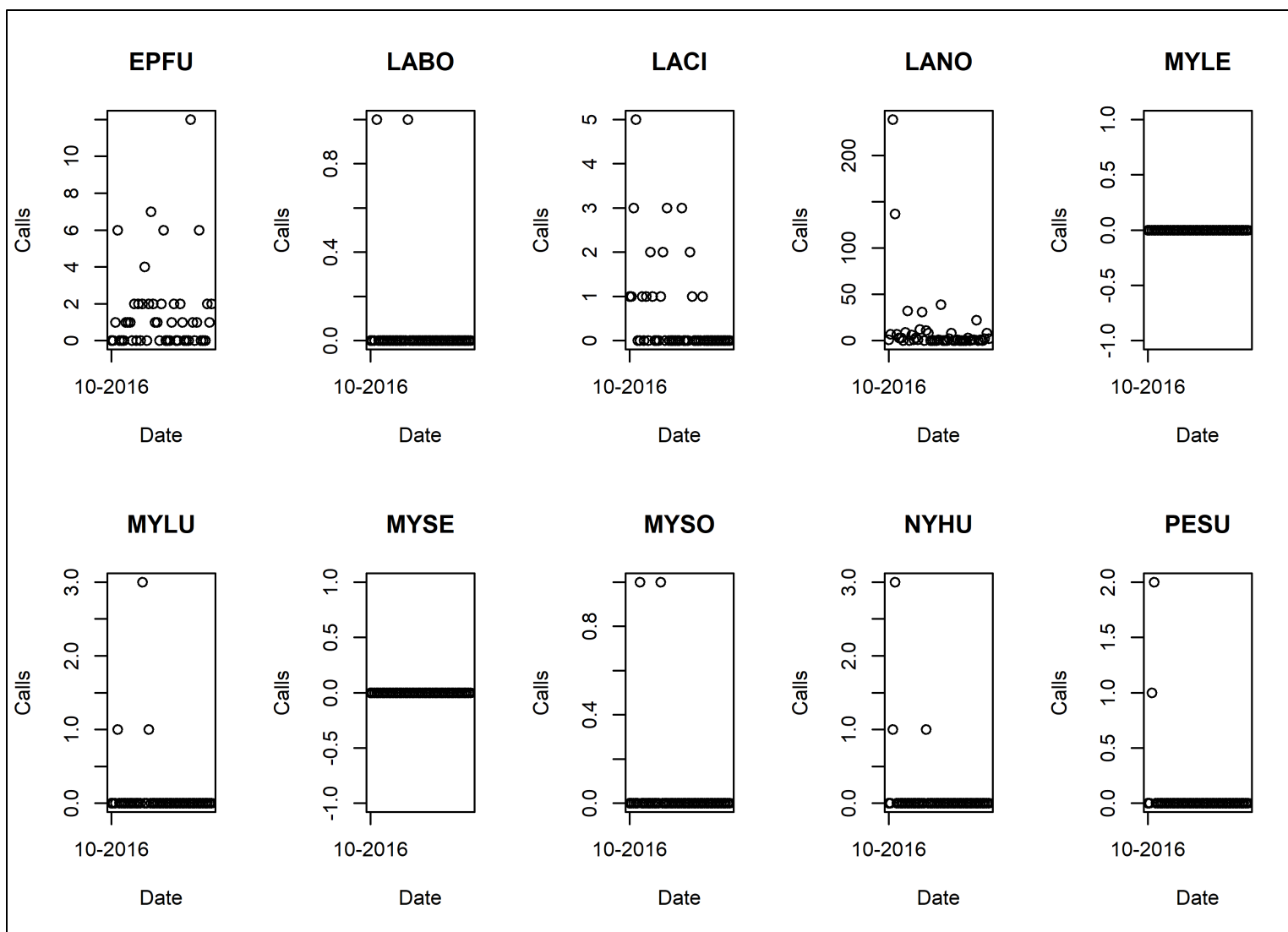


Figure C6. Echolocation calls recorded at KE-NR1-ACT.

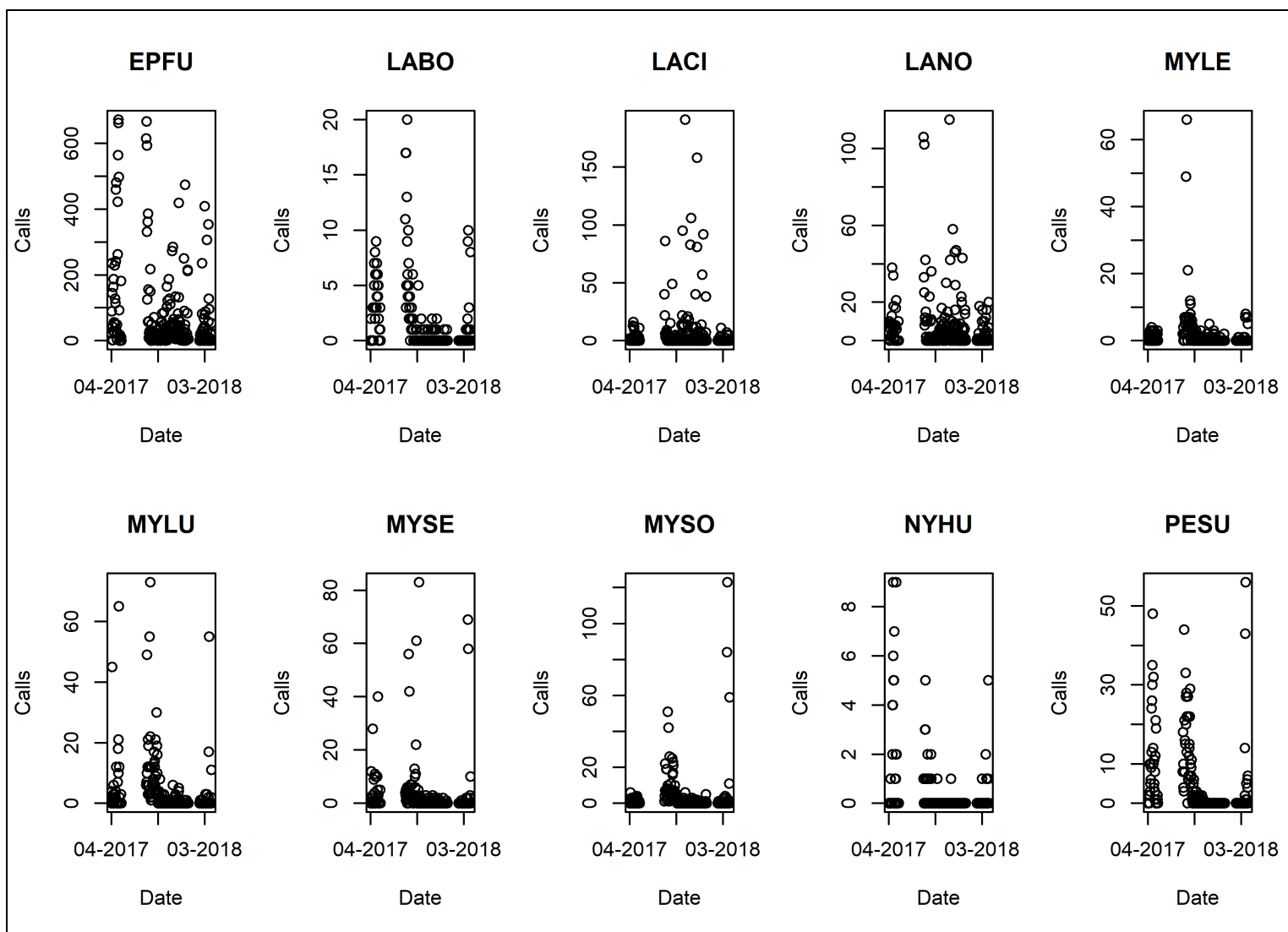


Figure C7. Echolocation calls recorded at KE-NR2-ACT.

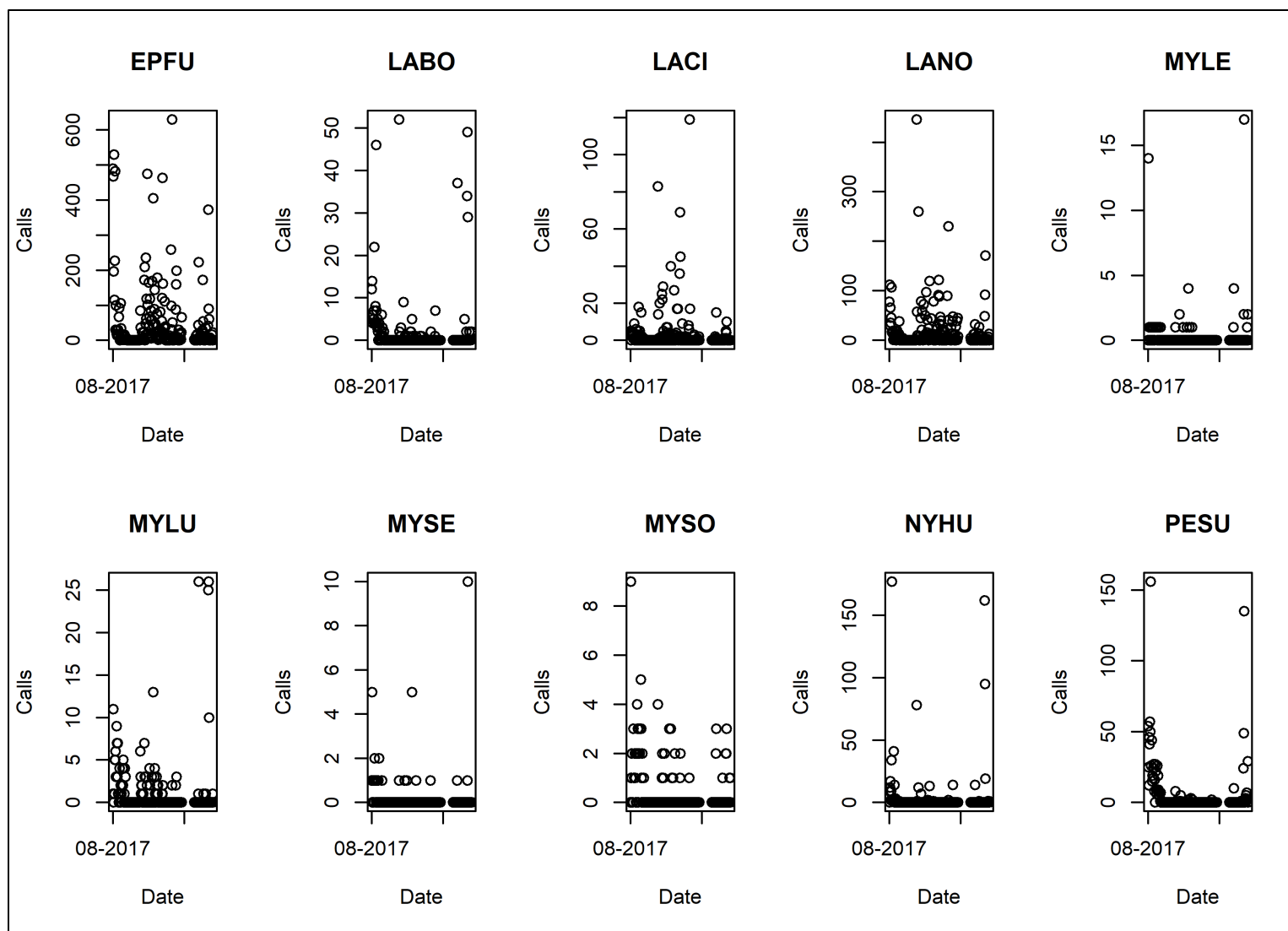


Figure C8. Echolocation calls recorded at KE-NR3-ACT.

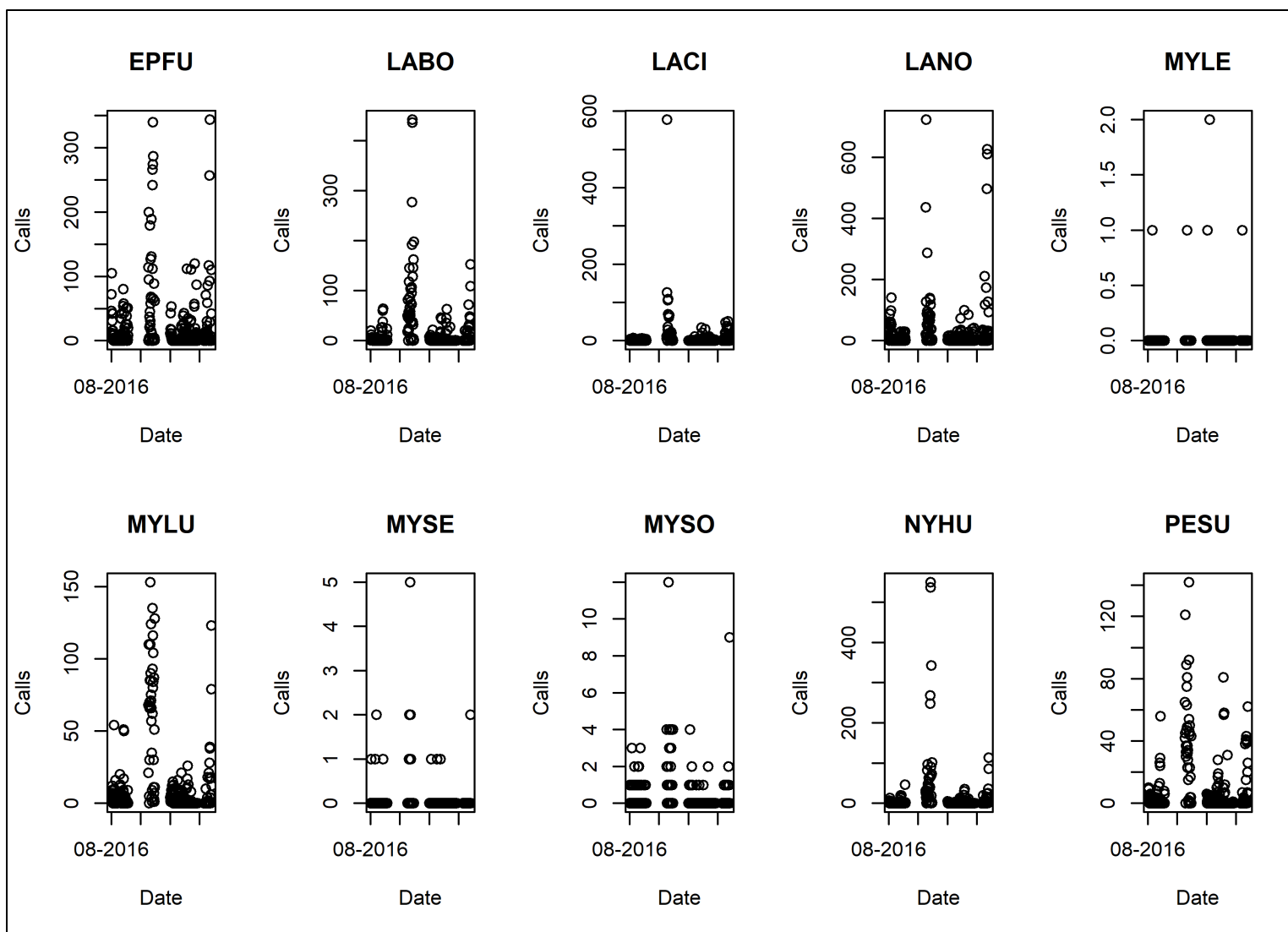


Figure C9. Echolocation calls recorded at PP-NR1-ACT.

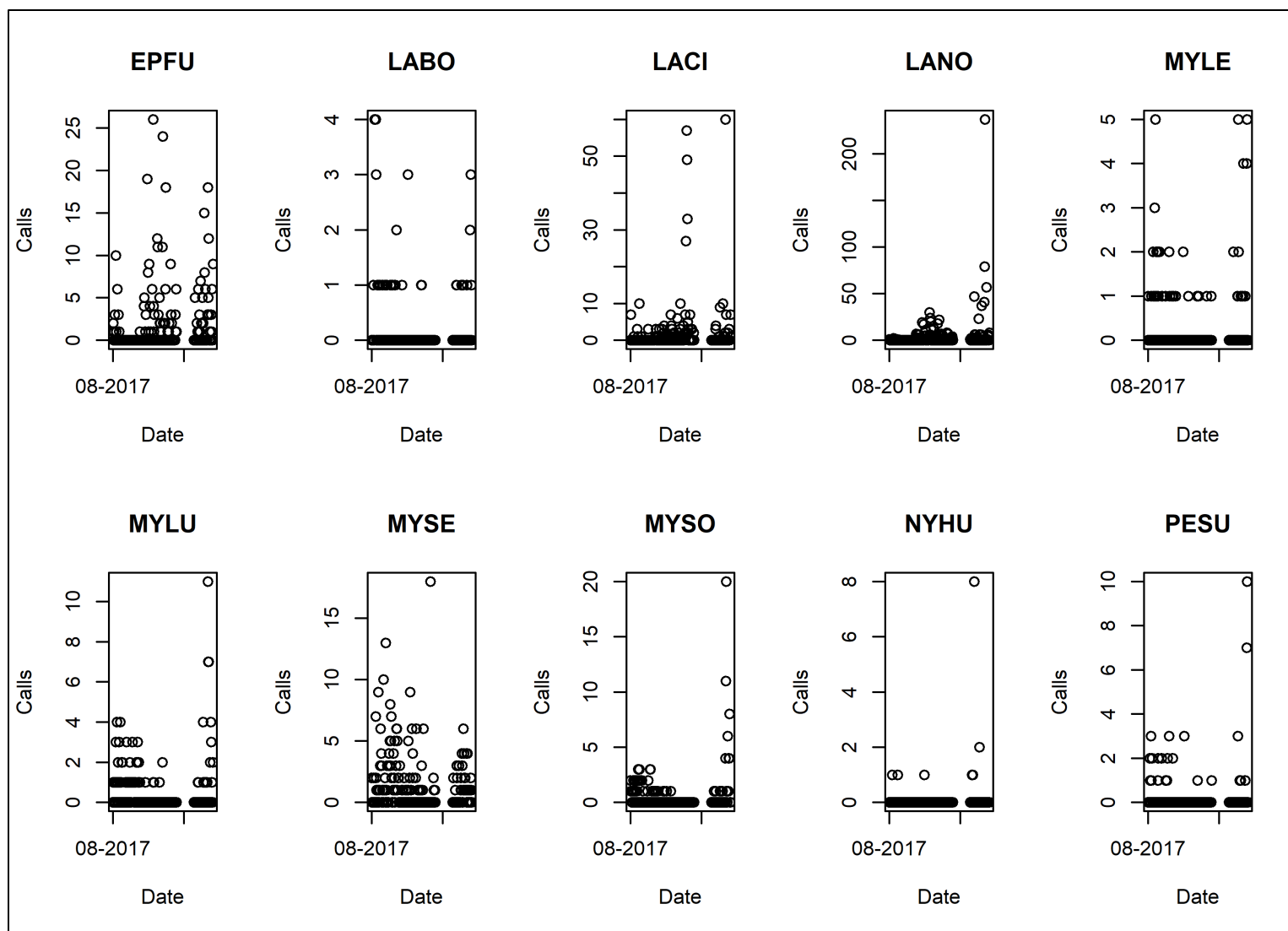


Figure C10. Echolocation calls recorded at RCAVE5-ACT.

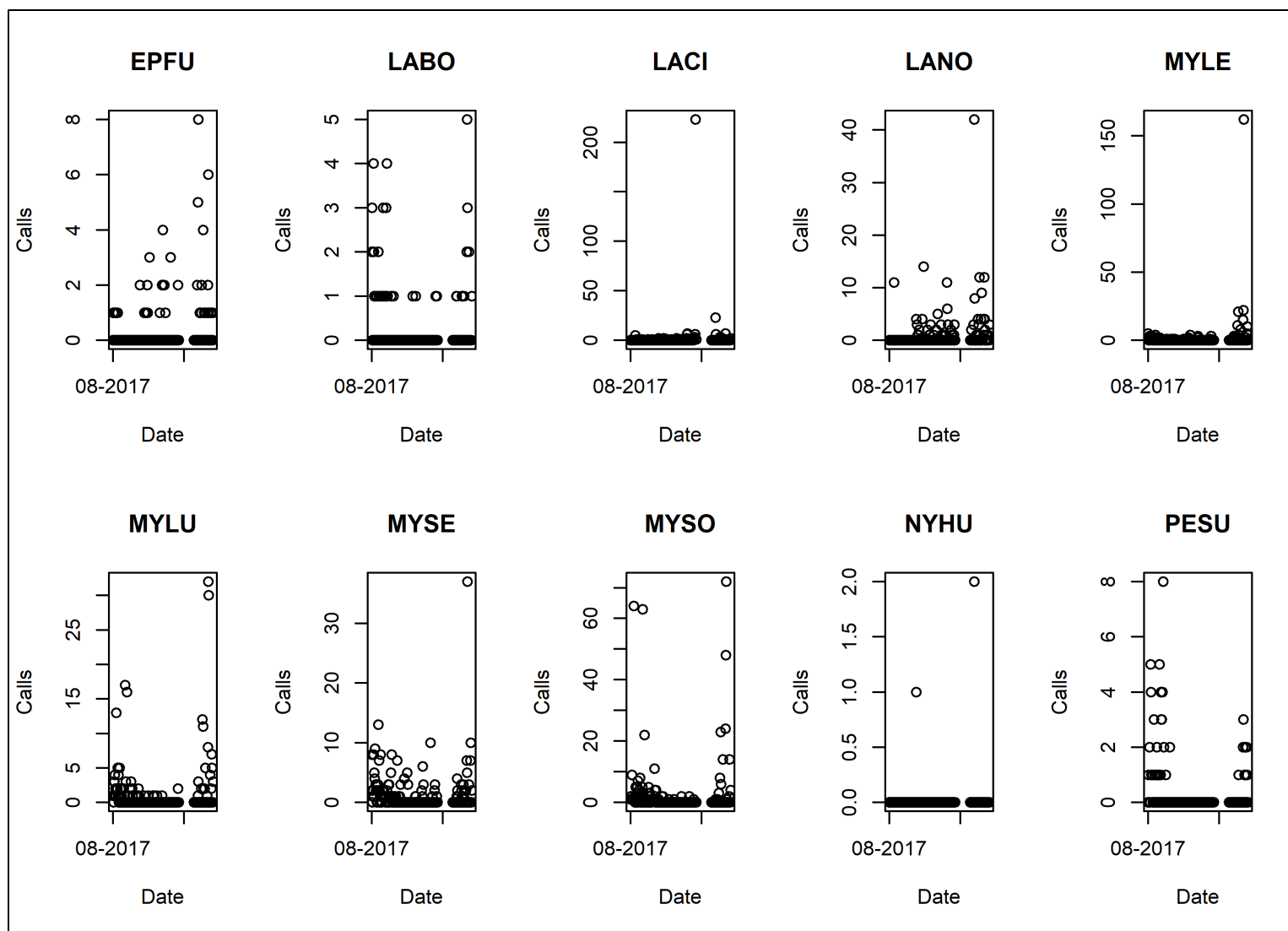


Figure C11. Echolocation calls recorded at RCAVE6-ACT.

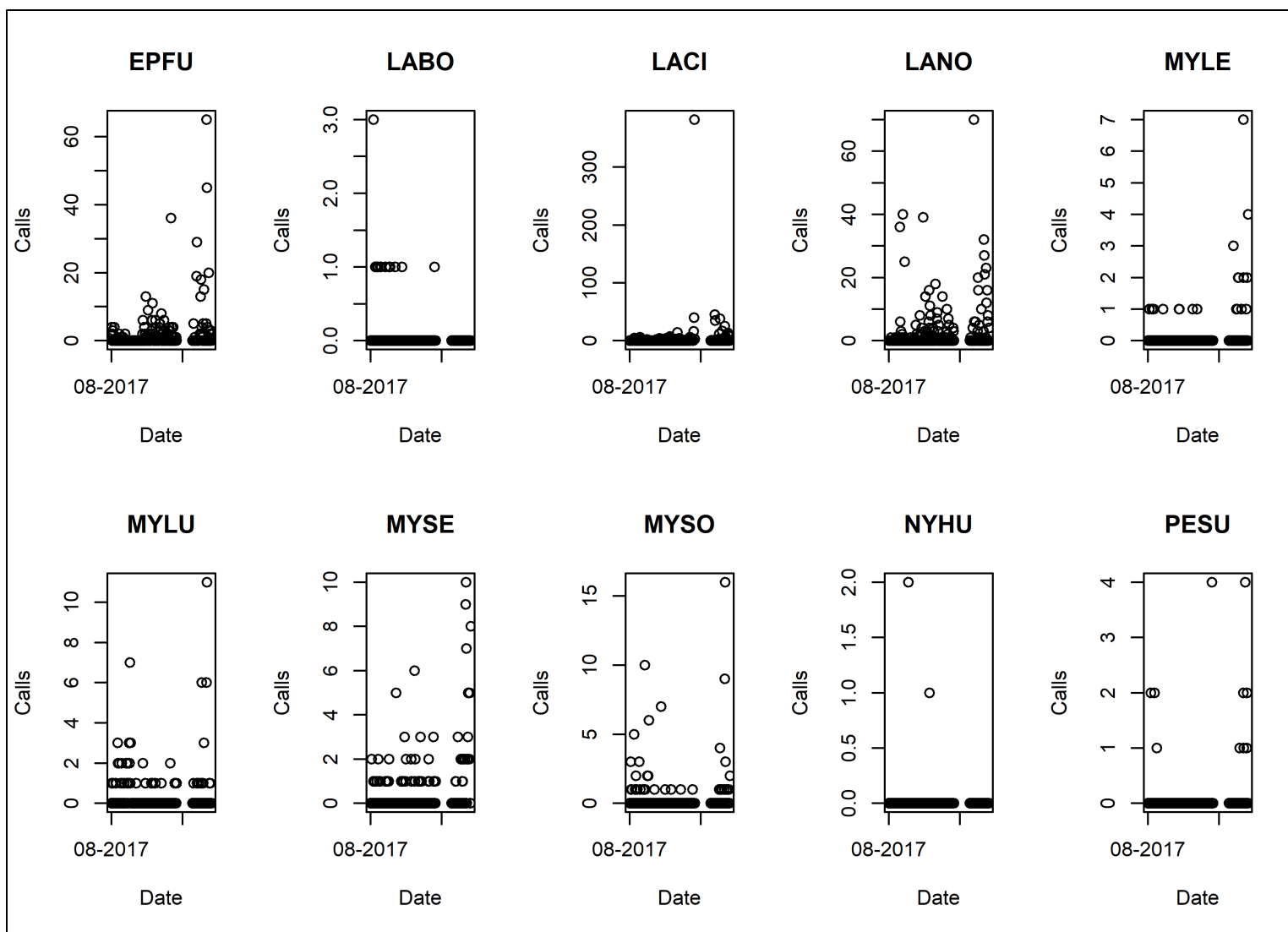


Figure C12. Echolocation calls recorded at RCAVE7-ACT.

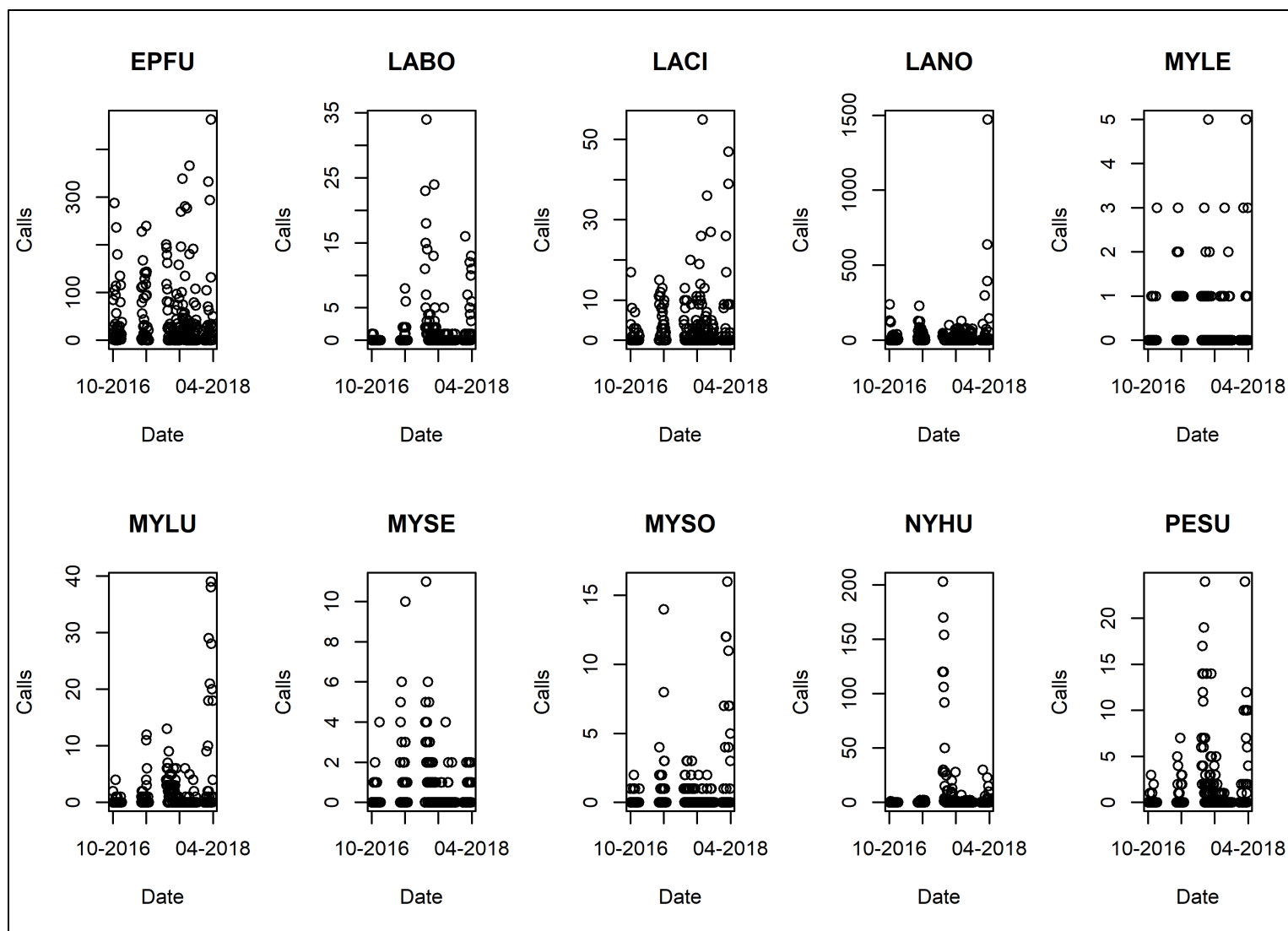


Figure C13. Echolocation calls recorded at ST-NR1-ACT.

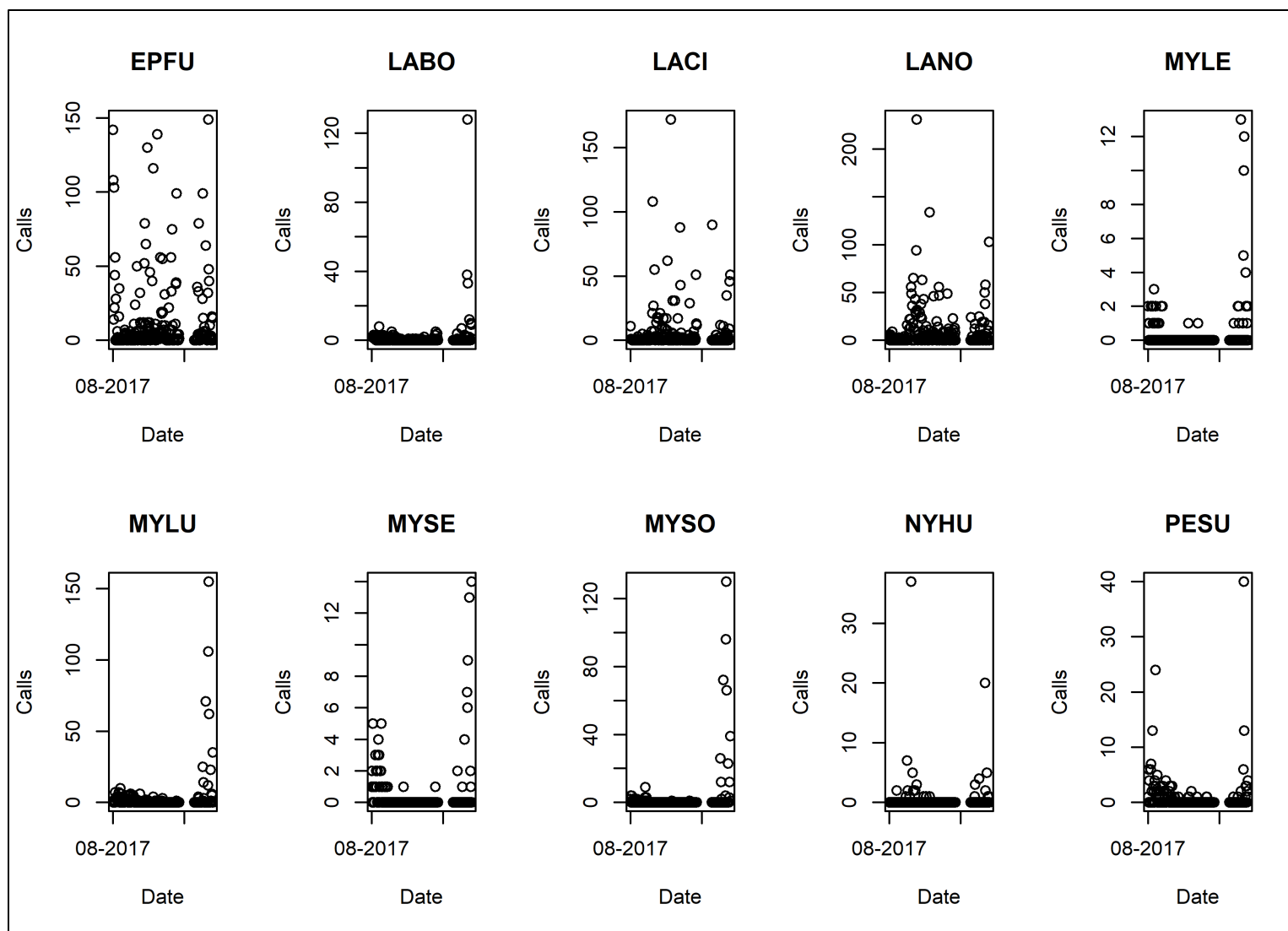


Figure C14. Echolocation calls recorded at ST-NR1-ACT.

Appendix D. Passive Acoustic Site-level Shannon-Wiener Diversity Indices

Table D1. Passive acoustic sites sampled within National Capital Region units, 15 May to 14 August 2016–2018 (Deeley et al. 2021b), and associated Shannon-Wiener Diversity Index (Index) and North American Bat Monitoring Program grid identification code (GRTS ID). Index values were based on the number of species identified as present at each site, based on Kaleidoscope Bats of North America 4.2.0 classifier MLE < 0.05.

Site	GRTS ID	Index
2LCAVE-ACT	110608	0.00
AA-FO1-ACT	49392	1.36
AA-OP1-ACT	49392	1.65
AB-FO13-ACT	51440	2.18
AB-FO1-ACT	51440	1.88
AB-FO2-ACT	51440	1.77
AB-FO4-ACT	51440	1.41
AB-FO6-ACT	51440	1.83
AB-OP1-ACT	51440	1.24
AB-OP2-ACT	51440	2.16
A-DEV1-ACT	1984	1.57
AD-FO15-ACT	53504	1.31
AD-FO17-ACT	53504	0.98
AD-FO1-ACT	53504	0.00
AD-FO3-ACT	53504	0.81
AD-FO4-ACT	53504	1.16
AD-FO6-ACT	53504	0.72
AD-FO8-ACT	53504	1.87
AD-FO9-ACT	53504	1.38
AD-OP1-ACT	53504	1.48
AE-FO1-ACT	55536	1.56
AF-FO1-ACT	61376	1.82
AF-FO2-ACT	61376	1.87
A-FO1-ACT	1984	1.27
AF-OP2-ACT	61376	1.79
AF-WE1-ACT	61376	1.74
AG-FO1-ACT	67071	1.25
AG-NR1-ACT	67071	1.66

Site	GRTS ID	Index
AG-NR2-ACT	67071	1.63
AG-ST	89937	1.80
AG-TR	89937	1.74
AG-WE2-ACT	67071	1.30
AJ-FO1-ACT	69848	2.17
AJ-FO2-ACT	69848	0.83
AJ-NR1-ACT	69848	1.52
AJ-NR2-ACT	69848	0.94
AJ-NR3-ACT	69848	0.84
AJ-OP10-ACT	69848	1.32
AJ-OP1-ACT	69848	1.04
AJ-OP3-ACT	69848	0.60
AJ-OP8-ACT	69848	1.21
AL-FO1-ACT	76120	1.82
AL-OP1-ACT	24832	1.68
AL-OP2-ACT	76120	1.74
AL-OP3-ACT	39152	1.59
AM-FO1-ACT	85757	0.90
AN-FO1-ACT	78210	1.24
AN-FO2-ACT	78210	0.83
AN-OP1-ACT	78210	1.65
ANTI-NR1-ACT	24832	1.67
ANTI-NR2-ACT	24832	1.57
ANTI-NR3-ACT	24832	1.82
ANTI-NR4-ACT	76120	0.33
ANTI-NR5-ACT	76120	1.23
ANTI-NR6-ACT	76120	1.08
ANTI-NR7-ACT	39152	0.33
ANTI-NR8-ACT	39152	1.03
AN-WE1-ACT	78210	0.62
AO-FO1-ACT	78725	1.36
AO-FO2-ACT	78725	1.99
AO-OP3-ACT	78725	1.53
A-OP1-ACT	1984	1.88
A-OP2-ACT	1984	1.54
AP-DEV1-ACT	81576	1.75

Site	GRTS ID	Index
AP-FO1-ACT	81576	1.05
AP-OP2-ACT	81576	1.70
AR-FO10-ACT	84482	1.02
AR-FO12-ACT	84482	0.00
AR-FO17-ACT	84482	0.92
AR-FO1-ACT	84482	1.93
AR-FO4-ACT	84482	1.63
AR-FO8-ACT	84482	1.66
AR-NR1-ACT	84482	0.82
AR-NR2-ACT	84482	1.55
AR-NR3-ACT	84482	0.80
AR-NR4-ACT	84482	1.39
AR-NR5-ACT	84482	1.07
AR-OP1-ACT	84482	1.23
AR-OP4-ACT	84482	1.18
AR-WE1-ACT	84482	1.56
AT-FO10-ACT	86574	1.44
AT-FO3-ACT	86574	1.98
AT-FO5-ACT	86574	1.07
AT-OP1-ACT	86574	1.58
AT-WE1-ACT	86574	1.70
AU-DEV1-ACT	89937	1.84
AU-FO11-ACT	89937	1.81
AU-FO13-ACT	89937	0.98
AU-FO14-ACT	89937	1.91
AU-FO15-ACT	89937	1.86
AU-FO16-ACT	89937	1.50
AU-FO18-ACT	89937	1.98
AU-FO1-ACT	89937	1.75
AU-FO3-ACT	89937	1.72
AU-FO9-ACT	89937	1.08
AU-OP1-ACT	89937	1.79
AU-OP5-ACT	89937	1.65
AU-RC1-ACT	89937	1.36
AU-RC2-ACT	89937	1.56
AU-RC3-ACT	89937	0.77

Site	GRTS ID	Index
AX-FO1-ACT	96210	1.43
AY-FO1-ACT	98064	1.99
AY-FO2-ACT	98064	0.85
AY-FO3-ACT	98064	1.89
AY-FO6-ACT	98064	1.69
AY-FO7-ACT	98064	1.68
AY-FO8-ACT	98064	1.71
AY-OP1-ACT	98064	1.77
AZ-DEV1-ACT	89937	1.14
AZ-FO1-ACT	100000	1.59
AZ-FO4-ACT	100000	1.22
AZ-OP13-ACT	89937	1.46
AZ-OP1-ACT	100000	1.75
AZ-WE2-ACT	100000	1.30
BA-OP1-ACT	100523	1.63
BC-DEV1-ACT	108363	1.84
BC-FO1-ACT	108363	1.06
BC-NR1-ACT	108363	1.33
BC-NR2-ACT	108363	1.65
BD-FO1-ACT	110086	1.86
BD-FO3-ACT	110086	1.86
BD-FO5-ACT	110086	1.92
BD-FO6-ACT	110086	1.99
BD-FO7-ACT	110086	1.83
BD-NR1-ACT	110086	1.54
BD-OP1-ACT	110086	0.69
BD-OP2-ACT	110086	1.73
BE-FO11-ACT	110608	1.69
BE-FO1-ACT	110608	0.76
BE-FO8-ACT	110608	0.00
BE-OP3-ACT	110608	1.85
BE-OP4-ACT	110608	1.47
BF-FO1-ACT	112699	1.57
BF-FO2-ACT	112699	1.92
BF-FO3-ACT	112699	1.96
BF-FO5-ACT	112699	2.08

Site	GRTS ID	Index
B-FO1-ACT	3312	1.47
B-FO2-ACT	3312	1.59
BG-DEV5-ACT	114111	1.66
BG-FO2-ACT	114111	1.30
BG-NR1-ACT	114111	0.71
BG-NR2-ACT	114111	2.01
BG-OP1-ACT	114111	1.93
BG-OP4-ACT	114111	1.87
BG-WE1-ACT	114111	1.38
BG-WE2-ACT	114111	1.77
BH-FO1-ACT	114790	1.36
BH-FO2-ACT	114790	1.91
BH-FO3-ACT	114790	1.94
BH-FO4-ACT	114790	1.85
BH-FO5-ACT	114790	2.11
BH-FO6-ACT	114790	1.65
BH-FO7-ACT	114790	1.78
BH-NR1-ACT	114790	2.08
BI-DEV1-ACT	115680	1.59
BI-FO3-ACT	115680	1.63
BI-FO4-ACT	115680	0.63
BI-FO5-ACT	115680	1.24
BI-OP10-ACT	115680	1.66
BI-OP13-ACT	115680	1.84
BI-OP14-ACT	115680	1.41
BI-OP20-ACT	115680	1.98
BI-OP3-ACT	115680	1.78
BI-OP4-ACT	115680	1.27
BI-OP5-ACT	115680	1.71
BI-OP6-ACT	115680	1.66
BI-OP8-ACT	115680	1.93
BI-OP9-ACT	115680	1.60
BK-FO1-ACT	118972	0.78
BK-FO2-ACT	118972	0.72
BK-WE1-ACT	118972	1.05
BK-WE2-ACT	118972	1.71

Site	GRTS ID	Index
BM-FO1-ACT	94937	1.58
BM-FO2-ACT	94937	0.80
BM-OP1-ACT	86574	0.45
BM-OP2-ACT	94937	1.91
BM-WE2-ACT	94937	0.69
BM-WE3-ACT	94937	1.07
B-NR1-ACT	3312	1.04
Burma_Fall-Winter	77393	1.39
CATO-10-ACT	53504	1.91
CATO-11-ACT	84482	1.52
CATO-12-ACT	84482	1.93
CATO-13-ACT	84482	1.43
CATO-14-ACT	53504	1.54
CATO-15-ACT	53504	1.27
CATO-16-ACT	53504	1.34
CATO-17-ACT	53504	1.73
CATO-18-ACT	53504	1.81
CATO-19-ACT	53504	1.69
CATO-1-ACT	84482	1.55
CATO-20-ACT	53504	0.21
CATO-21-P17	53504	1.00
CATO-22-ACT	53504	2.07
CATO-23-ACT	53504	1.97
CATO-24-ACT	53504	1.65
CATO-25-ACT	53504	1.04
CATO-2-ACT	84482	1.64
CATO-4-ACT	84482	1.04
CATO-5-ACT	84482	1.99
CATO-6-P17	84482	0.00
CATO-9-ACT	84482	1.04
C-FO13-ACT	3776	0.69
C-FO14-ACT	3776	0.54
C-FO1-ACT	3776	1.67
C-FO3-ACT	3776	1.94
CHAP-NR1-ACT	18368	1.36
CHOH-37-ACT	69848	1.79

Site	GRTS ID	Index
CHOH-38-ACT	69848	1.45
CHOH-39-ACT	61376	1.62
CHOH-41-ACT	61376	2.08
CHOH-42-ACT	16320	2.13
CHOH-43-ACT	78210	1.55
CHOH-44-ACT	78210	2.08
CHOH-45-ACT	86574	1.84
CHOH-46-ACT	86574	1.87
CHOH-48-ACT	86574	1.85
CHOH-49-ACT	94937	1.78
CHOH-50-ACT	94937	1.97
CHOH-51-ACT	94937	1.91
CHOH-52-ACT	28928	1.39
CHOH-NR1-ACT	47808	0.60
CHOH-NR2-ACT	47808	0.47
CHOH-NR3-ACT	47808	0.95
CHOH-NR4-ACT	47808	1.35
CHOH-NR5-ACT	47808	1.90
CHOH-NR6-ACT	47808	1.45
CHOH-NR7-ACT	47808	1.62
CHOH-NR8-ACT	47808	1.10
C-OP15-ACT	3776	1.97
C-OP1-ACT	3776	2.05
C-OP6-ACT	3776	1.10
C-OP8-ACT	3776	1.77
C-WE1-ACT	3776	1.30
C-WE2-ACT	3776	1.83
C-WE6-ACT	3776	0.00
DCAVE-ACT	118972	0.00
DREAM-NR1-ACT	89937	1.70
DREAM-NR2-ACT	89937	1.61
DYKE-NR1-ACT	114111	1.69
DYKE-NR2-ACT	114111	1.23
Elaine_Edge	85757	2.18
F-FO1-ACT	15040	2.18
FORTM-NR2-ACT	89937	1.69

Site	GRTS ID	Index
FORTS-NR1-ACT	100000	1.33
GARCH-NR1-ACT	89937	1.79
GARCH-NR2-ACT	89937	0.94
G-FO5-ACT	16320	1.61
G-FO6-ACT	16320	1.74
GFP-NR1-ACT	47808	1.58
GFP-NR2-ACT	47808	2.02
GFP-NR3-ACT	47808	1.11
G-OP1-ACT	16320	1.64
G-WE1-ACT	16320	1.93
HAFE-12-ACT	69848	1.22
HAFE-13-ACT	69848	1.68
HAFE-4-ACT	69848	1.73
HAFE-8-ACT	69848	1.50
HAFE-9-ACT	69848	1.43
HAFE-NR1-ACT	69848	0.00
HAFE-NR2-ACT	69848	0.57
HAFE-NR3-ACT	69848	0.00
HAFE-NR4-ACT	69848	1.28
HAFE-NR6-ACT	69848	0.54
HAFE-NR7-ACT	69848	1.63
HAFE-NR8-ACT	69848	1.73
HAFE-NR9-ACT	69848	0.00
H-DEV10-ACT	18368	0.95
H-DEV13-ACT	18368	1.19
H-DEV14-ACT	18368	1.86
H-DEV18-ACT	18368	1.47
H-DEV3-ACT	18368	2.02
H-FO10-ACT	18368	1.21
H-FO11-ACT	18368	1.33
H-FO12-ACT	18368	1.56
H-FO13-ACT	18368	1.36
H-FO1-ACT	18368	1.58
H-FO6-ACT	18368	1.89
H-FO8-ACT	1984	1.39
H-NR1-ACT	18368	1.45

Site	GRTS ID	Index
H-NR2-ACT	18368	1.11
H-NR3-ACT	18368	1.94
H-OP16-ACT	18368	1.70
H-OP18-ACT	18368	1.83
H-OP1-ACT	18368	1.65
H-OP20-ACT	18368	1.97
HUNT-NR1-ACT	29632	1.70
HUNT-NR2-ACT	29632	1.00
H-WE3-ACT	18368	1.25
IN-NR1-ACT	19696	2.05
IN-NR2-ACT	19696	1.72
J-FO15-ACT	19696	1.85
J-FO17-ACT	19696	1.98
J-FO18-ACT	19696	1.88
J-FO1-ACT	19696	1.91
J-FO20-ACT	19696	1.76
J-FO2-ACT	19696	2.02
J-FO3-ACT	19696	1.85
J-NR1-ACT	19696	0.90
JONES-NR1-ACT	114111	1.15
JONES-NR2-ACT	114111	1.82
KCAVE-ACT	78725	1.39
KE-NR2-ACT	51440	2.03
KE-NR3-ACT	51440	1.91
Lake_One_Fall-Winter	77393	1.95
LBJ-NR1-ACT	18368	1.91
LBJ-NR2-ACT	18368	1.68
L-FO12-ACT	24832	0.22
L-FO1-ACT	24832	0.59
L-FO3-ACT	24832	1.98
L-FO6-ACT	24832	1.74
L-FO7-ACT	24832	1.88
L-FO9-ACT	24832	0.88
L-OP6-ACT	24832	1.70
L-OP7-ACT	24832	1.74
MONO-NR1-ACT	115680	0.98

Site	GRTS ID	Index
MONO-NR2-ACT	115680	0.88
M-OP1-ACT	25840	1.87
NACC-10-ACT	18368	1.75
NACC-14-ACT	18368	1.17
NACC4-ACT	18368	1.74
NACC5-ACT	18368	1.89
N-FO1-ACT	26864	0.68
N-FO1-ACT2	26864	1.78
N-FO2-ACT	26864	1.35
N-FO3-ACT	26864	0.73
N-NR1-ACT	26864	1.38
O-DEV1-ACT	28928	1.41
O-FO1-ACT	28928	0.81
O-OP1-ACT	28928	1.88
O-WE1-ACT	28928	0.66
P-FO15-ACT	29632	1.61
P-FO1-ACT	29632	0.21
P-FO20-ACT	29632	1.28
PINE-NR1-ACT	89937	1.84
PINE-NR2-ACT	89937	1.61
P-NR2-ACT	29632	1.32
P-NR3-ACT	29632	0.00
P-OP17-ACT	29632	1.82
P-OP19-ACT	29632	1.47
P-OP4-ACT	29632	2.00
PP-NR1-ACT	51440	2.06
PW_B_INT_2_ACT	96210	0.71
PW_B_INT_3_ACT	96210	1.35
PW_B_INT_6_ACT	15040	1.76
PW_B_INT_9_ACT	15040	1.74
PW_B_LOW_1_ACT	96210	0.82
PW_B_LOW_3_ACT_U!	15040	2.21
PW_B_LOW_6_ACT	96210	1.97
PW_B_LOW_7_ACT	96210	0.59
PW_B_UP_2_ACT	96210	1.21
PW_B_UP_3_ACT	96210	0.79

Site	GRTS ID	Index
PW_B_UP_7_ACT	96210	2.06
PW_B_UP_9_ACT	96210	1.96
PW_U_INT_13_ACT	85757	1.44
PW_U_INT_18_ACT	85757	1.05
PW_U_INT_2_ACT	85757	1.80
PW_U_INT_26_ACT	85757	0.70
PW_U_INT_27_ACT	85757	0.62
PW_U_INT_33_ACT	85757	1.27
PW_U_INT_40_ACT	96210	1.36
PW_U_INT_7_ACT	96210	0.94
PW_U_LOW_1_ACT	15040	2.18
PW_U_LOW_2_ACT	96210	1.93
PW_U_LOW_26_ACT	77393	1.90
PW_U_LOW_31_ACT	85757	2.12
PW_U_LOW_35_ACT	96210	2.13
PW_U_LOW_45_ACT	96210	1.93
PW_U_LOW_52_ACT	96210	2.17
PW_U_LOW_9_ACT	96210	1.14
PW_U_UP_13_ACT	85757	1.51
PW_U_UP_17_ACT	96210	1.10
PW_U_UP_21_ACT	96210	0.80
PW_U_UP_28_ACT	77393	0.35
PW_U_UP_3_ACT	77393	2.08
PW_U_UP_31_ACT	96210	2.04
PW_U_UP_33_ACT	96210	1.47
PW_U_UP_4_ACT	77393	1.89
P-WE3-ACT	29632	0.95
RCAVE5-ACT	98064	0.00
RCAVE6-ACT	98064	0.69
RCAVE7-ACT	98064	0.00
R-FO1-ACT	33024	0.76
R-FO1-ACT-2	33024	1.94
R-NR1-ACT	33024	1.94
R-NR2-ACT	33024	1.46
ROCR18-A1	89937	1.38
ROCR18-B1	89937	0.46

Site	GRTS ID	Index
ROCR18-B2	89937	1.31
ROCR18-B3	89937	1.28
ROCR18-B4	89937	0.89
ROCR18-B5	89937	1.43
ROCR18-B6	89937	0.75
ROCR18-C1	89937	1.22
ROCR18-C10	89937	1.13
ROCR18-C11	89937	0.95
ROCR18-C12	89937	1.17
ROCR18-C13	89937	1.04
ROCR18-C14	89937	1.45
ROCR18-C2	89937	1.41
ROCR18-C3	89937	1.70
ROCR18-C4	89937	0.93
ROCR18-C5	89937	1.01
ROCR18-C6	89937	1.39
ROCR18-C7	89937	1.29
ROCR18-C8	89937	1.35
ROCR18-C9	89937	1.33
ROCR18-D1	89937	1.57
ROCR18-D10	89937	1.46
ROCR18-D11	89937	1.55
ROCR18-D12	89937	1.31
ROCR18-D13	89937	1.58
ROCR18-D14	89937	1.50
ROCR18-D15	89937	1.07
ROCR18-D16	89937	0.93
ROCR18-D17	89937	0.68
ROCR18-D18	89937	1.06
ROCR18-D19	89937	1.35
ROCR18-D2	89937	1.06
ROCR18-D20	89937	1.16
ROCR18-D21	89937	1.35
ROCR18-D3	89937	1.86
ROCR18-D4	89937	1.00
ROCR18-D5	89937	1.81

Site	GRTS ID	Index
ROCR18-D6	89937	1.74
ROCR18-D7	89937	1.69
ROCR18-D8	89937	1.40
ROCR18-D9	89937	1.67
ROCR18-E1	89937	1.58
ROCR18-E10	89937	1.82
ROCR18-E11	89937	1.74
ROCR18-E12	89937	1.77
ROCR18-E13	89937	1.38
ROCR18-E14	89937	1.53
ROCR18-E15	89937	1.51
ROCR18-E16	89937	1.10
ROCR18-E17	89937	1.08
ROCR18-E18	89937	1.37
ROCR18-E19	89937	0.98
ROCR18-E20	89937	1.20
ROCR18-E21	89937	1.13
ROCR18-E22	89937	1.61
ROCR18-E23	89937	1.55
ROCR18-E24	89937	1.78
ROCR18-E25	89937	1.34
ROCR18-E26	89937	1.84
ROCR18-E3	89937	1.34
ROCR18-E4	89937	1.64
ROCR18-E5	89937	1.53
ROCR18-E6	89937	1.81
ROCR18-E7	89937	1.74
ROCR18-E8	89937	0.91
ROCR18-E9	89937	1.36
ROCR18-F1	89937	1.52
ROCR18-F10	89937	1.43
ROCR18-F11	89937	1.61
ROCR18-F12	89937	1.62
ROCR18-F13	89937	1.74
ROCR18-F14	89937	1.78
ROCR18-F15	89937	1.42

Site	GRTS ID	Index
ROCR18-F16	89937	1.81
ROCR18-F17	89937	1.34
ROCR18-F18	89937	0.93
ROCR18-F19	89937	1.52
ROCR18-F2	89937	1.36
ROCR18-F20	89937	1.45
ROCR18-F21	89937	1.26
ROCR18-F22	89937	1.09
ROCR18-F23	89937	0.97
ROCR18-F24	89937	1.24
ROCR18-F25	89937	1.13
ROCR18-F26	89937	0.80
ROCR18-F27	89937	0.58
ROCR18-F28	89937	0.97
ROCR18-F29	89937	1.19
ROCR18-F3	89937	0.97
ROCR18-F30	89937	0.58
ROCR18-F4	89937	0.97
ROCR18-F5	89937	1.02
ROCR18-F6	89937	1.34
ROCR18-F7	89937	1.53
ROCR18-F8	89937	1.78
ROCR18-F9	89937	1.57
RO-NR1-ACT	89937	1.87
S-FO11-ACT	35056	1.81
S-FO2-ACT	35056	1.34
S-FO4-ACT	35056	1.43
S-FO5-ACT	35056	1.60
S-FO6-ACT	35056	1.87
S-FO9-ACT	35056	1.87
SLOCUM-NR1-ACT	100000	1.58
S-OP1-ACT	35056	0.69
S-OP2-ACT	35056	1.82
ST-NR1-ACT	114790	1.90
ST-NR2-ACT	114790	1.89
T-FO1-ACT	35520	1.52

Site	GRTS ID	Index
T-FO2-ACT	35520	1.85
T-OP1-ACT	35520	1.96
T-OP2-ACT	35520	1.70
T-OP5-ACT	35520	1.68
T-OP9-ACT	35520	1.43
TOTTEN-NR2-ACT	100000	2.17
TRI-NR1-ACT	81576	0.96
TRI-NR2-ACT	81576	1.52
TURK-NR1-ACT	89937	1.32
TURK-NR2-ACT	89937	1.20
T-WE3-ACT	35520	1.58
V-FO10-ACT	39152	1.67
V-FO1-ACT	39152	1.64
V-FO2-ACT	39152	1.92
V-FO9-ACT	39152	1.68
V-NR1-ACT	39152	0.62
V-NR2-ACT	39152	1.66
V-NR3-ACT	39152	1.48
V-OP10-ACT	39152	1.32
V-OP11-ACT	39152	1.83
V-OP1-ACT	39152	1.65
V-OP2-ACT	39152	1.82
V-OP3-ACT	39152	1.64
WASH-NR1-ACT	29632	1.12
WASH-NR2-ACT	29632	1.52
WASH-NR3-ACT	29632	1.77
WOTR-1-ACT	31424	1.61
WOTR-2-ACT	47808	1.39
WOTR-3-ACT	47808	2.01
WOTR-4-ACT	47808	1.61
WOTR-6-P17	47808	1.63
WOTR-8-ACT	47808	1.34
WOTR-NR1-ACT	47808	1.73
WOTR-NR2-ACT	47808	1.58
WOTR-NR3-ACT	47808	1.51
WOTR-NR4-ACT	31424	1.74

Site	GRTS ID	Index
WOTR-NR5-ACT	31424	1.29
WOTR-NR6-ACT	31424	1.65
WOTR-NR7-ACT	47808	1.26
WOTR-NR8-ACT	47808	1.01
WOTR-NR9-ACT	47808	1.31
Z-DEV2-ACT	47808	1.43
Z-FO14-ACT	47808	1.26
Z-FO1-ACT	47808	1.67
Z-FO3-ACT	47808	1.72
Z-FO4-ACT	47808	1.61
Z-OP2-ACT	47808	1.86
Z-OP5-ACT	47808	1.68
Z-OP6-ACT	47808	1.93
Z-WE1-ACT	47808	1.55

Appendix E. North American Bat Monitoring Program Grid-Level Presence Data for National Capital Region Units

North American Bat (NABat) Monitoring Program grid-level mean presence of little brown (*Myotis lucifugus*; MYLU), northern long-eared (*Myotis septentrionalis*; MYSE), Indiana (*Myotis sodalis*; MYSO), and tri-colored bat (*Perimyotis subflavus*; PESU) between 15 May and 14 Aug 2016–2018 (Figures E1–E4). Species were determined as present using Kaleidoscope Bats of North America 4.2.0 classifier $MLE < 0.05$. The grid-level mean presence was calculated by taking the mean of the proportion of nights a species was present at each passive acoustic site contained within the grid cell.

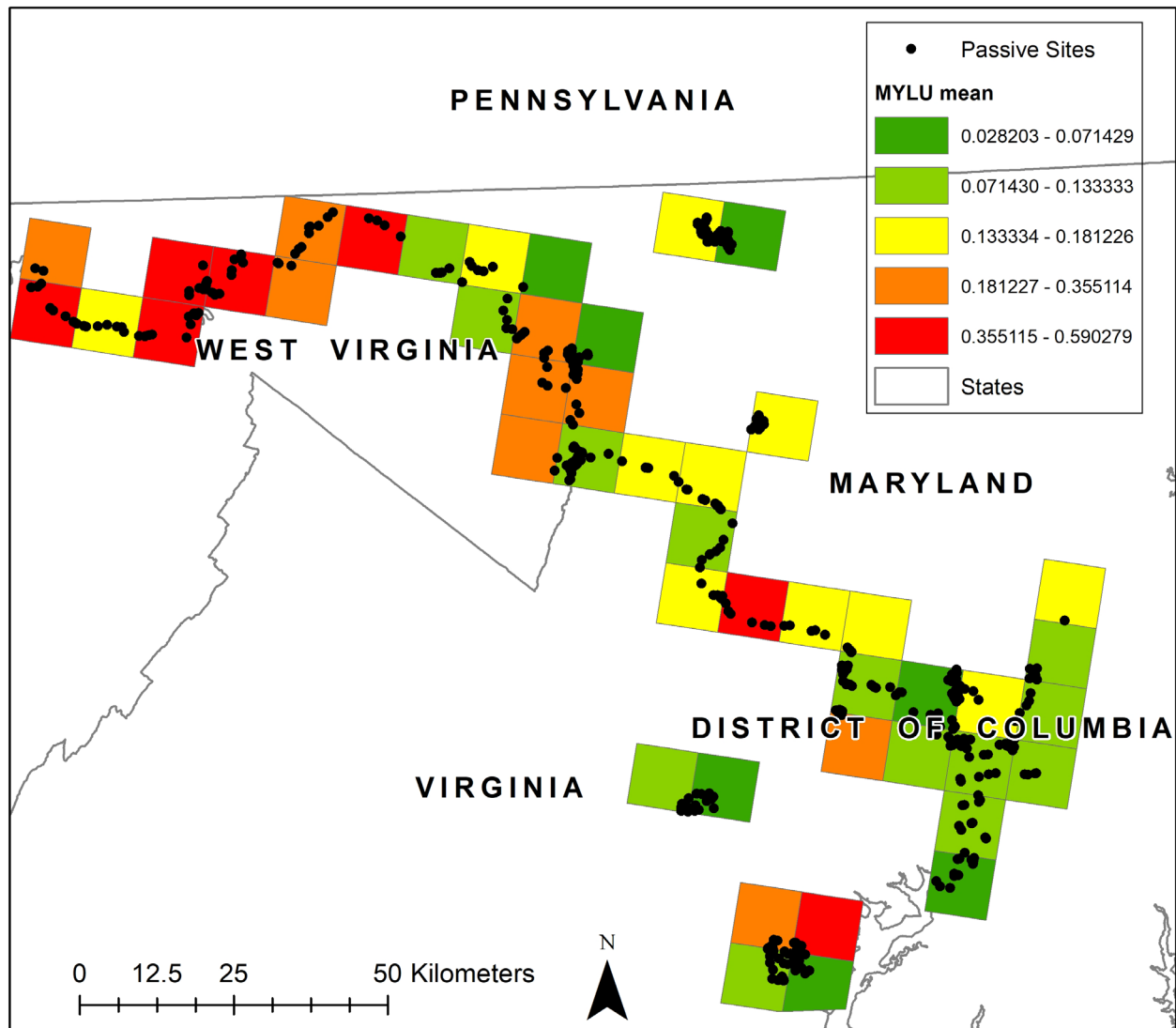


Figure E1. Mean presence of MYLU by NABat grid.

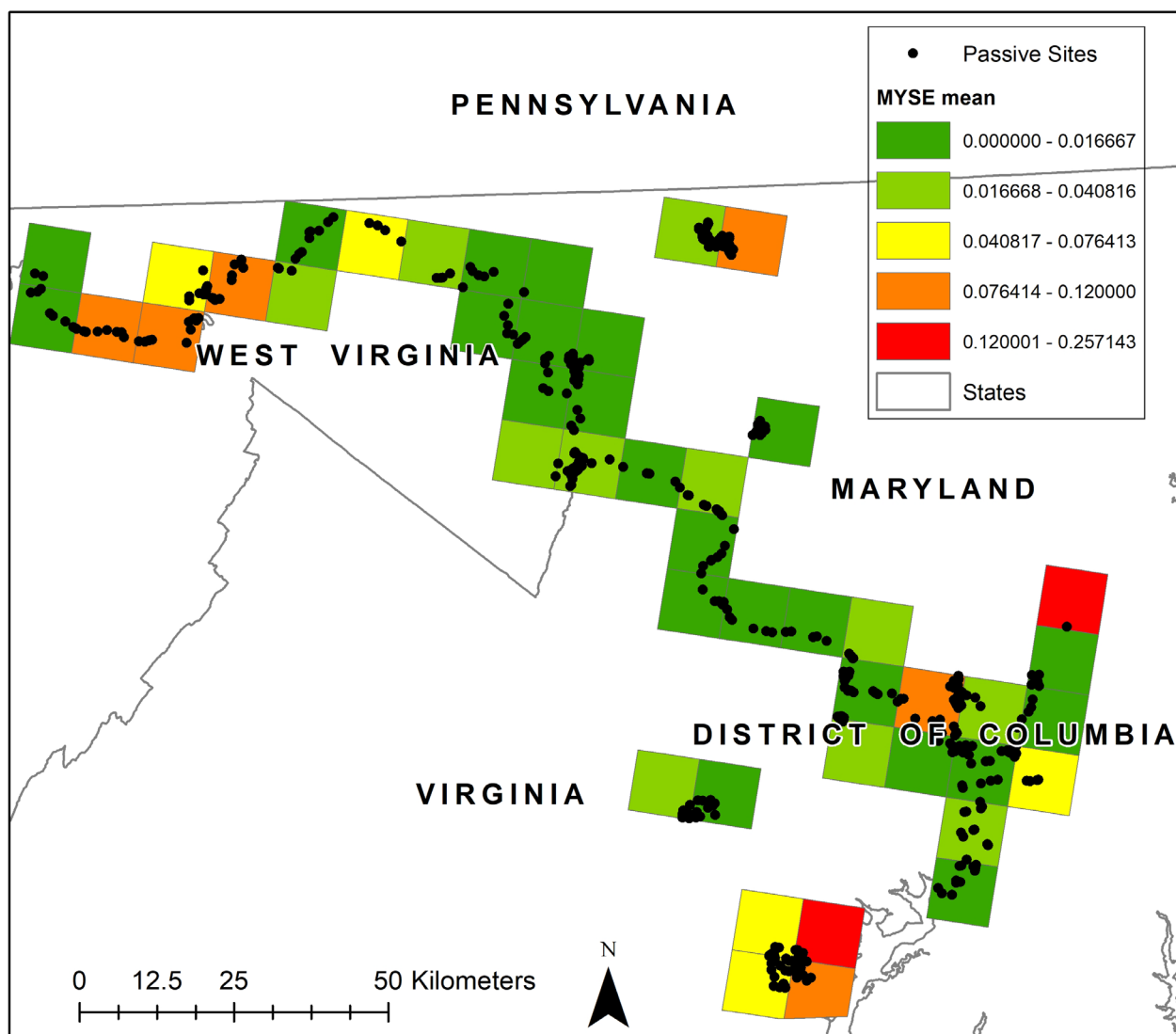


Figure E2. Mean presence of MYSE by NABat grid.

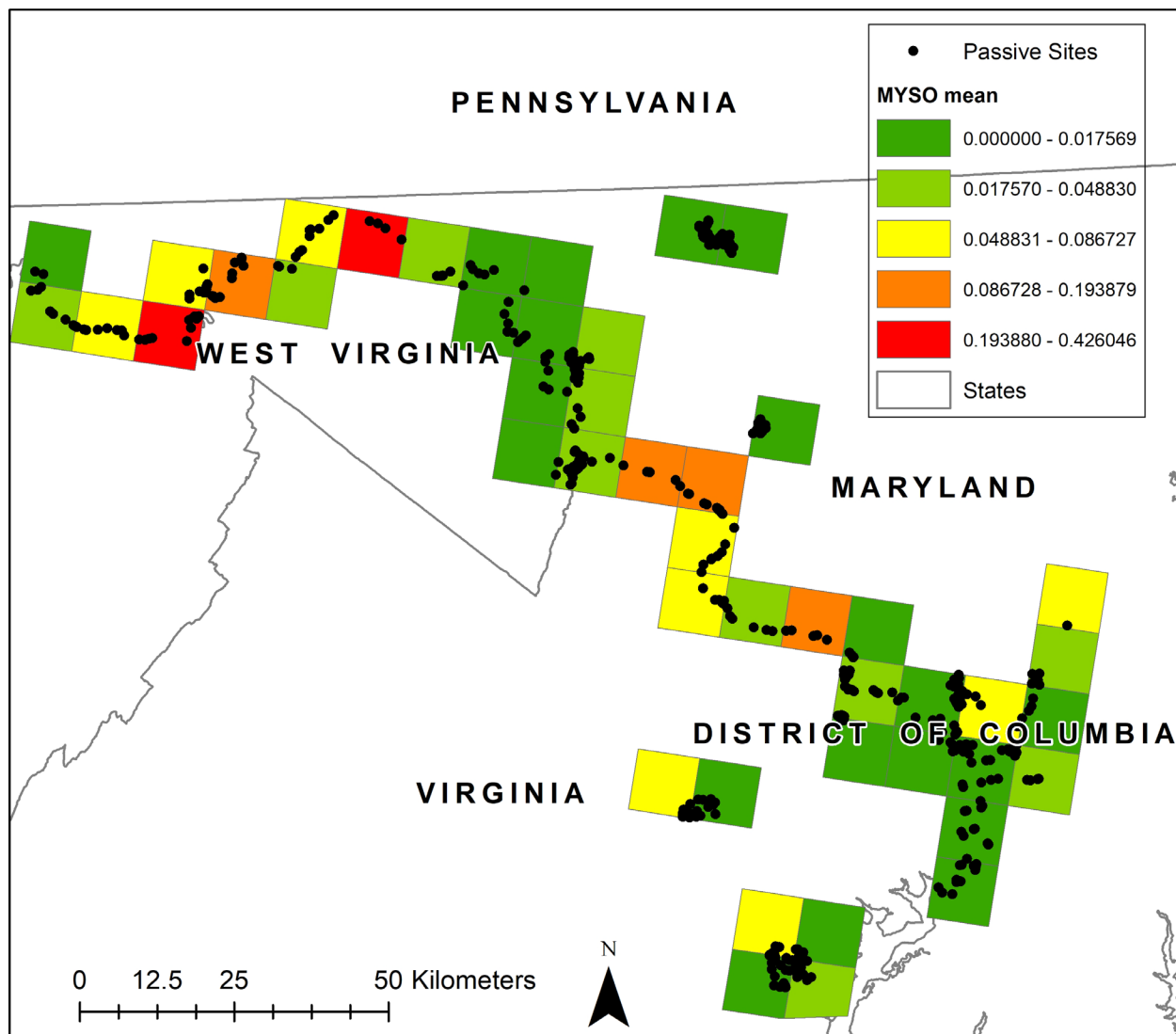


Figure E3. Mean presence of MYSO by NABat grid.

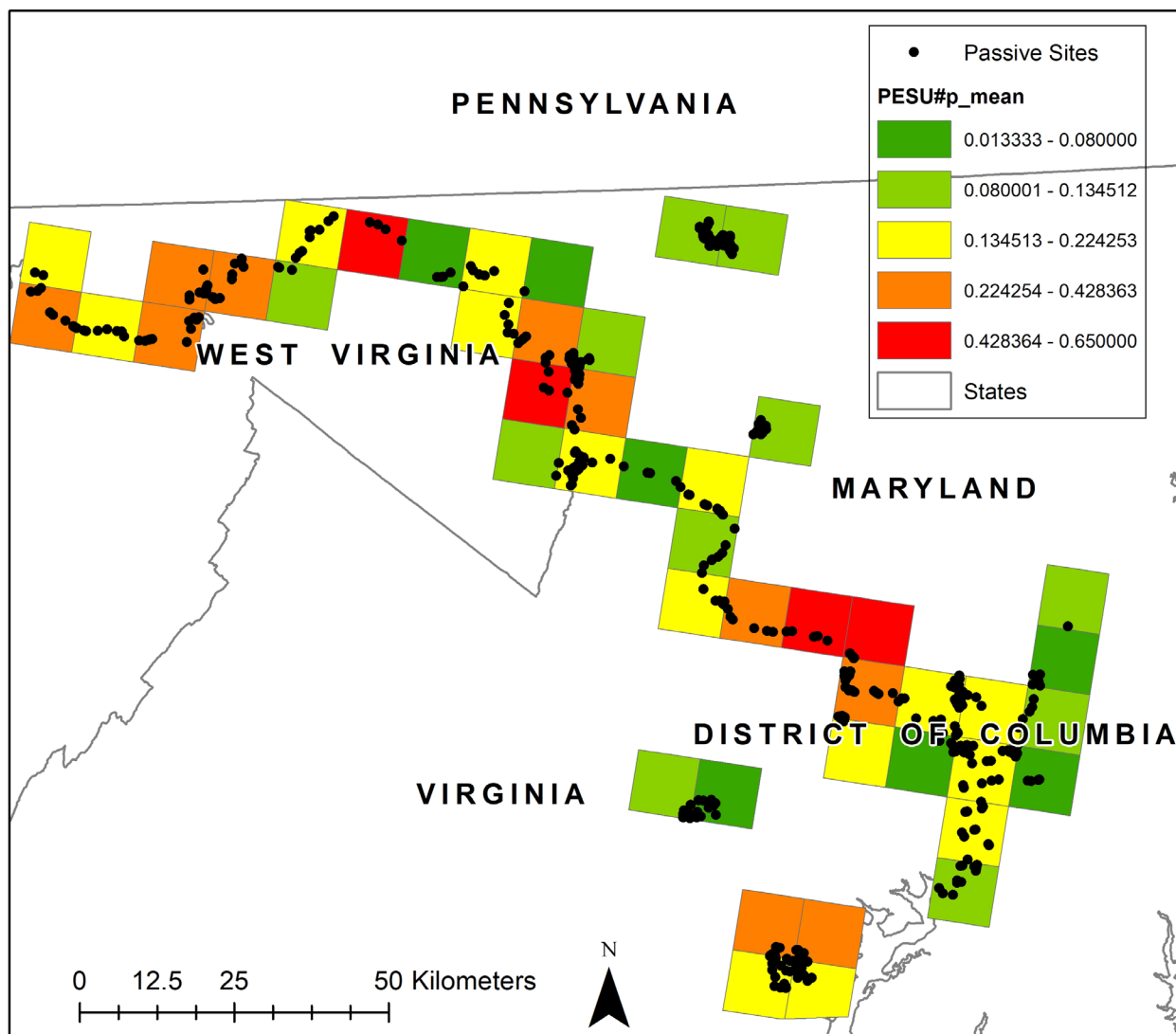


Figure E4. Mean presence of PESU by NABat grid.

Appendix F. Bat Day Roosting within Three National Capital Region Units

Roosting information for northern long-eared (*Myotis septentrionalis*; MYSE) and tri-colored bats (*Perimyotis subflavus*; PESU), based on bat captures within the NPS National Capital Region 2016 – 2018 (Tables F1–F2).

Table F1. Northern long-eared bat day roosts in Prince William Forest Park (PRWI) and Rock Creek Park (ROCR), and one tri-colored bat roosting area in Chesapeake and Ohio Canal National Historical Park (CHOH).

Unit	Year	Site	Latitude	Longitude	Comment	Tree Condition	Tree DBH (cm)	Tree Species	Roost Type
PRWI	2017	A56654-1	38.562132	-77.372335	–	Snag	47.4	<i>Quercus rubra</i>	Bark
PRWI	2017	A56654-2	38.565949	-77.371124	–	Snag	69	<i>Quercus rubra</i>	Bark
PRWI	2017	A56654-3	38.565863	-77.370349	–	Snag	34	<i>Liriodendron tulipifera</i>	Bark
PRWI	2018	A53549-1	38.549342	-77.39095	–	Snag	7.5	<i>Acer rubrum</i>	Cavity
PRWI	2018	A53549-2	38.55142	-77.390356	–	Live	10.8	<i>Acer rubrum</i>	Cavity
ROCR	2016	ROCR-R1-16	38.954883	-77.047121	–	Live	5.5	<i>Acer rubrum</i>	Cavity
ROCR	2016	ROCR-R2-16	38.952993	-77.048165	–	Live	6.5	<i>Fagus grandifolia</i>	Cavity
ROCR	2016	ROCR-R3-16	38.958485	-77.046743	–	Snag	24.4	<i>Liriodendron tulipifera</i>	Cavity
ROCR	2016	ROCR-R5-16	38.954898	-77.046971	–	Live	2.7	<i>Acer rubrum</i>	Cavity
ROCR	2017	ROCR-R1-17	38.96685	-77.045992	–	Live	47.5	<i>Nyssa sylvatica</i>	Bark
ROCR	2017	ROCR-R2-17	38.968955	-77.044075	–	Live	46.5	<i>Liriodendron tulipifera</i>	–
ROCR	2017	ROCR-R4-17	38.953659	-77.041185	–	Live	19.3	<i>Fagus grandifolia</i>	–
ROCR	2017	ROCR-R5-17	38.958881	-77.039631	–	Live	47.5	<i>Quercus alba</i>	Bark
ROCR	2017	ROCR-R6-17	38.920975	-77.083032	–	Live	34.2	<i>Liriodendron tulipifera</i>	Cavity & Bark
ROCR	2017	ROOST-RC3-17	38.970557	-77.04354	–	Live	5.7	<i>Acer rubrum</i>	Cavity
ROCR	2018	.655R1	38.921003	-77.083894	Could not find exact tree	Unknown	–	–	–
ROCR	2018	2725HOUSE-16JUNE18	38.985447	-77.05639	Private Property	House	–	–	House

Table F1 (continued). Northern long-eared bat day roosts in Prince William Forest Park (PRWI) and Rock Creek Park (ROCR), and one tri-colored bat roosting area in Chesapeake and Ohio Canal National Historical Park (CHOH).

Unit	Year	Site	Latitude	Longitude	Comment	Tree Condition	Tree DBH (cm)	Tree Species	Roost Type
ROCR	2018	ROCR18-R1	38.95047	-77.052397	–	Live	201	Quercus alba	Bark
ROCR	2018	ROCR-18-R2	38.94838	-77.047806	–	Live	8.9	Fagus grandifolia	Cavity
ROCR	2018	ROCR-18-R3	38.944439	-77.046358	–	Snag	3.6	Acer rubrum	Cavity
ROCR	2018	ROCR-18-R4	38.946867	-77.050584	–	Live	3.6	Fagus grandifolia	Cavity
ROCR	2018	ROCR-18-R5	38.949463	-77.043985	–	Live	33	Quercus montana	-
ROCR	2018	ROCR2018-R6	38.920876	-77.08332	–	Live	17.9	Quercus alba	Cavity & Bark
ROCR	2018	ROCR-R10	38.98415	-77.050366	–	Live	28	Quercus coccinea	Cavity & Bark
ROCR	2018	ROCR-R11	38.984318	-77.050401	–	Live	15	Fagus grandifolia	Cavity
ROCR	2018	ROCR-R12	38.983513	-77.04649	–	Live	9.7	Fagus grandifolia	Cavity
ROCR	2018	ROCR-R7	38.957244	-77.055323	–	Live	31.3	Liriodendron tulipifera	Bark
ROCR	2018	ROCR-R8	38.95829	-77.054621	–	Live	17.2	Fagus grandifolia	Cavity
ROCR	2018	ROCR-R9	38.985497	-77.05432	–	Live	34.5	Quercus falcata	Cavity
CHOH	2018	*PESU roost	39.570417	-77.83025	Could not find exact tree	Unknown	–	–	–

Table F2. Exit counts of northern long-eared bat day roosts in Prince William Forest Park (PRWI) and Rock Creek Park (ROCR).

Area	Date	Site	Bats
ROCR	24-May-16	ROCR-R2-16	8
ROCR	26-May-16	ROCR-R1-16	0
ROCR	26-May-16	ROCR-R2-16	0
ROCR	26-May-16	ROCR-R3-16	4
ROCR	26-May-16	ROCR-R5-16	1
ROCR	30-May-16	ROCR-R2-16	0
ROCR	30-May-16	ROCR-R3-16	0
ROCR	24-Jun-16	ROCR-R1-16	2
ROCR	24-May-17	ROCR-R4-17	0
ROCR	26-May-17	ROCR-R4-17	0
ROCR	27-May-17	ROCR-R5-17	1
ROCR	13-May-18	ROCR-18-R2	1
ROCR	15-May-18	ROCR-18-R2	0
ROCR	15-May-18	ROCR-18-R4	0
ROCR	15-May-18	ROCR-18-R5	1
ROCR	30-May-18	.655R1	0
ROCR	01-Jun-18	ROCR2018-R6	0
ROCR	08-Jun-18	ROCR-R7	1
ROCR	14-Jun-18	2725HOUSE-16JUNE18	0
ROCR	18-Jun-18	ROCR-R9	0
ROCR	19-Jun-18	ROCR-R11	0
PRWI	16-Jul-17	A56654-1	1
PRWI	17-Jul-17	A56654-2	4

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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