Federal Aid in Wildlife Restoration

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# Species of Greatest Conservation Need Mammal Research and Management

Final Report

for

January 1, 2019–December 31, 2021

Revised on 12/21/2022


**NJ Department of Environmental Protection**

**DIVISION OF FISH AND WILDLIFE**

**ENDANGERED AND NONGAME SPECIES PROGRAM**

**P.O. BOX 420**

**TRENTON, NJ 08625**

## Project 1. SGCN Mammal Research and Management

The objectives of this grant are to:

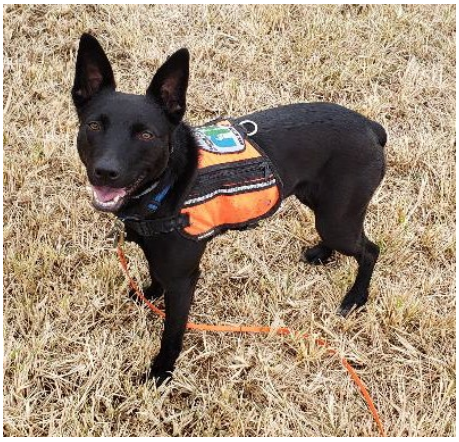
1. Identify and monitor the distribution, abundance and density, population and genetic structure, demographics, mortality factors, stressors, and habitat needs of New Jersey's bobcat population, and use the information to guide recovery and inform management decisions.
2. Understand the size and trend of NJ's Allegheny woodrat (*Neotoma magister*) population, and assess and mitigate threats including those posed by raccoon roundworm (*Baylisascaris procyonis*) and genetic bottleneck(s).
3. Develop and implement survey and habitat sampling protocols for several species of terrestrial small mammals that can be used to measure and monitor small mammal populations statewide.
4. Identify, characterize, monitor, and manage the seasonal habitats and needs of New Jersey's bat species, particularly those impacted by White-nose Syndrome, such as little brown bats (*Myotis lucifugus*) and the federally listed Indiana (*M. sodalis*) and northern long-eared (*M. septentrionalis*) bats, as well as NJ migratory bat species.
5. Identify and implement habitat management projects that benefit the state's mammal population and evaluate success with appropriate pre- and post-monitoring surveys. For ground-based, terrestrial mammals, the high road density of NJ results in separation of suitable habitat patches that can limit species movement and population recovery. Identifying these limiting sites is one of the objectives of the CHANJ project (NJ WSFR grant T-11-T-2, Job 3). Mitigating them with habitat management, and follow-up monitoring, is essential to an adaptive management approach.

**Objective 1 – Bobcat population management**

Prepared by: Gretchen Fowles

Key Findings:

- ENSP continued surveying for bobcat scat using the new detection dog, "Fly," acquired in June 2019 from Working Dogs for Conservation (WD4C). We continued to survey across NJ with her, in northern NJ as well where she would have a greater likelihood of finding bobcat scat, to keep her confidence high. The detection team surveyed approximately 35 sites in 2021 (N = 17 north of Rte. 78, N = 18 south of Rte. 78) (Fig. 1). All samples collected were GPSed and submitted to the National Genomics Center for Wildlife and Fish Conservation for DNA analysis. There are 5 samples yet to be analyzed, but otherwise, at the sites north of Rte. 78, 16 bobcat scats were confirmed, representing 8 individuals. At the sites south of Rte. 78, no bobcat scats were collected. The results were added to ENSP's bobcat database.



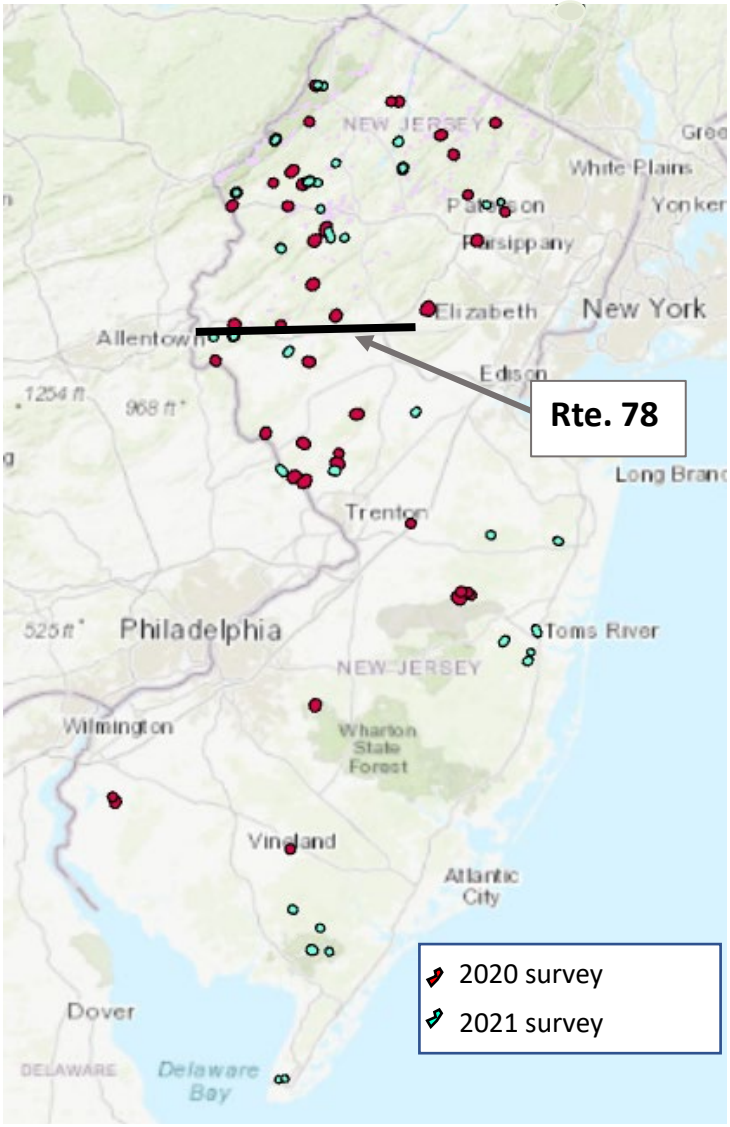



Figure 1. Sites surveyed by detection dog team for bobcat scat in NJ in 2020 and 2021. Approximately 47 sites were surveyed north of Rte. 78 (black line) and 38 south of Rte. 78, with all bobcat scats (N=60) except for 1 found north of Rte. 78.

- ENSP is continuing to collaborate with two Wildlife Conservation Corps (WCC) volunteers to conduct camera monitoring at sites in southern NJ in 2021. The 6 cameras have been moved periodically over the course of the year to target different locations. There have been no bobcat pictures recorded as of 12/31/21.
- Forty-three tissue samples were collected from animals hit by cars (N = 23), accidentally trapped (N = 9), and an abandoned bobcat kitten found (N = 1) during the reporting period. Researchers at Black Rock Forest near Cornwall, NY, also collected 3 bobcat tissue samples and sent to ENSP to incorporate into the gene flow analyses. All samples were submitted to the National Genomics Center for Wildlife and Fish Conservation for DNA analysis.
- ENSP continued to work with the National Genomics Center for Wildlife and Fish Conservation to evaluate the genetic structure of bobcats in the region, as well as the substructure and gene flow of the NJ bobcat population to determine if there are impediments

to movement that are resulting in genetic substructuring. In 2019 the lab completed an update to analyses previously run, this time using additional samples from NJ, PA, and NY. A report was written by the lab and provided to ENSP describing the analyses and results, which were reported previously in the 2019 Interim Report.

- Necropsies were conducted on 25 bobcat carcasses during the sampling period. Body condition was assessed for each individual. DNA samples were taken, teeth were extracted for aging analysis, liver samples were collected, and reproductive tracts of females were analyzed.
  - The teeth from the 31 bobcats collected between 2018 and 2020 and submitted last reporting period were analyzed and added to the aging database, for a total of 131 teeth analyzed 2007-2021. The data give us a better understanding of the age structure of the population (Fig. 2) and age specific mortality, such as >73% (58/79) of road-killed bobcats were less than 2 years old.
  - The rodenticide testing of bobcat liver samples collected between 2018 and 2020 was completed and compiled with the results since 2013. Of the 85 bobcats screened for rodenticide exposure since 4/1/2013, 31 (36%) had exposure to at least one rodenticide at a trace level, and 19 (22%) had exposure to at least one rodenticide at greater than a trace level. ENSP is collaborating with Erica Miller, DVM at UPenn, and David Needle from NH Veterinary Diagnostic Laboratory at UNH on an assessment of rodenticide exposure of bobcats across the region and shared data collected in NJ on bobcat rodenticide exposure between 2013 and 2020.

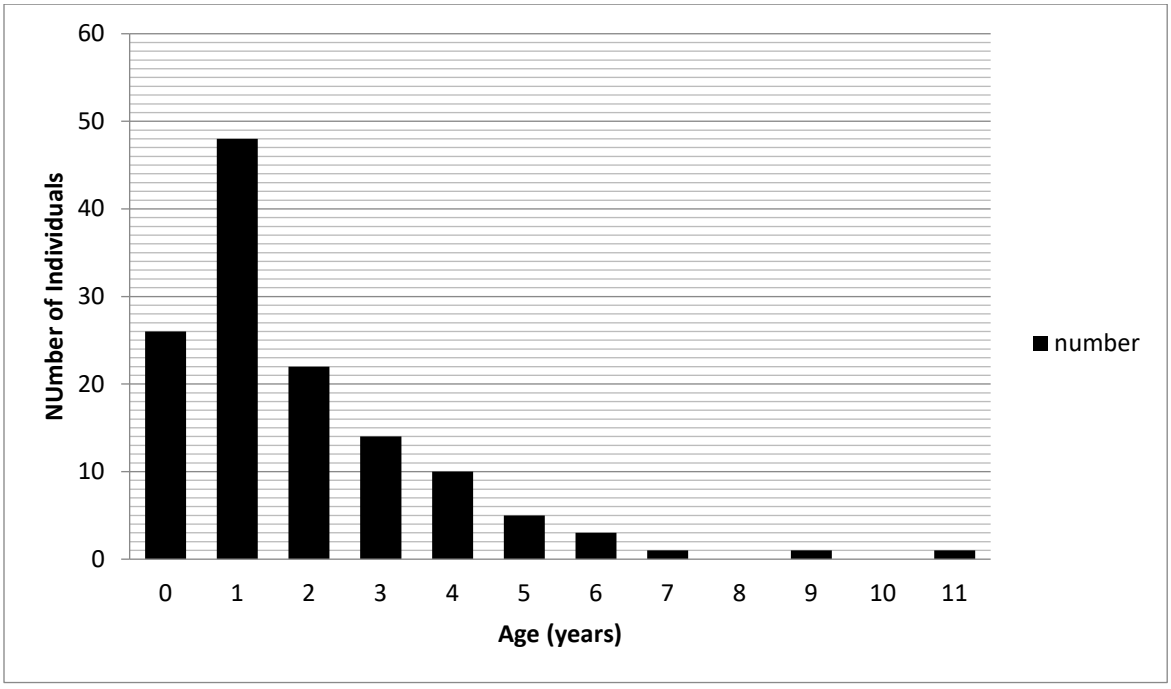



Figure 2. Age of bobcats in New Jersey between 1/25/2007 and 4/14/2020 analyzed via teeth cementum of lower canines extracted from carcasses (N=131).

- Project leader G. Fowles continued to collaborate with Bureau of Wildlife Management (BWM) biologists to respond to bobcats accidentally captured in cable restraints. A total of 9 trapped

bobcats were reported by trappers during the reporting period. Two (22%) died and 7 (78%) were released successfully. Ear tags were attached and DNA samples were taken from all bobcats. The number of trapped bobcats reported this reporting period was the fewest in the past 5 years, and less than half the number from 2020 (Fig. 3).

- There were 23 road-killed bobcat carcasses recovered by ENSP. There were more roadkills recorded in 2021 than in any previous year to date (Fig. 3). Six of the roadkills in 2021 (26%) occurred on state Route 15, a north-south running highway in northwestern New Jersey with high traffic volume (>10,000 vehicles per day).
- Over 81% of the trapped and roadkilled bobcats reporting during the grant period were from just 2 counties in northwestern NJ – Warren and Sussex.

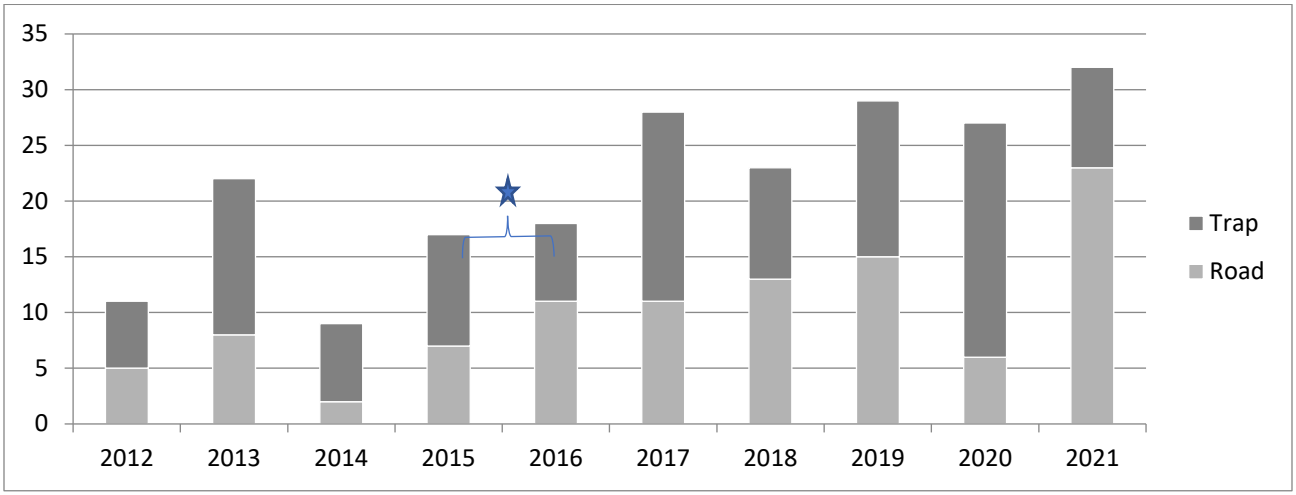



Figure 3. The number of reported and confirmed bobcats hit by cars and accidently trapped in cable restraints between 2012 and 2021. The 2015-2016 (starred) was the first year the DFW required reporting of trapped bobcats.

- Habitat analyses continued as part of a partnership between ENSP and the University of Delaware (UDel) whereby UDel funded a Master's degree student and ENSP provided additional support in the fall of 2020 to conduct bobcat research. The study began in September 2018 with a project to analyze regional habitats in NJ with a focus on interconnectivity and the options for the establishment and maintenance of a central and southern bobcat population. These analyses are helping to inform bobcat recovery plan metrics. The student successfully defended her thesis in early 2021 and provided an additional synopsis report to ENSP; G. Fowles served on her graduate committee.
    - A weighted habitat suitability index (HSI) for bobcats was developed.
    - Landscape connectivity analyses have been completed using the HSI to identify discrete "core" habitat patches for bobcats across the state as well as the inverse of HSI values to evaluate landscape resistance and movement potential across the landscape. Barrier and bottleneck analyses were also completed to help identify critical areas to work to protect and manage habitat, and mitigate road barriers, particularly in central NJ where habitat is the most fragmented.
    - Lastly, a spatially explicit agent-based model (SEABM) was developed to assess the results of 3 different management strategies: 1) status quo, 2) barrier reduction, and

3) single translocation over a 25-year time frame. The results led to recommendations to continue working to mitigate barriers through roadways by creating safe passageways for bobcats and to protect and maintain habitat within identified corridors. The final translocation scenario needs some model adjustments before being used to inform management decisions.

- Collaboration is continuing with the student and major professor to adjust the final model, to incorporate results into the bobcat assessment/recovery plan, and to develop manuscripts for publication.
- A new culvert crossing is being monitored by a newly recruited Wildlife Conservation Corps (WCC) volunteer under Interstate 287 after a resident reported observing a bobcat photo on her trail camera and the dog-handler team investigated and Fly found bobcat scat. During the course of the survey, the team came upon a large dry culvert under Interstate 287 where there are 6 lanes of high-volume traffic (Fig. 4). Bobcat tracks were found in the culvert. The resident agreed to monitor the structure with her camera thenceforth and has picked up regular bobcat activity through the culvert, as well as at least 10 other mammals species using the culvert not designed for wildlife, but serving as a safe passageway for them.

Figure 4. A culvert under a major multi-lane highway in northeastern New Jersey, built for water passage, but used frequently by wildlife including bobcats.

- Additional studies to monitor and assess road structures and habitat corridors identified by the CHANJ mapping, as well as collect roadkill data and recommend improvements are being conducted under NJ W-78-R-1.
- In 2021, bobcat location data submitted by the public and collected in our survey work were entered in our NJ Wildlife Tracker Application (developed under NJ T-11-T-3) and ultimately entered into the NJ Biotics database.
- No bobcats were collared during the reporting period.
- G. Fowles continues to update the draft bobcat status assessment with new data and literature references.

Conclusions:

- A new wildlife detection dog, 'Fly', is proving effective at surveying for bobcat scat in northern and southern New Jersey. She has done well finding scat in northern NJ (79 bobcat scats representing 30 individuals), but has found only one bobcat scat in central/southern NJ so far where there are very few confirmed records. Fly is proving to be an effective PR tool as well, with a temperament compatible with demonstrations of her work to partners.
- Remotely triggered cameras have been deployed in southern NJ since July 2020 and are being maintained by WCC volunteers as another tool to try to better understand bobcat distribution in the state. There have been no bobcat pictures yet.
- Scat samples were provided to the University of Delaware for a study on developing a technique to distinguish felid and canid scats in the field.
- ENSP continues to collaborate with the National Genomics Center for Wildlife and Fish Conservation on analyzing the tissue, scat, and hair samples collected in NJ, the results of which have all been added to the long-term NJ bobcat database that ENSP maintains of bobcat individuals in time and space. ENSP also continues to collaborate with the lab on evaluating the substructure and gene flow of the NJ bobcat population. The analysis may be updated again soon because additional samples from southern NY are being collected and genotyped, in partnership with Black Rock Forest in NY. Any bobcat samples from central and southern NJ will also be added if obtained.
- ENSP has continued to track bobcat roadkills over time, with 2021 being the highest recorded number of bobcat roadkills in a year, after very few in 2020 likely related to decreased traffic at the onset of COVID. ENSP also continues to work with BWM to respond as quickly as possible to reported trapped bobcats to have the best chance of releasing the bobcats successfully. The numbers of reported trapped bobcats have fluctuated over the reporting period due to several factors that may include COVID and winter storm events.
- The necropsies and sample analyses (DNA, teeth, reproductive tracts, rodenticide testing of livers, body condition scores) are improving our understanding of bobcat status and health and are contributing valuable information to the bobcat assessment and recovery plan. Some results are also contributing to regional analyses, such as the rodenticide exposure.
- ENSP continues close collaboration with partners at the University of Delaware where a master's degree student defended her thesis in 2021. The analyses she has conducted on a statewide bobcat habitat suitability index, statewide habitat connectivity assessment, and spatially explicit simulation modeling focused on establishment of bobcat populations in central and southern NJ will be very informative for the bobcat recovery plan once the modeling is fine-tuned. The connectivity analyses provide a basis, along with CHANJ mapping (developed under NJ T-11-T-3), for identifying key corridors to protect and road barriers to mitigate with crossing structures, particularly in central New Jersey where habitat is particularly fragmented to enable gene flow between northern and southern NJ.
- A draft of a bobcat status assessment continues to be updated.

Recommendations:

- Continue to conduct bobcat scat surveys using the new wildlife detection dog, targeting areas especially in central and southern NJ. Confirmed bobcat scats will confirm presence in an

area, and will be added to the long-term bobcat DNA database housed at the National Genomics Center for Wildlife and Fish Conservation, which is useful for the gene flow analyses, to evaluate recaptures over time and space, etc. Also continue the camera monitoring in southern NJ and if there is a confirmed bobcat photo, survey the area with the dog to hopefully acquire a DNA sample.

- Continue to collaborate with the National Genomics Center for Wildlife and Fish Conservation to update the substructure and gene flow analyses of the NJ bobcat population particularly as new samples are acquired from new partners in southern NY, as well as in areas of NJ (i.e. east of Route 287 and south of Route 78) where we currently have very few samples.
- Continue to opportunistically collect tissue samples from live and dead bobcats to add to long-term NJ bobcat genetic library housed at the National Genomics Center.
- Continue to collaborate with the Bureau of Wildlife Management to respond to bobcats accidentally captured in traps and work to collect data, tag, and safely release the animals, and to identify and implement ways of decreasing the rate of injury and mortality to bobcats accidentally trapped in New Jersey.
- Continue collecting and analyzing teeth, reproductive tracts and liver samples to better understand the age structure, fecundity, and pregnancy rates of the population, and to evaluate rate of exposure to rodenticides, and incorporate the results in the bobcat assessment/recovery plan.
- Continue to collaborate with researchers at UPenn and UNH on a regional analysis of bobcat rodenticide exposure.
- Collect bobcat roadkill data to measure trend in road mortality, to validate the CHANJ core and core modeling, and to help prioritize mortality hot spots to focus road mitigation efforts. Continue to reach out to agencies and the public to increase the recovery rate of bobcat roadkill data and carcasses.
- Continue to collaborate with partners at the University of Delaware on refining the statewide the simulations modeling and use those results as well as the finalized habitat suitability model and connectivity analyses to update the bobcat assessment and inform the recovery metrics. Utilize the connectivity analyses along with CHANJ also to prioritize areas, especially in central NJ for habitat projection, management and road mitigation.
- Finalize a draft of the bobcat status assessment and the recovery plan component and seek input from experts in the field. Develop outreach information based on the analyses and assessment to distribute to trappers, state and municipal police, and animal control officers to inform them about the health and status of the New Jersey bobcat population and the important contribution samples from both road-killed and trapped bobcats have been making to our understanding of the population to encourage increased reporting.

**Objective 2 – Allegheny Woodrat research and management**

Prepared by: Gretchen Fowles

Key Findings:

- ENSP has continued to implement a year-round roundworm mitigation plan at the Palisades habitat in collaboration with a researcher now at the National Wildlife Research Center. Sixteen dispensers (Fig. 1), deployed since 11/18/2016 for delivery of pyrantel pamoate-treated fishmeal/polymer baits to free-ranging raccoons, are spaced approximately 1km apart above and below the Palisades cliffs along the length of the habitat area. The dispensers were continuously re-loaded on a 6-8 week schedule with approximately 50 baits each, year-round during the reporting period.
- ENSP and volunteers collected and GPSed 22 raccoon scats at the Palisades in August (N = 1), September (N = 9), and October (N = 12) (Fig. 1) to evaluate the prevalence of *B. procyonis* egg loads in the scat. Another 8 scats were collected in April and July from 2 historic woodrat sites in the Delaware Water Gap in northwestern NJ that we monitored with cameras. The scats were sent to Wheaton College for analysis. The results were all negative.

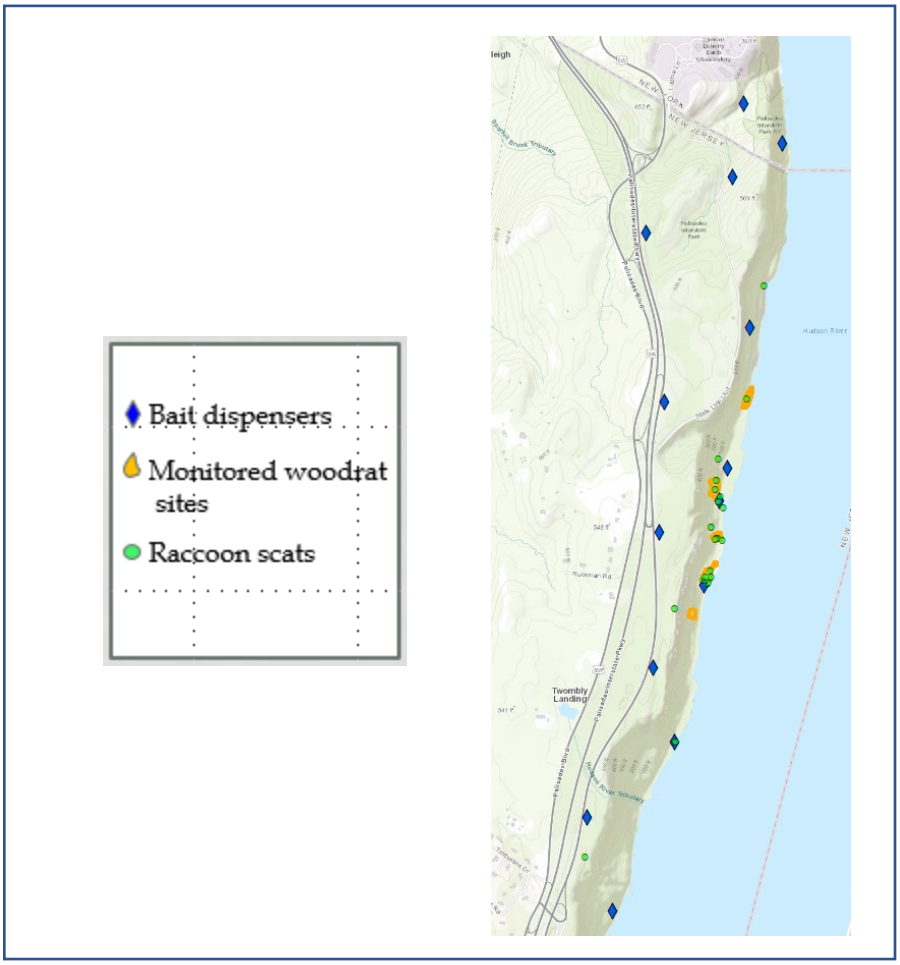



Figure 1. The locations of 16 raccoon roundworm bait dispensers, the monitored Allegheny woodrat sites, and the locations of the 22 raccoon scats collected in 2021 to monitor raccoon roundworm load at the Palisades.

These results continue a trend of very low to no prevalence of *B. procyonis* egg loads in raccoon scat since the implementation of the year-round comprehensive roundworm mitigation plan at the Palisades (Table 1).

Table 1. The results of raccoon scat analysis evaluating the prevalence of *B. procyonis* egg loads in scat between 2007 and 2021 at the Palisades. A year-round comprehensive mitigation plan was implemented in 2016.

| Year | # Raccoon Scats | # Positive for *B. procyonis* | % Positive |
|---|---|---|---|
| 2007 | 20 | 3 | 15 |
| 2008 | 58 | 21 | 36 |
| 2013 | 3 | 3 | 100 |
| 2015 | 15 | 0 | 0 |
| 2016 | 55 | 3 | 5 |
| 2017 | 75 | 1 | 1 |
| 2018 | 99 | 0 | 0 |
| 2019 | 38 | 0 | 0 |
| 2020 | 37 | 0 | 0 |
| 2021 | 22 | 0 | 0 |

- Standard trapping protocol was conducted at five separate talus slope sites in the Palisades Interstate Park during the end of September 2021. Tomahawk TM Model 201 (5”x5”x16”) Collapsible and Standard Single-door Live Traps were used for sampling. The traps were baited with apple slices and peanut butter.
    - Forty-two traps were set for two nights (9/29 and 9/30) for a total of 84 trap-nights of sampling effort.
    - Twenty-four unique individuals were captured in 2021. The capture index (# of individuals captured/10 trap nights) was 2.86 (Fig. 2). This was back to the levels it was in 2016, 2017, and 2019.
    - No non-target species were captured in 2021.
    - All captured woodrats were held for several minutes prior to their release to determine if they exhibited any symptoms of infection by *B. procyonis*; no animals displayed any symptoms. All animals were sexed, weighed and ear-tagged at the point of capture. An ear punch from each ear was taken from each newly captured individual for genetic analysis.

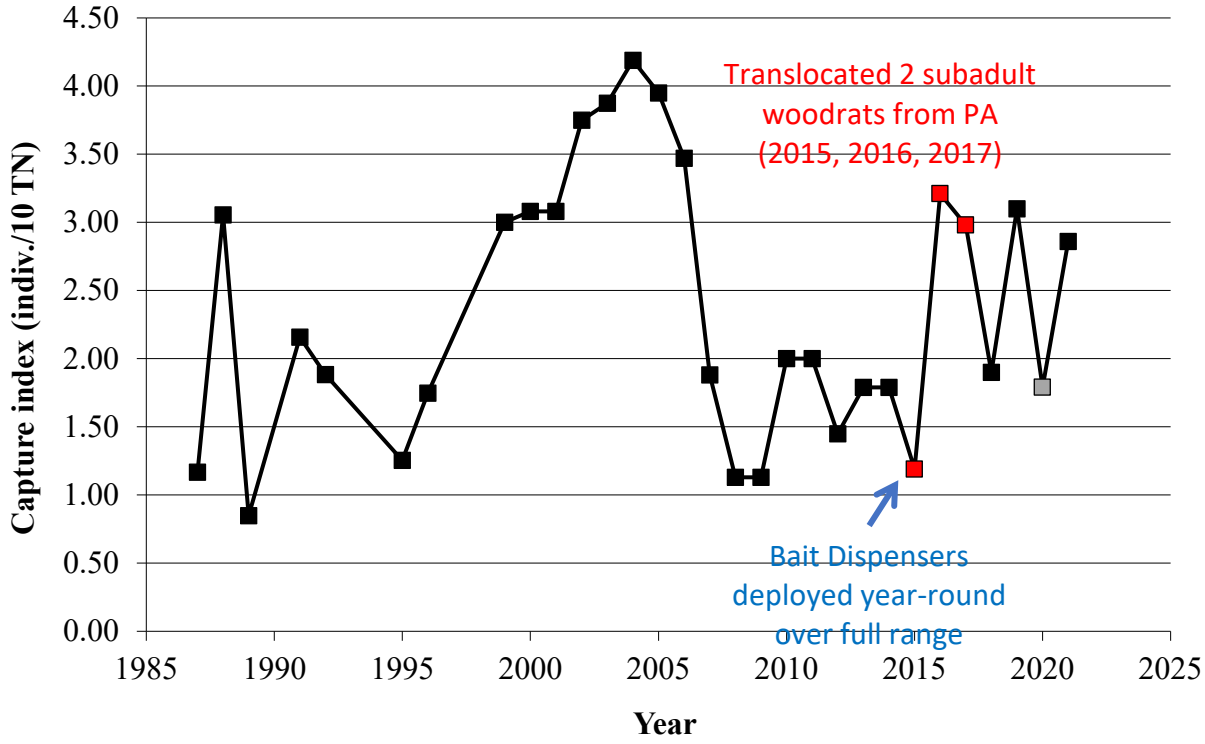



Figure 2. The results of ENSP's trapping effort in the Palisades over the last several years, setting 42 traps for two consecutive days in six trap areas in the fall, for a total of 84 trap-nights of sampling effort/year. Translocations of 2 subadult woodrats from Pennsylvania occurred in 2015, 2016, and 2017 (■). There were 21 non-target captures in 2020, which was highly unusual ( ■ ).

- ENSP continued our collaboration with a geneticist at Towson University who maintains the Allegheny woodrat genetic library, including all past NJ Palisades samples.
  - The mean observed heterozygosity (Ho) was evaluated through 2021 using tissue samples, which were genotyped using a panel of SNPs, showing sustained higher levels since the translocation of woodrats from PA between 2015 and 2017 (Fig. 3).

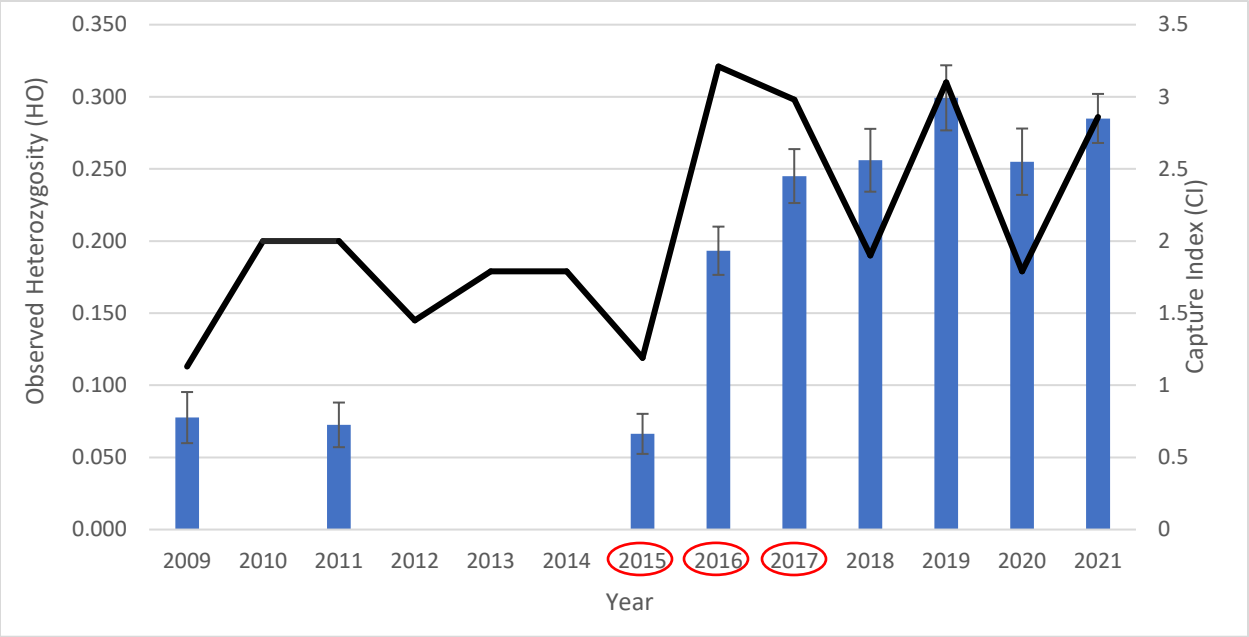



Figure 3. Observed heterozygosity (Ho) (blue bars) and capture index (CI) (black line) of the Allegheny woodrat population in the Palisades, NJ over time. Translocations of 2 subadult woodrats from Pennsylvania occurred in 2015, 2016, and 2017.

- A manuscript was finalized and submitted for publication describing the SNP assay used to analyze the variability of the Palisades woodrat population in 2021.
- We sent tissue samples from 18 new individuals collected during the annual trapping effort in 2021 to Towson for analysis. The tissues were all genotyped using a panel of SNPs and mean observed heterozygosity (Ho) was evaluated to compared to the past few years (Fig. 3). A report was submitted by Towson detailing the results.
- Towson performed high-throughout sequencing of chloroplast DNA extracted from woodrat scat previously collected in summer (July 5, 2018) and fall (October 2 and 4, 2018) for the first time in hopes of revealing woodrat diet compositional across seasons. The analyses were successful; chloroplast sequences were species, genus, or family. There were 77 and 66 unique taxonomic groups identified, respectively, in the summer and fall collected scat. Some taxonomic groups were found in high frequencies in both summer and fall (Figure 4), such as *Ailanthus altissimus* (tree of heaven), while others were disproportionately represented in one season compared to the other, such as *Querus* (oak) in the fall and *Solanoideae* (sweetgum) in the summer.
- A molecular sex marker was identified by Towson in 2021. No molecular sexing marking for Allegheny woodrats is currently documented in the literature. This will be particularly useful for scat, where the woodrat is not in-hand.

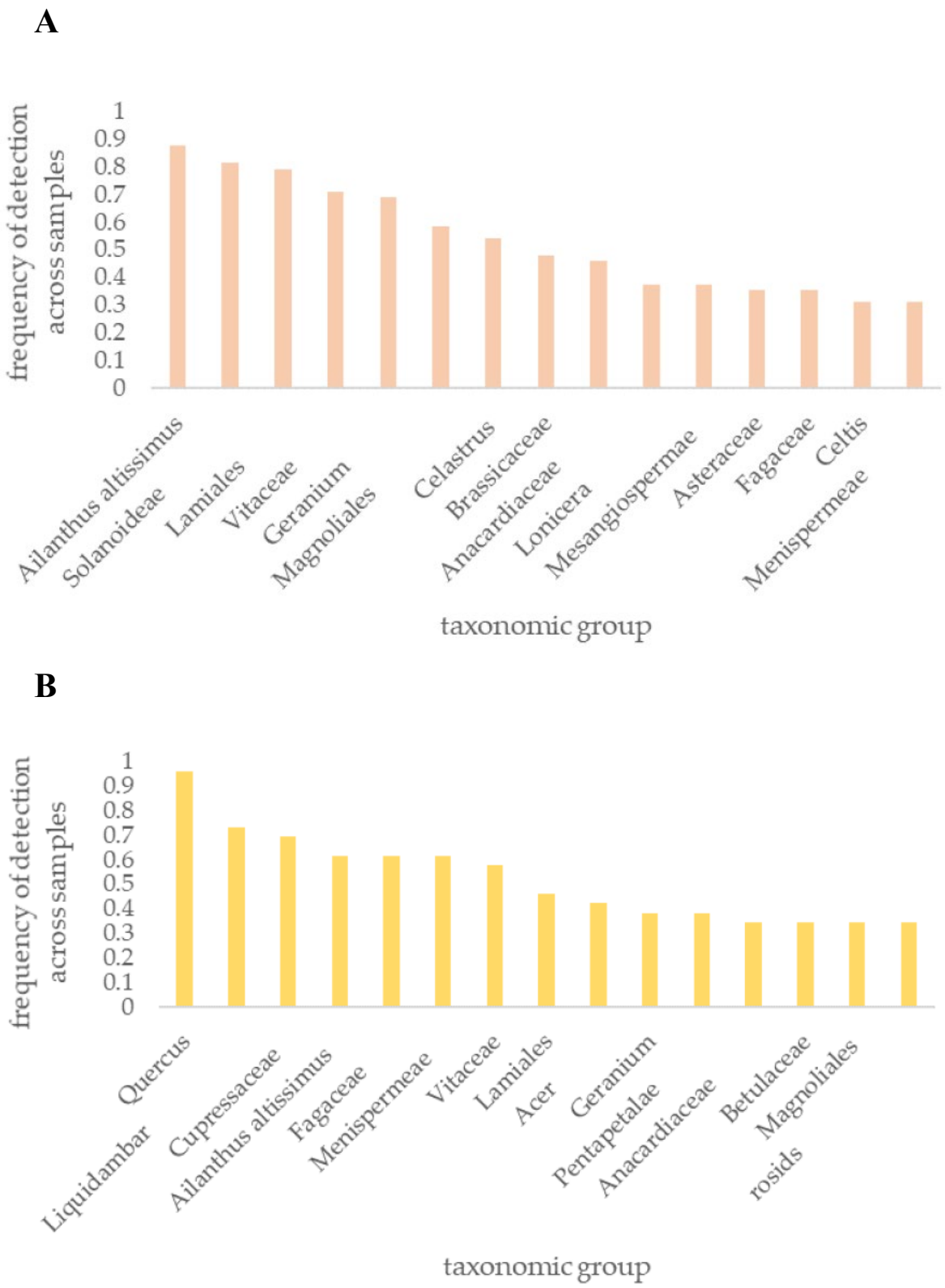



Figure 4. Frequency of detection across scat samples collected in the summer (A) and the fall (B). The graphs show only the 15 most frequently represented taxonomic groups identified.

- ENSP identified, tagged, and GPSed 36 hard mast trees with the help of an arborist (N=19 and N=17 above and below the cliffs at the Palisades, respectively). The trees included 4 species of oak, 3 species of hickory, and 1 species of beech. We then conducted a mast survey using a 30-second count on those tagged trees on 9/20/2021 (Koenig et al. 1994). Unfortunately, very few acorns were counted on the trees, with many green to brown acorns observed on the ground. Hurricane Ida had hit the area on 9/1-2/21 with heavy rain and strong winds and had a large impact on the area, likely negatively affecting the survey.
- ENSP contracted a habitat assessment of the 5 talus sites (that we trapped annually) to quantify the habitat availability within and surrounding those sites. All mast-bearing trees >25cm dbh were identified, health rated, and categorized as hard mast, soft mass, or other. Hard and soft/other mast plant density and diversity were calculated for each site and across all sites. Forest sampling was also conducted at each site, with canopy, subcanopy and woody debris and litter metrics calculated. The percent cover of soft mast producing understory was also evaluated. The consultants submitted the GPS locations of all mast-bearing trees >25 dbh identified as well as a report detailing their analysis and findings.
- Motion-triggered cameras continued to be deployed at 7 historic woodrat locations in the Delaware Water Gap in 2021 (Fig. 5) following a standardized woodrat camera monitoring protocol. No woodrats were identified at 6 of the sites, and we have not yet analyzed the data from the last site. Eleven mammal and 3 bird species were identified on the cameras.

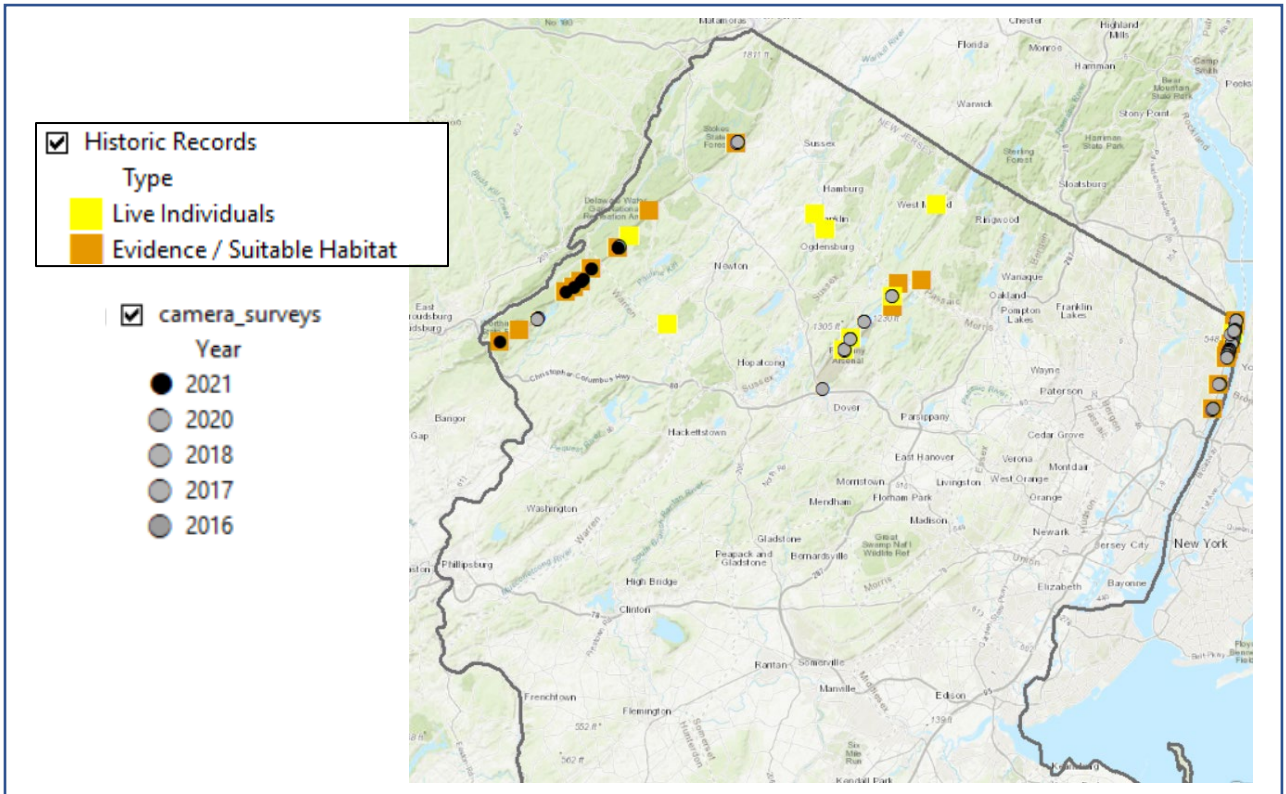



Figure 5. Historic Allegheny woodrat locations in NJ and camera monitoring efforts to survey them between 2016 and 2021.

- ENSP continues to organize bi-monthly web meetings of the newly formed regional Allegheny woodrat working group that was formed in 2020. In 2021 there are 13 states involved and approximately 60 biologists from state agencies, academia, and zoos. The group covered several topics in 2021 including mast survey protocols, camera trapping protocols, effects of prescribing burning, etc.
    - A captive breeding subgroup was formed in July 2021 with involvement from 7 states. The Maryland Zoo in Baltimore and the Toledo Zoo have both committed to starting Allegheny woodrat captive breeding programs potentially as early as 2022. The subgroup is working on developing a protocol for these programs.
    - In June 2021, the regional Allegheny woodrat working group was also recently highlighted in a National Geographic article.
- ENSP has begun training the program's wildlife detection dog, Fly, to find woodrat scat as a new target scent. The training began with a consultation with the trainers at Working Dogs for Conservation, from whom we acquired Fly, and some preliminary trials were run near our office using woodrat scat collected at the Palisades (Fig. 6).

Figure 6. ENSP's detection dog, Fly, alerting to woodrat scat (yellow arrow pointing to) placed by her handler on the grounds of one of our ENSP offices during training exercises.

Conclusions:

- The anthelmintic bait coverage provides a thorough temporal and spatial coverage of roundworm de-worming to keep this serious mortality factor at bay. The de-worming effort has been effective as measured by low prevalence of roundworm eggs in raccoon scat collected at the Palisades woodrat sites.
- Allegheny woodrat captures were back up to the levels they were in 2016, 2017 and 2019 after the translocation effort. ENSP has been encouraged that the abundance as measured by the capture index, has been back up to levels last seen in the early 2000s in the past 4 of the 6 years post the first translocation, with one of the low years (2020) being an anomaly due to more nontarget animals in traps than ever before.

- The genetic analyses conducted by Towson University have been very successful in understanding of the genetic variability in the New Jersey population. The results from the past few years have been very positive, with a continuing high level of the heterozygosity numbers since the translocation efforts began in 2015.
- The sequencing of chloroplast DNA from woodrat scat as a means of identifying dietary items in the scat samples was effective and the results demonstrated seasonal differences between summer and fall. The data will enable us to better understand which plant species make up the bulk of the woodrats' diet in the Palisades so we can develop an informed management plan.
- We are excited that a molecular sex marker was identified by Towson, which will be useful especially for analyses of scat data.
- A habitat assessment of the 5 trapping areas was conducted for the first time, quantifying the mast plants and the canopy, subcanopy and woody debris and litter available at each site.
- We have continued the work of camera monitoring at historic woodrat sites with no presence of woodrats detected yet. A detection dog is now being trained to detect woodrat scat, which adds another tool to the toolbox in our evaluations of historic woodrat sites and sites with suitable habitat to determine if the sites are occupied by woodrats.
- The formation of a regional Allegheny woodrat working group in 2020 has been very successful, now with approximately 60 individuals involved from 13 states. The group continued to meet virtually bi-monthly to cover a variety of topics. The working group has led to several collaborative efforts, standardized protocols, data sharing, and generation of new ideas. In addition a captive breeding subgroup was formed in 2021 to develop a protocol for captive breeding programs to be initiated at the Toledo Zoo and the Maryland Zoo in Baltimore.

Recommendations:

- Research suggests that *B. procyonis* infection in Allegheny woodrat populations is a serious mortality factor and can result in rapid population declines for the intermediate host (LoGuidice 2000, McGowan 1993). Therefore, continue to implement the year-round raccoon roundworm mitigation effort and collect and analyze raccoon scat for *B. procyonis* egg prevalence on an annual basis at least as well as opportunistically when in the field at the Palisades to monitor the effectiveness of the strategy.
- Continue to conduct the annual trapping effort to collect genetic samples as well as to evaluate capture success trends over time as one means of evaluating status of the population.
- Genetic testing has indicated that inbreeding depression was a serious threat to the NJ population. Introductions of animals from the PA population has resulted in continued improvement of heterozygosity. We recommend continued monitoring of genetic samples from all trapped individuals, and the analysis of parentage to specifically identify the extent to which translocated woodrats have bred. Continue to collaborate with the regional team of experts to decide on a plan forward regarding future translocation efforts.
- Continue to collaborate with Towson University on using chloroplast sequencing of woodrat scat as a means of identifying particular dietary items, seasonally, which would help inform habitat management efforts. Compare the results of the chloroplast DNA analysis with the habitat assessment completed in 2021 to assess use vs. availability.
- Conduct a mast survey at the Palisades annually now that trees are tagged and methodology piloted, to understand the hard mast resources available to the woodrat population each year.

- Continue assessment of historic woodrat sites using motion-triggered cameras and soon our wildlife detection dog once fully trained.
- Continue leading and collaborating with the new regional Allegheny woodrat working group and staying involved with the new captive breeding subgroup.

**Literature Cited**

Koenig, W.D., J.M.H Knops, M.J. Carmen, M.T Stanback, R.L. Mumme. 1994. Estimating acorn crops using visual surveys. Canadian Journal of Forest Research 24 (10).

LoGuidice, K. 2000. *Baylisascaris procyonis* and the decline of the Allegheny woodrat (*Neotoma magister*). Ph.D. dissertation, Rutgers, The State University of New Jersey, 101pp.

McGowan, E. 1993. Experimental release and fate study of the Allegheny woodrat (*Neotoma magister*). Unpublished report of New York State Department of Environmental Conservation, Endangered Species Unit. 15 pp.

**Objective 3 – Small mammal research**

Prepared by: Gretchen Fowles

Key Findings

- Due to staff limitations, ENSP biologists have not had the capacity to complete the surveys that ultimately are needed to better understand the status of many small species in the state.
- The habitat assessment work conducted at the Palisades as part of the Allegheny Woodrat project at the end of the reporting period may help inform similar assessments for other small mammals.
- The preliminary work with ENSP's detection dog "Fly" on detecting Allegheny Woodrat scat will help us understand if using the dog as a tool for other small mammals will be a viable option.

Recommendations

- Seek professionals who have expertise and interest (and perhaps contributory funding), to design and conduct surveys to document rare small mammals statewide.

**Objective 4 – Bat conservation and management**

Prepared by: MacKenzie Hall

Key Findings:

Interagency Consultations & Coordination

- ENSP biologists collected specimens from NJ Department of Health Rabies Lab, which holds rabies-negative bat specimens of interest (such as *Myotis* species and migratory bats) for the ENSP to analyze. During 2021, this arrangement provided the ENSP with locational and physical data for 20 more bats of interest, including two Northern long-eared bats from homes in Gloucester County during the winter, and 13 more records of Silver-haired bats, which are uncommonly encountered by other methods.
- ENSP collaborated with the USFWS NJ Field Office and NJ Department of Transportation in 2021 to continue training and surveillance for bats roosting in bridges, following the

guidance we finalized in 2019. The in-person, group classroom and field training workshops we started in 2019 were not held in 2020 or 2021 because of the COVID-19 pandemic, but the recorded Bats in Bridges workshop presented by ENSP and USFWS at the September 2020 Northeastern Transportation and Wildlife Conference served as a replacement for our normal classroom portion of the training, and ENSP was able to hold field trainings with one group from DOT Operations and their contractors, plus two interested consultants, in 2021.

Just over 100 bridges were inspected for bats this year by the ENSP and/or trained DOT personnel and their consultants, of which five bridges were found to house bat colonies (all of them Big Brown Bats; colony sizes ranging from approx. 10-35 bats) and two bridges were found to have minor/incidental bat use. A single, healthy female Northern long-eared bat – confirmed via physical capture by ENSP bat biologist – was discovered roosting at one of the last bridges surveyed in October 2021 (Fig. 1). The structure is a concrete girder style bridge over a stream with narrow riparian buffers in Mercer Co., NJ. A single small bat dropping found at another bridge in July was submitted to a genetics lab to identify the species (results are pending).


Figure 1. Concrete girder style bridge over a stream in central NJ (a) where surveyors from Davey Resource Group and ENSP documented a Northern long-eared bat roosting (b).

Overall, 247 bridges scheduled for maintenance work were surveyed during the grant period, with 20 (=8%) of them having bats or bat evidence. Results are being tracked in a master database managed by the ENSP and DOT. Bat presence/absence details will soon also be mapped in a web application as a reference for agency personnel.

- Bat occurrence data from consultant/permittee reports were reviewed and prepared for entry into ENSP's rare wildlife tracking database, Biotics. Bat mist-netting projects were minimized in 2020 and 2021 due to the COVID-19 pandemic, but more than 500 bat capture records were received from permittees during the three-year grant period, including 7 Northern long-eared bats from two study locations and 2 Little brown bats from one location.
- ENSP's bat biologist participated in various training opportunities, workshops, and DEP reviews during the grant period related to the upcoming offshore wind energy development taking place off the NJ coast. In 2021, the ENSP began planning for research and monitoring efforts of bats and birds to begin in the pre-construction timeframe.

- ENSP's bat biologist provided technical and/or in-field assistance to outside principal investigators for projects exploring the use of UV light treatments against the White-nose Syndrome fungus (*Pseudogymnoascus destructans*) in a bat hibernaculum, the use of eDNA as a detection method for bats roosting in bridges, the relationship between invasive plant communities and bat activity using acoustic monitoring, the creation of 'Bug Buffets' with artificial light lures as a possible way to increase body mass of WNS-vulnerable bats before entering hibernation, the presence of pathogens in bat ectoparasites, the success of bat houses installed at exclusion sites, and the presence of microplastics in bat droppings.
- In a push by the North American Bat Monitoring Program (NABat) to standardize and centralize bat colony counts from winter hibernacula across the continent, ENSP formatted and uploaded NJ's dataset into the NABat database.
- ENSP's bat biologist attended the annual meetings of the Northeast Bat Working Group and participated in regular agency White-nose Syndrome calls throughout the grant period.
- ENSP continued our successful bats-in-buildings program, offering guidance to homeowners and Nuisance Wildlife Control Operators (NWCOs) on effective, bat-friendly exclusion practices. Seasonal email updates were sent to our NWCO contact list and were also shared by the NJ Pest Management Association with their entire membership. ENSP fielded approximately 64 calls and emails from the public and from NWCOs in 2021 regarding bat exclusion guidance and resources, for a total of 236 instances of technical assistance provided to NJ residents on this topic during the three-year grant period. We provided and installed three more free bat houses this year as replacement roosts for excluded bat colonies.

<u>Summer Surveys</u>

- The COVID-19 pandemic hampered summer mist-netting plans in 2020 and 2021, both because of the group nature of this work and because of ongoing continent-wide concerns over the possible risk of transmitting the SARS-CoV-2 virus to native bats. Our waylaid plans were more than compensated by the added consultation and survey work related to bats and bridges that emerged as a priority during the grant period (described in the previous section) and by additional efforts to nanotag migratory bats in late summer and fall 2021 (described below). Furthermore, our discovery of bat tick (*Carios kelleyi*) larvae on four Big brown bats captured during summer 2019 led to additional efforts to document and publish these novel records for our state. We continue to collaborate with entomologists at Rutgers University's Center for Vector Biology and NJDOH to further investigate and understand the implications of these ectoparasites.
- To supplement the number of migratory bats affixed with nanotag transmitters in 2019 by Virginia Tech graduate student Mike True, ENSP again collaborated on this study in 2021 by supplying 30 nanotags, maintaining and/or downloading data from several Motus receiver stations along the NJ coast and Delaware Bay, coordinating the NJ field team and site access for mist-netting, and participating in 7 nights of mist-netting between August 2 and September 3. ENSP also made a post to the Division of Fish and Wildlife social media outlets on October 12 to solicit sightings of Silver-haired and Hoary bats, resulting in one timely report of a Silver-haired bat roosting on the exterior of a school building in Atlantic City that same day. ENSP was able to catch and tag the adult female bat, whose movements were subsequently detected by six Motus receiver stations over nine days, the last being along the Patuxent River, MD, on October 22 (Fig. 2).

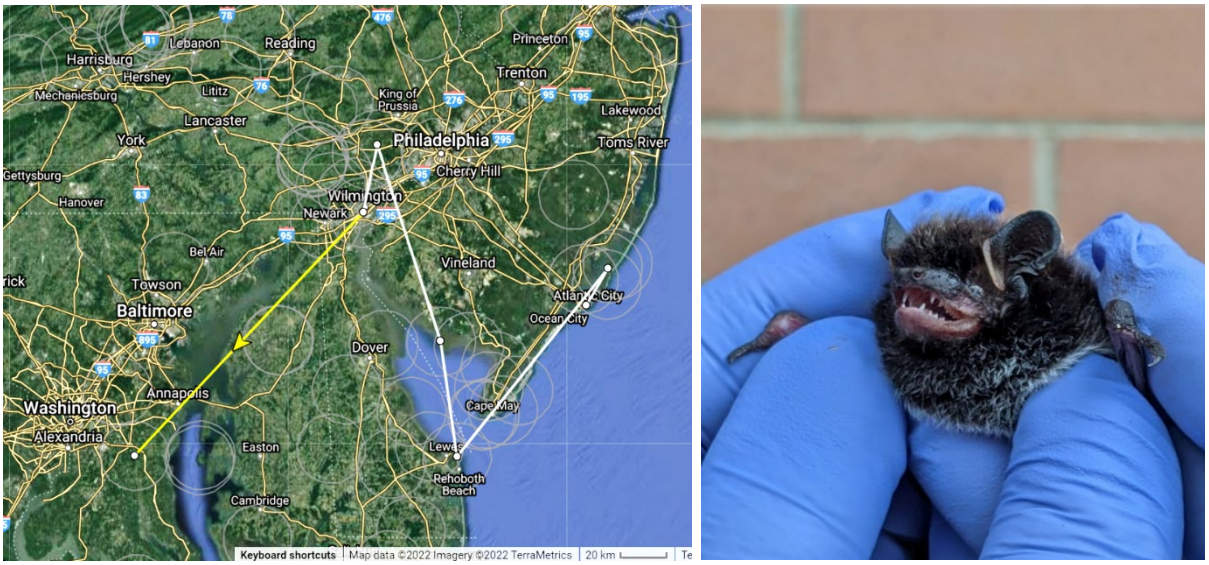


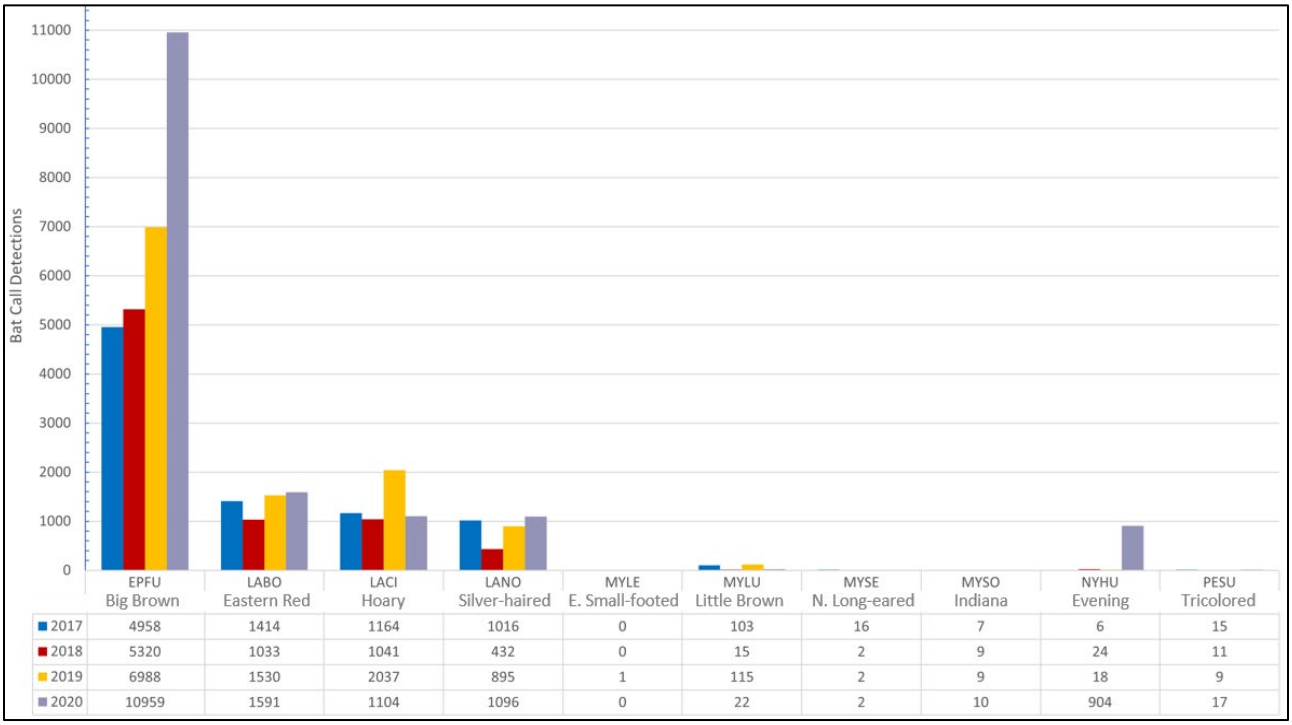

Figure 2. Map from motus.org showing the interpolated movements of the adult female Silver-haired bat (ID #37058; also pictured) who was nanotagged in Atlantic City on October 13, 2021. White dots on the map represent Motus receiver stations where the bat was detected over a nine-day period.

In total, 40 Eastern red bats and 2 Silver-haired bats were nanotagged in NJ during the fall 2021 migration season. Ten of those bats were not detected by any Motus stations after their release, but the movements of our other tagged bats, along with those from other eastern states as well as bats tagged in 2019, will be detailed in Mike True's thesis paper.

- The Summer Bat Count was again coordinated by our contractor, the Conserve Wildlife Foundation. Emergence surveys were done at 3 sites with long-term count records. One location contains two bat houses used by Little brown bats, where counts were done weekly throughout the summer for a total of nine counts from May 31 to August 13, 2021. The counts showed a fission-fusion occupancy dynamic between the two boxes and a high count of 78 bats (up 4.5% from 2020) on the very first count, May 31, suggesting the colony uses at least one other unknown roost during the maternity season. The two other sites are church attics occupied by Big brown bats, where only one count was conducted at each site. We will therefore not draw any conclusions about their trends, other than to say the counts were consistent with previous years' results on similar dates. Participation in the Summer Bat Count was lower than usual in 2021, presumably because of upheavals from the pandemic.

  A Little brown bat roost at a box beam bridge over a reservoir was monitored weekly with both visual inspections and emergence surveys by kayak from April 9 to May 26, 2021, to determine the bats' arrival phenology. The first bat was observed on April 13; half of the colony arrived between April 26 and May 7, and 26 bats (full colony) were counted on May 26. Counts were not continued since our volunteer moved away in early summer.
- Largely because of logistical complications from COVID-19 and concerns about exposing native bats, we did not conduct surveys for Eastern small-footed bats during the grant period. Our goal of surveying 5 suitable rocky/talus sites was postponed to the following grant period instead.
- The ENSP completed our fifth consecutive year of NABat summer acoustic monitoring in 2021. Stationary point surveys were again completed in-house, while mobile (driving)

transects were performed by a combination of ENSP seasonal personnel, contractors from the Conserve Wildlife Foundation of NJ (CWF), and seven volunteers coordinated by CWF. Data from the 2021 season include 1,182 bat recordings from the mobile transect surveys and approx. 13,700 bat recordings from the stationary surveys; these files are still being manually vetted and formatted for uploading into the NABat database. Species trends from stationary point monitoring through 2020 show a marked increase in the number and proportion of Big brown bat recordings (reaching approx. 70% of all bat recordings in 2020), relatively stable amounts of activity by migratory tree-roosting bats (Eastern red, Hoary and Silver-haired), and a consistently low representation of White-nose vulnerable *Myotis* and *Perimyotis* bat species across the survey years (Fig. 3).




| | EPFU Big Brown | LABO Eastern Red | LACI Hoary | LANO Silver-haired | MYLE E. Small-footed | MYLU Little Brown | MYSE N. Long-eared | MYSO Indiana | NYHU Evening | PESU Tricolored |
|---|---|---|---|---|---|---|---|---|---|---|
| 2017 | 4958 | 1414 | 1164 | 1016 | 0 | 103 | 16 | 7 | 6 | 15 |
| 2018 | 5320 | 1033 | 1041 | 432 | 0 | 15 | 2 | 9 | 24 | 11 |
| 2019 | 6988 | 1530 | 2037 | 895 | 1 | 115 | 2 | 9 | 18 | 9 |
| 2020 | 10959 | 1591 | 1104 | 1096 | 0 | 22 | 2 | 10 | 904 | 17 |

Figure 3. Bat species trends from New Jersey's NABat stationary point monitoring efforts, based on the total number of recordings of each species at standardized survey points from 2017 to 2020.

Evening bats (NYHU) have an acoustic call pattern that is often indistinguishable from Eastern red bats, but the apparent potential increase in auto-classified recordings of Evening bats could be evidence of the continued range expansion of this species. To-date, only one Evening bat has been physically documented in NJ.

<u>Hibernaculum Management & Winter Surveys</u>

- A winter count and mark-recapture survey would have taken place once at Hibernia Mine during the grant period, but was not conducted due to the COVID-19 pandemic. We expect to be able to survey the hibernaculum in March 2022 or 2023.
- ENSP biologist did continuously monitor the temperature profile inside Hibernia Mine using climate loggers during the full grant period. Loggers are stationed at 14 survey points, starting at the adit (gated entrance) and ending approx. 50 meters from the terminus nearly a half-mile into the earth. Data are downloaded and batteries refreshed each year just prior to

hibernation season. Results show that temperatures appear to be quite favorable for hibernating bats in the winters following our fall 2017 entrance-widening and re-gating project. During the winter of 2020-2021 (Fig. 4), the average temperature from November 1 to March 31 was below the optimal growth range (~41-50°F) of the White-nose causative fungus (*Pseudogymnoascus destructans;* or Pd) while remaining above freezing in two-thirds of the tunnel's length. Even on the coldest day of winter, approx. 29% of the tunnel's length remained below the optimal Pd growth temperature but above freezing.

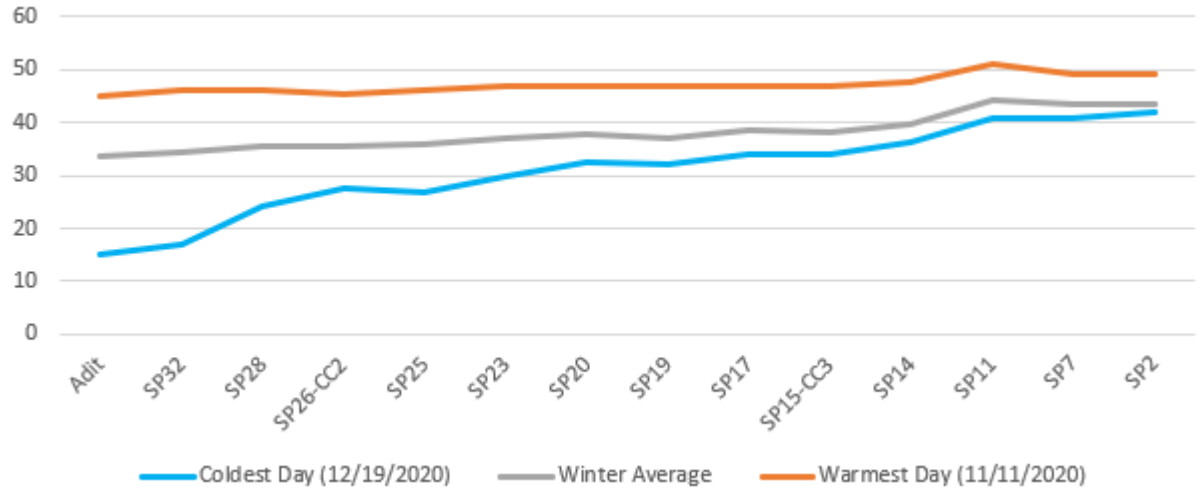



Figure 4. Temperature profile (°F) of Hibernia Mine on the warmest, the coldest, and the average winter day from November 1, 2020 to March 31, 2021.

- At Mount Hope Mine, a standardized mark-recapture survey was done by contractors from Sanders Environmental outside the gated west shaft during fall swarm in 2021, entailing nine nights of efforts from late August to early October. The final report with analysis of recaptured individuals is pending, but the raw data show a continued decline in Indiana bat numbers, an increase in Little brown bats to perhaps their highest numbers post-White-nose Syndrome, and a more than doubling of Eastern small-footed bat captures (Fig. 5). Eastern small-footed bats are now the most-captured species at this site, following a steady rise over the past ten years.

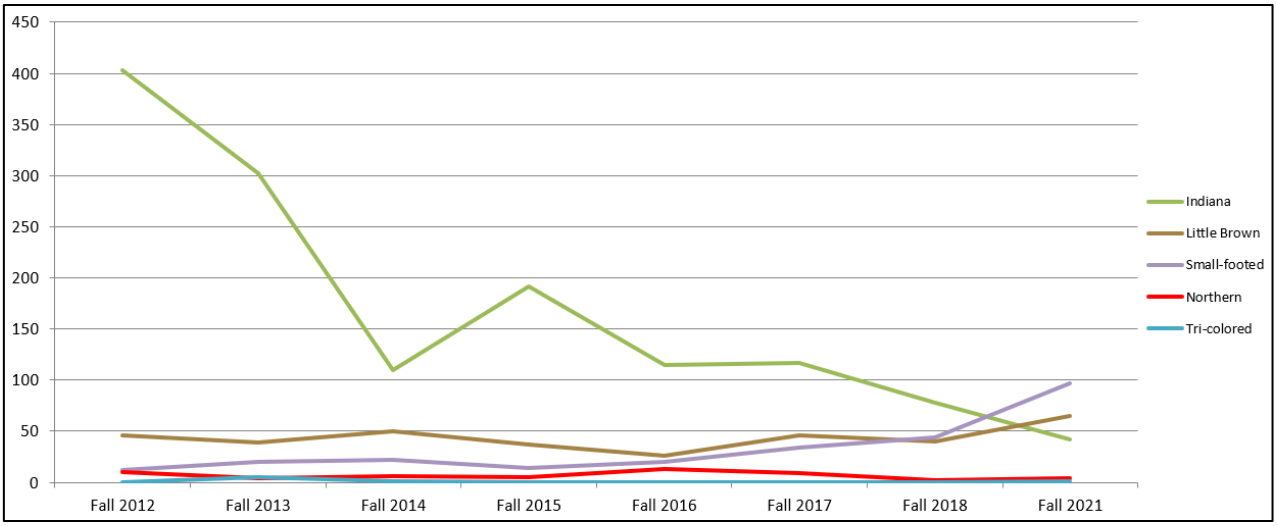



Figure 5. Trends in bat species captured during fall swarm surveys at Mount Hope Mine, 2021-2021. Note: Data from 2021 is raw and does not account for individuals captured more than once.

- Surveys of other known or suspected hibernacula were deterred by COVID-19 during the grant period. Our goal had been to investigate 5 sites. As described in our interim report from January 2021, the ENSP successfully used acoustic detectors to investigate bat use of three different abandoned railroad tunnels in late winter 2020. In 2021, in lieu of physical surveys below ground we conducted two more winter acoustic surveys in attic spaces to investigate bat presence, deploying bat detectors to passively record ultrasonic activity for a minimum of three weeks. Both surveys were in response to nuisance bat issues discovered at residences during the inactive season, when bat exclusion is not advised. Big brown bats were detected at one of the two sites, in Mercer Co., NJ, where 39 bat recordings were collected from six different evenings during the 22-day deployment in December. The maximum time between bat detections was nine days. The attic temperature averaged 58.8°F (range 48-70°F) and the humidity averaged 50.2% (range 37-64.5%) during the survey.

Conclusions:

- Our outreach efforts and resources for NJ residents and NWCOs are having a positive impact on bat conservation in nuisance situations. Through these contacts we are also learning more about winter behavior of bats in buildings, mainly Big brown bats. Passive winter acoustic surveys have become another tool for us to assist and advise NJ residents.
- The NJ Department of Health Rabies Lab continues to be a valuable source of occurrence data for bat species of interest, which also offer insights about habitat use and behavior across all seasons. We obtained occurrence data for 50 bat specimens of interest during the grant period. Three Northern long-eared bat individuals received from the Gloucester County area provide further evidence of this species' association with narrow forested riparian corridors and use of suburban refugia, where the bats are possibly overwintering in small numbers in buildings. Otherwise, the near-absence of *Myotis* bat specimens from the Rabies Lab is another measure of the lingering impact of White-nose Syndrome. The Rabies Lab is currently our leading source of Silver-haired bat occurrences.

- Before this grant period, bridges were a mostly-untapped resource for our summer bat monitoring efforts, and they appear to be a relatively important artificial roost type in NJ. New coordination between our agency, the US Fish and Wildlife Service and the NJ Department of Transportation is yielding results of bats roosting in bridges, with approx. 8% of bridges surveyed so far being occupied by bats to some extent. Most are used by Big brown bats, though rare species including Northern long-eared bat(s) and Little browns are known from two bridges. A Master database has been created for the partnering agencies to store and reference bridge inspection results as well as the consequent conservation measures and suggested timing restrictions for upcoming bridge work. A web-based system for tracking this data is still being developed.
- Summer mist-netting and bat-handling projects have been minimal since the onset of the COVID-19 pandemic. Surveys which have taken place, including summer acoustic surveys, show that populations of White-nose Syndrome-vulnerable species like the Little brown and Northern long-eared bat remain at very low numbers, though healthy and reproductive individuals do remain on the landscape. For Northern long-eared bats, new and recurring records during the grant period support other recent findings that lesser-quality forested stream habitats in suburban/urban contexts are being used by this species. Big brown bats continue to increase in number – or at least in detection – from year to year. Based on acoustic recordings, which are not fully reliable, Evening bats may have joined the NJ community as more than just an incidental species.
- Hibernacula surveys were likewise deterred by the pandemic, though one fall swarm survey at NJ's primary Indiana bat site showed a continued decline in Indiana bats, a small increase in Little browns, and a marked jump in Eastern small-footed bat captures. Acoustic surveys have proven to be a successful method to investigate bat presence and activity levels of different species/guilds, including *Myotis* bats, in difficult-to-survey locations and in attics. Our recommended survey period is at least three weeks.
- Efforts to nanotag migratory bats resumed in 2021 in partnership with Virginia Tech graduate student Mike True. Our target Eastern red bat sample size was met and exceeded handily, with far-south NJ being especially productive. Public outreach yielded sightings of other migratory species; this could be a valuable tactic in future nanotagging efforts.
- Bat ticks (*Carios kelleyi*) are now documented in New Jersey, raising questions about their distribution, commonness, implications for bat (and possibly human) health, and whether factors like climate change are causing a range expansion.

Recommendations:

- Continue training and assisting NJDOT and consultants to carry out bridge surveys for bats. Follow up on documented bridge bat colonies to determine species present, colony sizes, and seasonal arrival, departure, and possible overwintering phenology as possible. Expand outreach to county and municipal road managers to inform them about bats' use of bridges and train them to inspect bridges within their jurisdictions. Local roads may have a higher bat occupancy rate due to smaller road size, lower traffic volume, and better habitat context. As time allows, focus more survey attention on bridges with high likelihood of being used by bats, such as those along forested watercourses within endangered/threatened species' ranges, and/or those with favorable roosting characteristics (i.e., concrete box-beam expansion joints).

- Follow up with visual and/or acoustic surveys at the Mercer Co. bridge where a Northern long-eared bat was found roosting in mid-October 2021, to determine whether the bridge was simply a migration stopover or is also used by a summer maternity colony.
- Continue data-sharing with the NJ Department of Health Rabies Lab so that the ENSP has access to analyze and glean information from Rabies-negative specimens of interest.
- Increase public outreach and education efforts to solicit sighting reports of bat species of interest. These efforts will also help to inform people about bats and benefit conservation.
- Investigate summer use by bats at the newly preserved Mt. Hope Mine property and consider management activities like stabilizing and gating a secondary shaft on site.
- Acoustically survey additional "gallery forest"/suburban-context riparian forests for Northern long-eared bat populations; follow up with mist-netting if acoustic results are promising.
- Investigate the winter behaviors and use of buildings by Northern long-eared bats in suburban area(s) where inactive season presence has been confirmed via Rabies Lab records.
- Continue and/or expand efforts to monitor and research migratory bat species behavior and migration patterns in response to NJ's ambitious off-shore wind energy goals. Work to expand Motus receiver station coverage strategically within NJ and collaborate with surrounding states to ensure bats are nanotagged from areas with a high likelihood of having coastal/offshore migration pathways.
- When bat handling activities resume, use results of the NABat stationary monitoring program and other surveys and sightings to focus netting efforts for species of interest/concern, in order to confirm their presence, radio-track bats to their roosts, and further monitor colonies.
- When safe to do so, resume and catch up on regular monitoring of winter bat populations in known hibernacula (every 3-5 years), and investigate additional possible hibernacula.
- Continue to collaborate with entomologists at Rutgers University and NJDOH to further investigate and understand the implications of bat ticks in NJ.
- Continue participating in trainings, workshops, reviews and calls related to the research and minimization of offshore wind impacts on bats, as well as White-nose Syndrome.

**Objective 5 – Habitat management**

Prepared by: Gretchen Fowles

Key Findings

- Due to staff limitations, ENSP biologists did not have the capacity to implement any habitat management projects nor conduct monitoring surveys.

Recommendations

- Continue to identify areas where lack of habitat connectivity limits species movement and population recovery using the CHANJ tools, and pursue pre-monitoring surveys to verify need of habitat management in order to plan and implement effective habitat improvements.