Federal Aid in Wildlife Restoration

W-71-R-2

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Species of Greatest Conservation Need

Mammal Research and Management

Interim Report

for

September 1, 2017–September 30, 2018

PERFORMANCE REPORT

STATE: New Jersey   **PROJECT NUMBER:** W-71-R-2

PROJECT TYPE: Research and/or Management

PROJECT TITLE: SGCN Mammal Research and Management

STUDY NUMBER AND TITLE: 1. Mammals

PERIOD COVERED: September 1, 2017 to September 30, 2018

JOB NUMBER AND TITLE: 1A. Bobcat Conservation
Prepared by: Gretchen Fowles

OBJECTIVE: Determine the distribution, minimum size, population and genetic structure, and habitat needs of New Jersey's bobcat population and use the information to preserve the habitat necessary to maintain a viable population.

Key Findings:
- ENSP collaborated with a statistician in the DEP's Division of Science, Research, and Environmental Health to complete a spatially explicit mark-recapture analysis using all bobcat individual data (from tissues and scats) collected to date (2002 – 2016) to estimate population size and density over time within northwestern New Jersey. Many different models exist to estimate population density and size from capture-recapture data and so to find the one that was the best fit, the data was evaluated using four different statistical techniques. A fifth technique, a hierarchical Bayesian Spatial Capture-Recapture model, had been the planned estimator to use for the analysis because it takes into account individuals from previous years and thus is less crucial to have many recaptures in a given year. The program was attempted on multiple machines, but would not run because of the intensity of the analysis, and had to be abandoned. Of the four techniques that were run, the one with the most appropriate conservation metric estimates was the Bayesian Spatial Capture-Recapture models run using bobcat scat data only. This framework allowed for the most accurate estimation with small samples sizes and recapture rates, and also allows for the unstructured sampling associated with detection dog surveys (Thompson et al. 2012). The Division of Science, Research, and Environmental Health wrote a final report describing the analysis that they provided to ENSP.
  - The yearly density estimates ranged from 0.05 to 0.09 bobcats/km^2 and the yearly population sizes in the study area ranged from 179 to 355 bobcats (Fig. 1, Table 1).
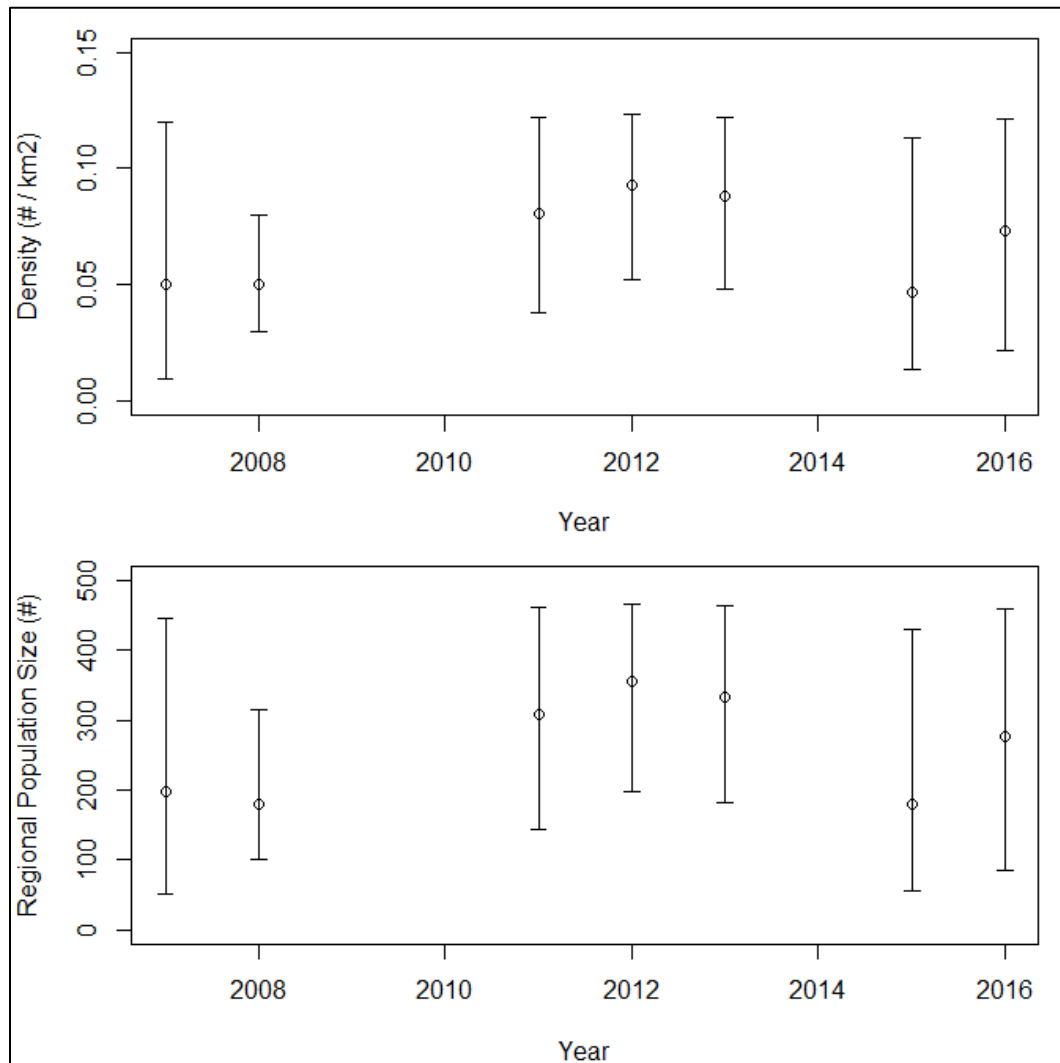
Figure 1. Results from Bayesian Spatial Capture-Recapture (SCR) Models using bobcat scat data. Bayesian spatial capture-recapture models were performed to estimate the density (bobcats/km²) and the population size (#) of bobcats in northwestern New Jersey Error bars display 95% Credibility Intervals.

Table 1. Estimates from the Bayesian Spatial Capture-Recapture (SCR) Models. Bayesian spatial capture-recapture models were performed using bobcat scat data to estimate the density (bobcats/km²) and the population size (#) of bobcats in northwestern New Jersey (LCL = Lower Confidence Level; UCL = Upper Confidence Level).

Year	Density	D_LCL	D_UCL	Pop	P_LCL	P_UCL
2007	0.05	0.01	0.12	197	51	447
2008	0.05	0.03	0.08	179	102	315
2011	0.08	0.04	0.12	308	145	462
2012	0.09	0.05	0.12	355	197	466
2013	0.09	0.05	0.12	334	183	463
2015	0.05	0.01	0.11	180	55	430
2016	0.07	0.02	0.12	276	85	459

- An analysis of habitat change over time was not completed, but ENSP's Habitat Change Analysis Project data for bobcat was completed and is reported under NJ T-11-T-1.
- The detection dog that ENSP has utilized for the detection of bobcat scat since 2006 passed away in November 2017.
- A trail camera photo of a bobcat was submitted to ENSP from the public in early 2018, in the area of the Great Swamp National Wildlife Refuge, east of Interstate 287, in an area where there have not been documented bobcat occurrences previously.
- Nineteen tissue samples were collected from animals hit by cars (N = 15), accidentally trapped (N = 2), dispatched due to rabies (N = 1), and an abandoned kitten (N = 1) during the reporting period. All samples were submitted to the National Genomics Center for Wildlife and Fish Conservation (formerly Rocky Mountain Research Lab) for DNA analysis.
- ENSP continues 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. The lab completed additional analyses using the samples previously collected from NY, PA, and ME between 2003 and 2010, and then additional NJ samples collected through 2017, for a total of 315 unique bobcats from New Jersey that were included in the analyses. A final report was written by the lab and provided to ENSP describing the analyses and results.
  - The lab completed an updated STRUCTURE analysis as well as a Geneland analysis that evaluates the genetic structure of a population by taking into account both genotypes and location information.
    - Bobcats in NJ are genetically closer to bobcats in PA and NY rather than ME. Results from the clustering analyses indicate that bobcats in NJ have their own unique population signal that is rare and not present in the other state samples. There is also evidence of a mixing zone in New York from bobcats in ME and those from PA and northern NJ.

- - The Geneland analysis supports bobcats in NJ being considered one population (distinct from bobcats sampled in other states), and fine-scale structuring of bobcats within NJ was not observed.
    - Population cluster assignments for each bobcat individual was provided by the lab to evaluate the within NJ variability in more detail and in relation to suspected movement barriers.
  - ENSP is collaborating with a graduate student at Cornell University who is conducting a regional bobcat genetic study centered around NY. ENSP shared samples with her and she shared NY bobcat samples in return that help fill in some gaps. The National Genomics Center for Wildlife and Fish Conservation will update the analysis with the new NY samples and with samples gathered in NJ over the reporting period.
- Two reproductive tracts and teeth from 14 animals were collected opportunistically from bobcat carcasses during the sampling period. The reproductive tracts were analyzed by a veterinarian. Both females were lactating at the time of the vehicle strike. The placental scars indicated that one had had two kittens and the other three. Twenty-six teeth samples collected through 5/3/2018 were prepared and submitted to Mattson's laboratory during the reporting period to estimate age of each animal from which teeth were extracted.
- Opportunistically-collected bobcat carcasses were also tested for rodenticide exposure (Fish and Wildlife Health Project, FW-69-R-19). Six carcasses collected between 5/3/3017 and 3/1/2018 were tested during the reporting period and none indicated exposure to rodenticides.
- An ad was again published again in the Division of Fish and Wildlife's Hunting Digest that requested information on bobcat sightings, vehicle mortality and accidental trapping and described the reporting mechanisms.
- The bobcat biologist within the Endangered & Nongame Species Program (ENSP) again collaborated with Bureau of Wildlife Management (BWM) biologists to respond to bobcats accidentally captured in cable restraints. ENSP continues to work on developing mechanisms to better understand and minimize injury and mortality resulting from accidental capture.
  - A similar protocol was followed by the ENSP and BWM biologists responding to bobcat calls as last trapping season. The protocol follows the latest recommendations from Safe-Capture International, Inc. training, and helps insure that standardized data are collected and samples and recorded information get to the appropriate ENSP biologist.
  - A total of 2 trapped bobcats (Fig. 1) were reported by trappers during the reporting period. Both individuals were successfully released. Ear tags were attached and DNA samples were taken from both bobcats.
- There were 13 road-killed bobcat carcasses recovered by ENSP during the reporting period (Fig. 2), from which tissue samples, teeth, reproductive tracts (females) were taken and rodenticide testing was performed. Another bobcat was found hit by a car, with chest and eye wounds that were surgically repaired, and was eventually released several weeks later. Of the road-killed bobcats, between May and July, 2 were lactating females and 3 were kittens. Another abandoned kitten was found by a homeowner and brought to a rehabilitator; it was determined that one of the lactating females was its mother.

- A bobcat tested positive for rabies during the reporting period for the second time in two years. These cases are the first since at least 1932 when rabies documentation began.
- During this reporting period, DNA confirmed that a bobcat that was originally tagged by NJDFW in 2014 as a juvenile and legally harvested in 2016 near Harrisburg, PA, a linear distance of 108 miles, was in fact a male, not a female as first reported by biologists from PA. The Note that ENSP and biologists from the PA Game Commission were collaborating on writing for the Northeastern Naturalist publication was cancelled due to the fact that long-distance dispersals by male juveniles are more common than for females.
- No bobcats were collared during the reporting period.
- ENSP has begun collaborating with the University of Delaware on a bobcat research project in New Jersey. The University is supporting a master's degree student, who will focus her work on a couple of elements that are needed to inform the NJ bobcat recovery plan, including habitat connectivity and availability analyses, particularly in central and southern New Jersey.
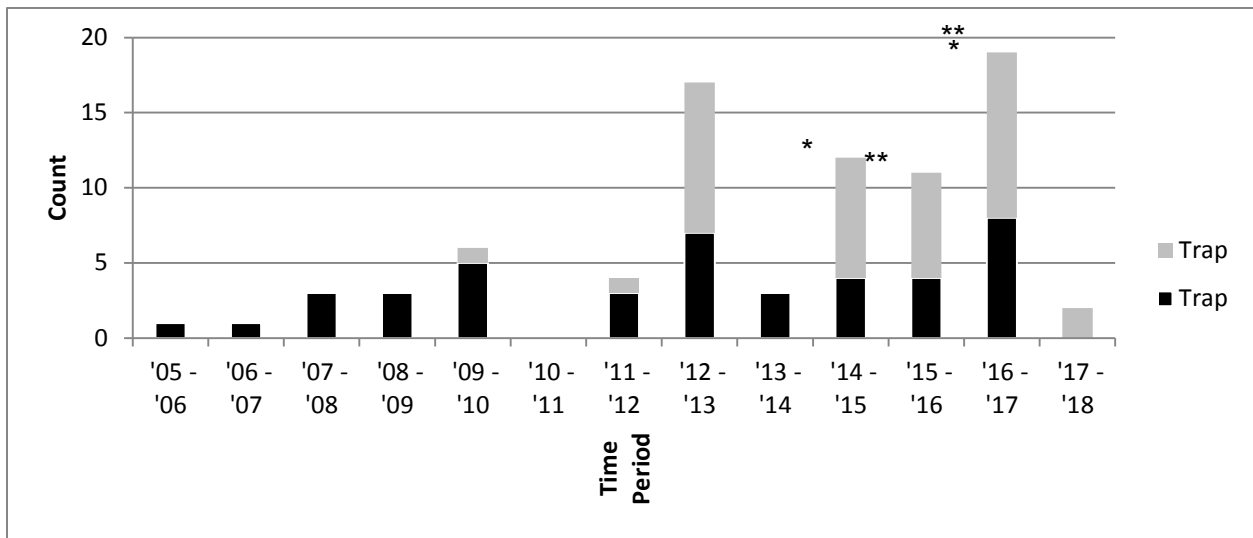- ENSP has put together a first rough draft of a bobcat status assessment.

Figure 1. Number of bobcats trapped accidentally in New Jersey over the past 13 reporting periods from September 1 to August 31 each year. The '09–'10 year was the first year of a trapper response team available to help release bobcats. The '15–16 year was the first year of mandatory reporting of bobcats.

* - 1 alive released by trapper, not sure of condition
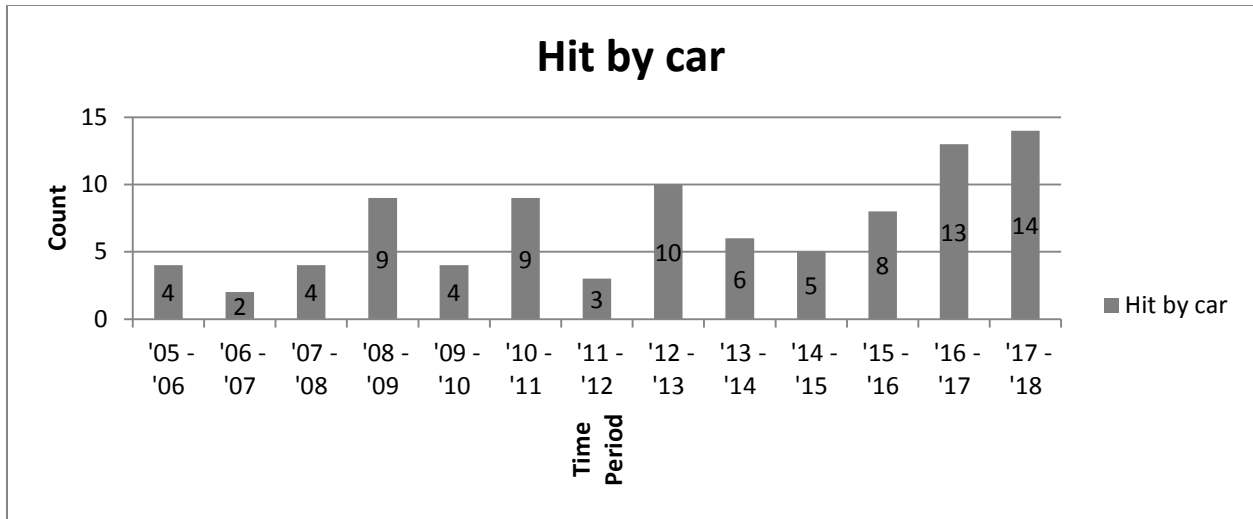** - 1 alive caught in cage trap

Figure 2. Number of confirmed bobcats struck by vehicles in NJ over the past 13 years, through 8/31/18.

Conclusions:

- A trail camera photo was submitted to ENSP that documents a range expansion; the sighting was near other known habitat, but separated by a major interstate.
- Sample analysis – DNA from live bobcats, and teeth, reproductive tracts, DNA, and rodenticide testing of dead bobcats – are all improving our understanding of bobcat status and health. Analysis of spatial data and documentation of threats also contribute to the information necessary for our bobcat status assessment.
- Population and density estimates for bobcats in northern New Jersey per year over 7 different years between 2007 and 2016 have now been completed by a statistician at DEP's Division of Science, Research, and Environmental Health in collaboration with ENSP. A final report was prepared detailing the analyses and results and shared with ENSP. This is the first time these estimates have been achieved for bobcats in New Jersey.
- Several analyses in collaboration with the National Genomics Center for Wildlife and Fish Conservation were completed that evaluated the substructure and gene flow of the NJ bobcat population. A report detailing the analyses and results was completed and shared with ENSP. Additional updates to the analyses are planned.
- None of the bobcat carcasses tested showed rodenticide exposure for the first time.
- The number of bobcats struck by vehicles increased slightly during this reporting period from previous years and represents the highest number on record in NJ. The number of lactating females (2) and kittens (3) struck by vehicles has never occurred previously.
- The number of non-target bobcats reported in traps has fluctuated over time, though the number reported during this reporting period was the lowest since 2010-2011 when no trapped bobcats were reported. This was despite the fact that last year was the highest number on record and there has been mandatory reporting since 2015-2016. Results of the trapper survey indicated that the canine trapping effort was lower across the state than it has been the past couple of years, but that it was higher in Warren County than it has

been in the previous 5 years and most accidentally trapped bobcats occur disproportionately in Warren County based on our data.

- A first rough draft of a bobcat status assessment has been completed.

Recommendations:
- 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 using new samples from NY and NJ.
- Continue to use scat, tissue, remotely triggered camera, and GPS collar data to help validate CHANJ core and corridor modeling and to inform guidance on increasing the permeability of the landscape for bobcats.
- Pursue getting a new wildlife detection dog. The use of a detection dog is particularly useful in areas where a target species occurs at low densities, such as central and southern NJ, where we have done limited surveys. A dog can also be very useful in finding scats along possible movement corridors to evaluate functional connectivity, which is extremely beneficial for validating and prioritizing the CHANJ modeling, and informing the accompanying guidance.
- Continue to opportunistically collect tissue samples from live and dead bobcats to add to the capture-recapture database, from which we can glean movement patterns over time, age, and parentage of individuals.
- 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.
- Continue to try to work with the Bureau of Wildlife Management and trappers, ideally in collaboration with the authors of AFWA's Best Management Practices for Trapping in the United States (http://jjcdev.com/~fishwild/?section=best_management_practices) to figure out ways to decrease the rate of injury and mortality to bobcats accidentally trapped in New Jersey.
- Continue collecting and analyzing reproductive tracts and teeth to gain a better understanding of the age structure, fecundity, and pregnancy rates of the population, and continue to test bobcat carcasses for rodenticide exposure to assess the extent of the risk factor.
- Continue to collect bobcat roadkill data to assess the extent of the risk factor, to validate the CHANJ core and core modeling, and to help prioritize mortality hot spot areas to focus road mitigation efforts for bobcats to help increase the permeability of the landscape. Continue to each out to agencies and the public who may not be aware that we are interested in the collection of the data and carcasses to increase the recovery rate of bobcat roadkill data and carcasses.
- Continue to collaborate with the University of Delaware on bobcat research that will inform a recovery plan.
- Continue to compile the results of the varied analyses in a bobcat status assessment/recovery plan and 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.

Literature Cited:

Thompson, C. M., Royle, J. A., and J. D. Garner. 2012. A Framework for Inference about Carnivore Density from Unstructured Spatial Sampling of Scat using Detector Dogs. The Journal of Wildlife Management. 76(4): 863-871.

STATE: New Jersey   **PROJECT NUMBER:** W-71-R-2

PROJECT TYPE: Research and/or Management

PROJECT TITLE: SGCN Mammal Research and Management

STUDY NUMBER AND TITLE: 1. Mammals

PERIOD COVERED: September 1, 2017 to September 30, 2018

JOB NUMBER AND TITLE: 1B. Allegheny Woodrat Conservation
Prepared by: Gretchen Fowles

OBJECTIVE: Annually monitor NJ's Allegheny woodrat (*Neotoma magister*) population and assess the potential exposure risk to raccoon roundworm (*Baylisascaris procyonis*). Actively manage raccoon roundworm levels in the raccoon population at New Jersey's last remaining Allegheny woodrat population through the use of medicated raccoon baits.

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, deployed 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 Palisades habitat area. The dispensers continue to be re-loaded on a 6-8 week schedule with approximately 50 baits each, year-round. The baits each have approximately 50mg of pyrantel pamoate, which is the low end of the recommended dose range for raccoons. During this reporting period we ordered a new batch of baits in coordination with Ohio DNR Division of Wildlife, which is starting a medicated baiting program with a higher dose of pyrantel pamoate, 150mg, per bait, to dose raccoons of slightly above average body size. We began distributing the second batch of baits on 8/27/18.
- In addition, ENSP and volunteers collected and GPSed 80 raccoon scats at the Palisades between 9/1/2017 and 9/30/2018, to evaluate the prevalence of *B. procyonis* egg loads in the scat. The scats were sent to Wheaton College for analysis. Just a subset (N = 16) have been analyzed by the reporting date and all were negative.
- Standard trapping protocol was conducted at six separate talus slope sites in the Palisades Interstate Park during October 12-13, 2017. 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 consecutive days (10/12 and 10/13) for a total of 84 trap-nights of sampling effort.
  - Twenty-five unique individuals were trapped, and the capture index (# of individuals captured/10 trap nights) was 2.98 (Fig. 1).
  - Captured animals consisted of eight adult males, 13 adult females, one juvenile male, and three sub-adult females.
  - One animal (male) was a recapture from 2013, eight were recaptures from 2016 (1 male, 7 females), and 16 animals were new captures (7 males, 9 females).

- All captured animals 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.
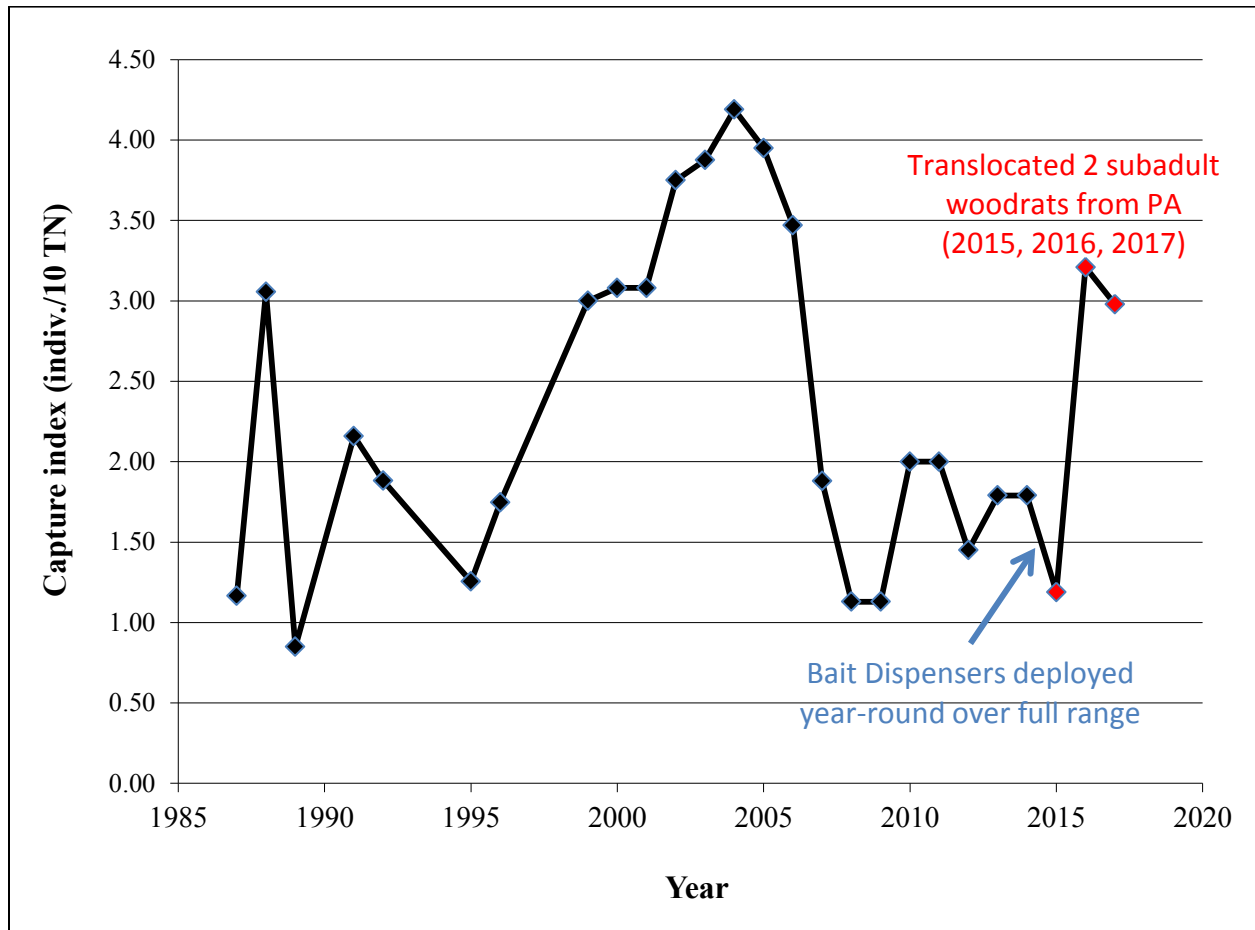

Figure 1. The results of ENSP's trapping effort in the Palisades over the last several years, setting 42 traps for two consecutive days in six trap areas in the fall, for a total of 84 trap-nights of sampling effort/year.

- Monitoring of the translocated male from 2015, and females from 2016 and 2017 has continued throughout the year with two motion-triggered cameras positioned where the animals were last located with telemetry before we removed their collars.
- A translocation was not conducted in 2018, as the plan was to conduct them for 3 consecutive years and then evaluate the results.
- Montclair State University funded two graduate students to work on Allegheny woodrat projects as the focus of their thesis research, in collaboration with ENSP. Both students successfully defended their theses in May 2018 and copies of their theses were shared with ENSP.

- One student GPSed the perimeters of and monitored 9 suitable talus slope sites within the Palisades range, but outside of the six sites ENSP has trapped annually, for woodrat presence, using 4-5 motion-triggered cameras at each site baited with peanut butter suet. The cameras were deployed for two weeks, and batteries, memory cards, and bait were refreshed after 1 week. She recorded woodrat activity at 5 out of 9 of the sites monitored and 2 of the sites had at least one juvenile present.
- The second student evaluated habitat quality, prevalence of *B. procyonis* egg loads in raccoon scat (N = 150 total samples), and presence of predators/competitors using baited motion-triggered cameras at 4 historic woodrat sites. The 4 sites are located along the same ridge system in northern New Jersey and were known historic sites with evidence of woodrats until about the mid-1980s. The student used the 3 factors she tested to rank the 4 sites for further investigation as to their suitability as possible reintroduction sites in the future. No woodrats were documented on camera, unfortunately.
- A collaboration between ENSP and a geneticist at Towson University who houses the Allegheny woodrat genetic library, including all NJ Palisades samples taken in the past, continues. Towson conducted the following analyses and submitted a report with the findings to ENSP.
  - The geneticist successfully genotyped 60 woodrat tissue samples collected at the Palidades in 2009 (n=5), 2011 (n=13), 2015 (n=8), 2016 (n=18) and 2017 (n=11) using SNPs.
  - Expected (H_E) and observed heterozygosity (H_O) was calculated across all samples using the program GenAlEx 6.501 (Peakall and Smouse 2012). Additionally, H_E and H_O was calculated for years before individuals from Pennsylvania were translocated into the population (2009 and 2011) and after (2015, 2016, 2017).
    - Across all woodrats sampled in New Jersey, H_O and H_E were 0.20 ± 0.02 and 0.17 ± 0.01, respectively.
    - Observed heterozygosity in the six woodrats translocated from Pennsylvania was 0.28 ± 0.02.
    - The mean H_O in Allegheny woodrats increased following introduction of translocated individuals in 2015, 2016 and 2017 (Fig. 2).
  - Parentage analysis indicated that three individuals captured in 2017 were the offspring of the female translocated from PA in 2015.
  - Similar to the last reporting period, DNA concentrations were high for the 35 scat samples (collected in 2017) analyzed, but only two produced high-quality genotypes indicating that DNA from other organisms was present.
    - On July 5, 2018, ENSP conducted a woodrat scat survey at the Palisades in an effort to collect fresh woodrat scat to test additional genetic laboratory procedures, with the aim of increasing the scat genotyping success rate. The scats that were collected (N = 50) were those not in contact with other scats, and that were dried using two different methods: 1) 100% ethanol and 2) silica desiccant. Either two or four scats were collected from a total of 15 woodrat latrines along the Palisades range. Each scat was placed in in a separate tube, half of which contained 100% ethanol and the other half contained silica desiccant to evaluate if one

treatment was more effective at preserving the DNA than the other. The locations of the scats were GPSed and photos were taken of each prior to collect. All scat samples were recorded and sent to Towson University for analysis. The analysis results were not yet available by the end of the performance period.
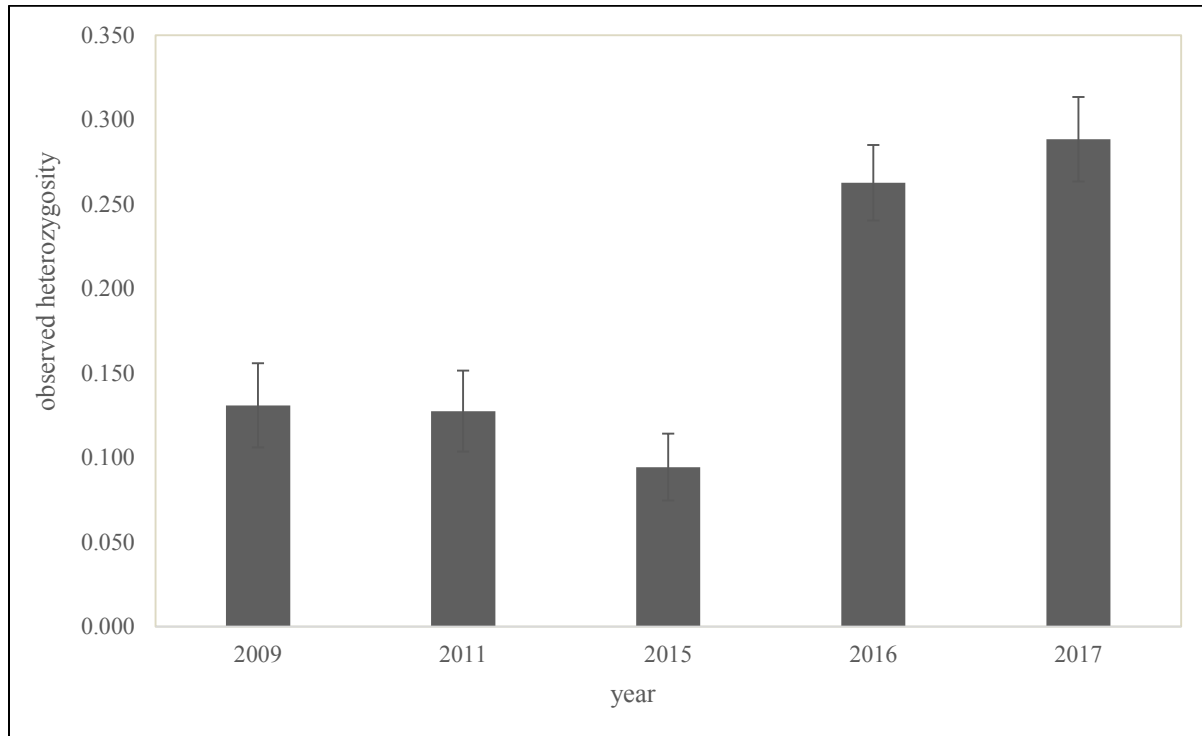

Figure 2. Mean observed heterozygosity (H_O) ± SE for Allegheny woodrats (*Neotoma magister*) captured in 2009 (n=5), 2011 (n=13), 2015 (n=8), 2016 (n=18) and 2017 (n=11) at the Palisades.

Conclusions:
- The anthelmintic bait coverage continues to extend the length of the Palisades woodrat habitat area including the NY/NJ border and is being implemented year-round, providing a thorough temporal and spatial coverage of roundworm de-worming to keep this serious mortality factor at bay. It is also important to give the translocation/genetic rescue efforts conducted the past 3 years every chance of success. The de-worming effort has been effective as measured by relatively low prevalence of roundworm eggs in raccoon scat collected at the Palisades woodrat sites, with only one positive sample recorded last year, and no positive samples during this reporting period, though most of the samples were awaiting analysis as of 9/30/18. This was the first year of collaborating with another state on the baiting approach.
- Allegheny woodrat captures were slightly lower than last year, but remain at the highest level in the past ten years, which is a good indicator that the roundworm mitigation and translocation efforts may be having a positive effect on the population.
- ENSP had coordinated for three consecutive years (2015, 2016, and 2017), with the PA Game Commission, the translocation of Allegheny woodrats from PA to the last remaining population in New Jersey. A translocation was not conducted during this

reporting period, and instead ENSP, the PA Game Commission, and woodrat experts in the region decided it best to monitor the genetics and capture success rate for a couple of years and then re-group to discuss future management strategies for the population.

- The camera monitoring work of one of the MSU graduate students is helping to identify and document the distribution of occupied woodrat areas along the Palisades range, outside of the six areas ENSP has monitored with annual live trapping for a couple of decades

- The camera work, habitat evaluation, and prevalence of raccoon roundworm at four historic woodrat sites by another MSU graduate student has provided helpful data regarding the suitability and ranking of those sites in regard to future management actions.

- The genotyping of individuals conducted by Towson University has been very successful in expanding our understanding of the genetic variability in the New Jersey population. We have learned that, as expected, the overall observed heterozygosity of the New Jersey population indicates relatively low genetic variability. However, we are also able to track that genetic variability over time and the values in 2015, 2016 and 2017 indicate an increase following introduction of translocated individuals in 2015, 2016 and 2017 (Fig. 2). The genotyping has also been helpful in determining whether translocated individuals have parented young. Our results from this year indicate that three individuals we sampled during the annual trapping effort were parented by a translocated individual.

- Towson continues to experiment with additional laboratory procedures to try to increase the scat genotyping success rate. The lab has learned that DNA concentration is an unreliable predictor of genotype quality, but that has led to other ideas which are being pursued such as chloroplast sequencing to evaluate plant species consumed.

Recommendations:
- Continue the collaborative efforts with Montclair State University, Pennsylvania, and Ohio to conduct research and develop management plans for the conservation of woodrats.

- 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 is a serious threat to the population in the past. While the overall observed heterozygosity of the population remains low, the genetic variability has increased in conjunction with the three translocations of subadults from nearby Allegheny woodrat populations in 2015, 2016, and 2017. Continue to collect genetic samples from all individuals trapped during the next annual trapping effort and compare them to the baseline samples collected in 2015, as well as to the 2016 and 2017 results to continue to monitor the trend in genetic variability over time. Continue to run parentage analyses to specifically identify if

translocated woodrats continue to breed. 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 the genetic analysis of woodrat scat samples with the goal of hopefully increasing the scat genotyping success rate to the point where genotyping noninvasively collected scat could be used to inform our understanding of the minimum population size in the Palisades. Also continue to collaborate on the exploration of chloroplast sequencing of woodrat scat as a means of identifying particular dietary items, which would help inform habitat management efforts.
- Continue the assessment of historic woodrat sites using baited motion-triggered cameras.
- Encourage Montclair State University to support other graduate students focusing on woodrat research.

Literature Cited

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.

Peakall R, Smouse PE (2012) GenAlEx 6.5: genetic analysis in Excel. Population genetic software for teaching and research--an update. Bioinformatics 28:2537–9. doi: 10.1093/bioinformatics/bts460

JOB NUMBER AND TITLE: 1C. Small Mammal Survey
Prepared by: Gretchen Fowles

OBJECTIVE: To develop survey and habitat sampling protocols for several species of terrestrial small mammal that can be used for sampling statewide.

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.

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

PERFORMANCE REPORT

STATE: New Jersey   **PROJECT NUMBER:** W-71-R-2

PROJECT TYPE: Research and/or Management

PROJECT TITLE: SGCN Mammal Research and Management

STUDY NUMBER AND TITLE: 1. Mammals

PERIOD COVERED: September 1, 2017 to August 31, 2018

JOB NUMBER AND TITLE: 2A. Bat Conservation and Management
Prepared by: MacKenzie Hall

OBJECTIVE 1: To identify, characterize and monitor summer bat colonies roosting within man-made structures and to provide guidance for proper management of those sites, especially where the federal endangered Indiana bats roost or maternity colonies exist.
OBJECTIVE 2: To identify, characterize, and monitor important winter habitats of New Jersey's bat species, including the federal endangered Indiana bat; and to gather Indiana bat winter population counts to contribute to USFWS database.
OBJECTIVE 3: To identify, characterize and monitor summer roost selections and maternity colonies of White-nose Syndrome affected bat species, including the little brown bat, Indiana bat, and the newly federally listed northern long-eared bat.

Key Findings:
Interagency Consultations & Coordination
- Records obtained from the NJ Department of Health Rabies Lab from buildings (Jan-Sept 2016) indicated a cluster of northern long-eared bat occurrences. Of the 13 northern long-eared bats the Lab received that year, nine of them came from within a <10 mile radius in Burlington, Camden, and Gloucester counties, with records spanning all seasons. The area is decidedly urban-suburban, with small stream courses and narrow riparian forests transecting mixed residential/commercial communities. To begin investigating the presence of northern long-eared bats and their seasonal use of the forested stream course areas, we gained permission from local open space agencies to do acoustic surveillance on township lands in Evesham and Washington Twp. Results of initial surveys (Oct 2018) and further plans will be discussed in our final report.
- NJ's Rabies Lab has been outsourcing their services since spring 2017 but will soon resume testing in-house (Oct 2018). The new staff agreed to hold all rabies-negative bat specimens of interest (such as *Myotis* species) for the ENSP to analyze, as their predecessors had in 2016.
- During summer 2018, Alicia Protus of the USFWS NJ Field Office invited ENSP's bat biologist (M. Hall) to collaborate on bats-in-bridges issues, starting with a training session for the NJ Department of Transportation (NJDOT) about surveying bridges for bats prior to maintenance work or other activities that could impact roosting bats. The NJ

Field Office is now requiring surveys of bridges within the state range of federally-listed Indiana and northern long-eared bats when a federal funding nexus exists. Where colonies of non-federally listed bats are documented, state protections against take will apply as per New Jersey's Endangered and Nongame Species Conservation Act. We prepared a training session for NJDOT engineering and Environmental Program personnel, which was held on Sept 5 and will be detailed in our final report.

- ENSP provided direct consultation to homeowners and Nuisance Wildlife Control Operators (NWCOs) on approximately 45 bats-in-buildings cases during this reporting period. Seasonal emails were sent to our NWCO contact list (70 individuals) and to the NJ Pest Management Association with timely reminders about seasonal restrictions and "safe dates" for bat exclusion, natural history tidbits, an offer of free bat houses for eviction sites, links to our Bat Conservation and Bats in Buildings webpages, and an open invitation for dialogue on these topics. As a result of our outreach, ENSP also provided 11 bat houses to homeowners where bats were being evicted from structures.
- ENSP's bat biologist attended the Joint Bat Working Group meeting (held in lieu of a Northeast Bat Working Group meeting) in Roanoke, VA in March 2018 and participated in regular agency WNS calls.

Summer Surveys
- ENSP's contractor, the Conserve Wildlife Foundation of NJ (CWF), coordinated the 2018 Summer Bat Count. Homeowners, interns and volunteers performed emergence counts every other week at nine roosts: five roosts are colonies of little brown bats (n=4) and big brown bats (n=1) in buildings, bat boxes, and other man-made structures and have been monitored regularly since pre-WNS; and four roosts where little browns (n=2) and big browns (n=2) have more recently been discovered. Based on seasonal high counts, big brown colonies numbered 25.9% higher this year than in 2017, with the one long-monitored colony up 43.7% since pre-WNS. Little brown colonies were 42.1% smaller in overall numbers this year than in 2017 and have dropped by 95.5% since pre-WNS. This year's drop in little browns is largely attributed to one bridge colony, where the high count was 146 bats in 2017 but just 7 this summer. This site warrants further investigation, since a new volunteer conducted the 2018 surveys, and those surveys are done from a challenging 300+ yard distance (or otherwise by boat). The other little brown colonies remained relatively stable compared to the previous few years; one bat house colony grew by more than 80% this year to surpass 100 individuals.
- No capture/banding surveys were done at summer roosts during this work period. We have gained valuable information from several colonies via capture/banding surveys since 2009 and felt we should give the bats a break from disturbance, using just emergence surveys to monitor their numbers.
- With the help of a seasonal employee, contractor (CWF), and more than 20 volunteers, we completed a second year of acoustic monitoring within 12 grid cells across the state in June and July, following the North American Bat Monitoring Program (NABat) framework. Each grid cell contains one mobile transect and two stationary points.

  The 12 mobile routes were run twice each (except one route which was run only once), generating approximately 1,400 total bat call files. Twenty-three of the 24 stationary acoustic points were passively monitored for 4 suitable weather nights each (one point was inaccessible due to flooding along a State Park access road). Data are currently

being processed by our contractor; results will be discussed in our final report and shared with NABat via their online submission site, for which we have created a profile.

Figure 1. Volunteer Nicole Dion prepares to run a mobile acoustic survey.

- Between June 12 and Aug 9, 2018, our team completed eight nights of mist-netting on six different sites across northern NJ. The previous two seasons had mainly targeted northern long-eared bats in southern NJ, but this year our site selections were mainly guided by acoustic reconnaissance indicating *Myotis* bat activity, and by incidental forest management/clearing projects which lacked baseline knowledge of listed/WNS-vulnerable bat species. Mist-netting sites included:
  - Sweet Hollow Preserve (NJ Natural Lands Trust, Hunterdon Co.) – June 12. Chosen for high *Myotis* bat activity from 2017 acoustic survey.
  - Beaver Brook Wildlife Management Area (NJ Division of Fish and Wildlife, Warren Co.) –June 19. Chosen for proximity to abandoned Manunka Chunk railroad tunnel where *Myotis* bats have been recorded.
  - Black River Park (Morris County Park Commission, Morris Co.) – June 26. Chosen for proximity to large proposed forest clearing and high suitability for Indiana Bats. Acoustic scouting showed moderate likelihood of Indiana Bat presence.
  - Fiddler's Creek Preserve (Mercer County Parks, Mercer Co.) – July 10 and 19. Chosen for lack of prior bat survey data needed to inform a Recreational Plan for the property. Acoustic scouting returned approximately 200 *Myotis* bat calls in just two nights.
  - Great Piece Meadows (NJ Natural Lands Trust, Essex Co.) – July 31 and Aug 8. Chosen for its high suitability for Indiana Bats but lack of prior surveillance.
  - Stokes State Forest (NJ Division of Parks and Forestry, Sussex Co.) – Aug 9th. Chosen for proximity to a forest management project on State Park land and lack of prior bat survey data. Acoustic scouting by volunteers at Montclair State University returned a high likelihood of *Myotis* bat activity.

  Our mist-netting resulted in the capture of 42 bats in total, including 4 bats of interest and 38 common bats:
  - A pregnant adult little brown bat at Sweet Hollow Preserve, which we attached a radio-transmitter to but spent three days tracking unsuccessfully within a >5 mile radius of the capture point before concluding that the transmitter (purchased in 2015) had likely failed.

- A non-reproductive adult female little brown bat at Fiddler's Creek Preserve, which we prepared to attach a transmitter to, but the transmitter (the last of the 2015 set) was dead prior to attachment.
- A juvenile male northern long-eared bat at Fiddler's Creek Preserve, which we would have radio-tracked but were out of functioning transmitters. We acquired new transmitters and returned to the site a second night but were unsuccessful in recapturing any bats of interest.
- A female little brown bat at Stokes State Forest, which escaped from a technician's hand before we could gather more info.
- 30 Big brown bats – of which 13 were adult females (12 of them reproductive), 12 were adult males, and 4 were juveniles (1 female, 3 males). One escaped from hand before it could be inspected.
- 8 Eastern red bats – all females (7 reproductive adults and 1 juvenile).

Hibernaculum Management & Winter Surveys
- ENSP and our contractors re-gated the aging bat-friendly gate at Hibernia Mine (Morris County, NJ) in Sept 2017 with funds from a Regional Conservation Needs grant, and also increased air flow into the mine by removing a section of an old reinforced concrete wall from the mine entrance. These modifications increased the mine opening by about seven times the size, from approximately 6 ft^2 to 48 ft^2. Our contractor installed an air control wall with several removable panels about 30 feet father inside the mine so that air flow may be managed if necessary. Our goal is to provide an optimal temperature range – around 35-42˚F – for bat hibernation and inhibition of the WNS causative fungus, *Pseudogymnoascus destructans* (Pd). For the first winter, we left more than half of the air control wall closed.

  We re-deployed about 20 temperature & humidity loggers throughout Hibernia's tunnel in fall 2017 in order to monitor changes in the internal climate resulting from increased cold air flow in winter. Figure 2 shows the temperature profile recorded by each logger from Nov 14, 2017, through June 2018, with outside daily temperatures overlaid. Temperatures appear to have been favorable throughout the winter overall. On the coldest day, Jan 7th, when outside temperatures dropped to 0-17˚F, the back of the mine held at 37˚F and the deepest seven sections (175 meters) remained at ≥35˚F, while the front twelve sections (300 meters) fell below freezing. In a walk-through survey on Jan 19, most bats in those front twelve sections were clustered into drill holes, where temperatures would have been warmer and better insulated than the wall temperatures where the loggers were recording. The average roosting temperature of each bat in a drill hole that day (recorded via laser thermometer) was 38.8˚F (range: 35.4 to 45.6˚F). Beyond section 12 the bats were positioned more in the open, at an average roosting temperature of 42.3˚F (range: 37.4 to 45.8˚F).
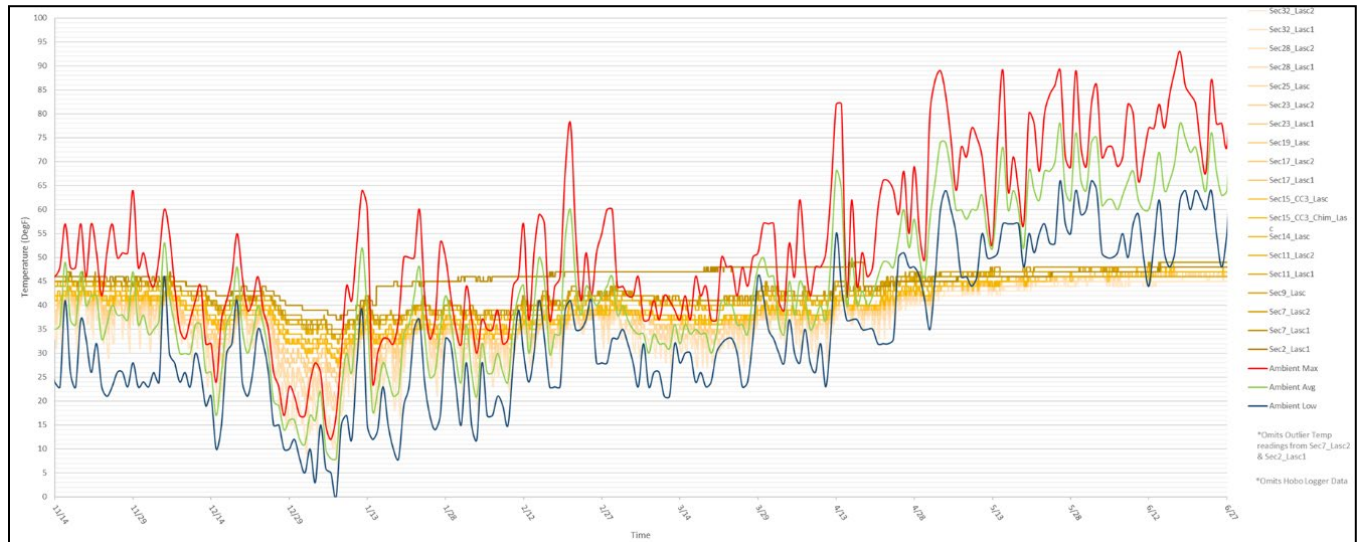
Figure 2. Temperature profile of Hibernia Mine after air flow modification and re-gating, from entrance to terminus (light to dark orange) and from Nov 2017 to June 2018 (x-axis), with outside low (blue), high (red), and average (green) daily temperatures overlaid.

- We continued post-WNS population and survivorship monitoring at Hibernia Mine with a pre-emergence census and banding survey on March 23, 2018. A total of 232 bats were tallied - a 35% drop from the 357 bats observed the previous year (March 20, 2017). Figure 3 shows the bat distribution and temperature profile throughout the tunnel. About 80% of the bats were roosting in drill holes during the March survey, where the average roosting temperature was 38.8°F (range: 36.3 to 42.9°F). The average roosting temperature of bats on the open walls and ceilings was 41.5°F (range: 37.0 to 48.2°F).

  We handled a total of 197 unique bats (all little browns) for banding or band-reading during the survey. Of these, 124 bats (=62.9%) were re-sightings and 73 (=37.1%) were new bats which we banded. The ratio of male bats was particularly high this year, with males making up 82.3% of re-sightings and 74% of new bats. While new females have always numbered fewer than new males in our annual banding surveys (Figure 4), with females making up about 38% of Hibernia's banded bats to-date, they are re-sighted at an even lower rate compared to males (Figure 5).

  Almost 60% of re-sighted bats were originally banded ≥6 seasons ago (2010-2012), suggesting moderate survivorship of those earliest post-WNS surviving individuals. We observed one male that had not been seen since his banding in 2010, and another male that had not been seen since his banding in 2011. One female hadn't been seen since 2012, and another hadn't been seen since 2013. One male little brown bat has been seen *every* year since he was banded in 2010.

  During our 2018 survey, only four bats displayed *Pseudogymnoascus destructans* fungal growth on their wings/forearm membranes, and each in minor amounts. Three of these bats were new encounters, likely first-year bats who were experiencing a novel exposure.
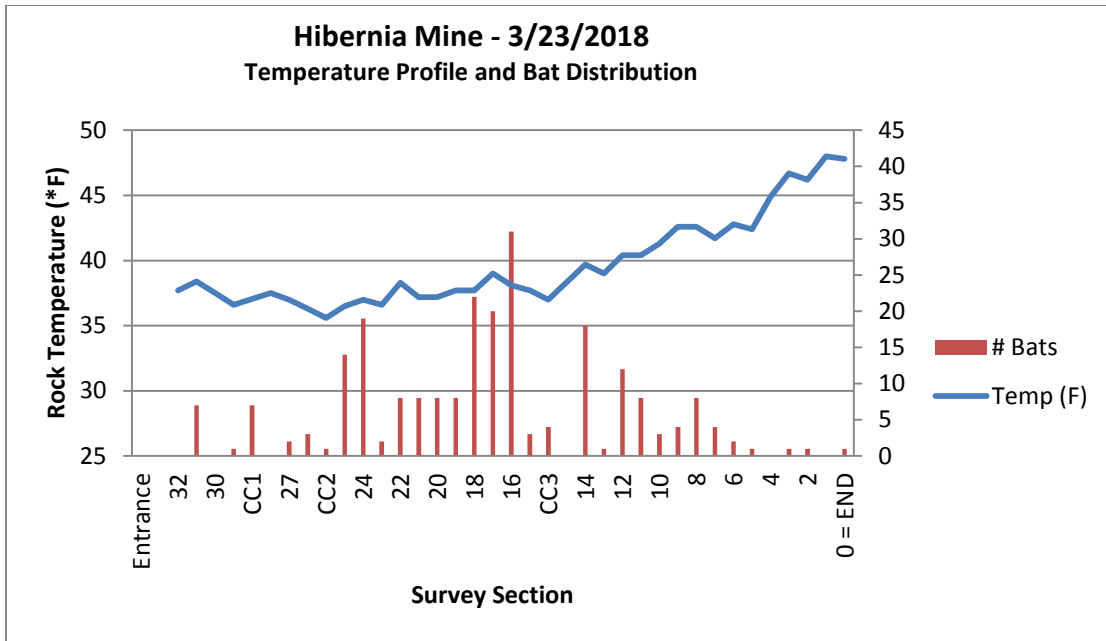
Figure 3. The distribution of bats and temperature profile throughout the Hibernia Mine tunnel during the March 2018 census. Temperatures reflect rock temperature at each 25-meter survey section marker.
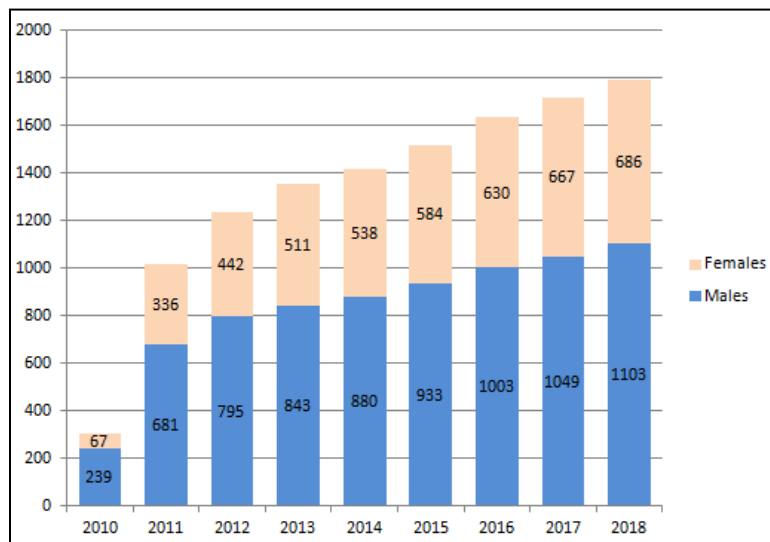

Figure 4. Cumulative number of little brown bats banded at Hibernia Mine, by sex.
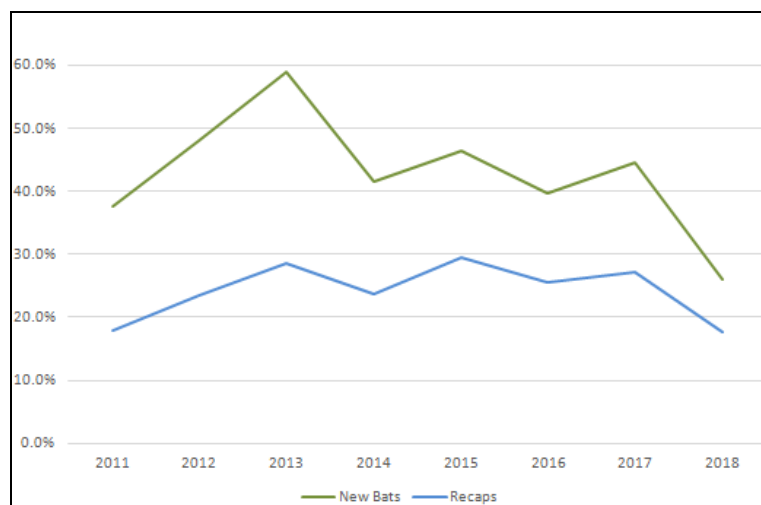
Figure 5. Proportion of Hibernia's new and re-sighted little brown bats that are females, by survey year.

- Monitoring of Indiana Bats and other cave-hibernating bats at the Mt. Hope Mine (Morris County, NJ) continued for the seventh consecutive year during the fall swarm, from late Aug to Oct 2017, with volunteer services provided by Sanders Environmental and EcolSciences, Inc. Sanders conducted 9 nights of harp-trapping and netting around the mine shaft entrance, following the same methods developed in 2011 for annual monitoring at the site. Their results showed consistent numbers of WNS-vulnerable species compared with the previous few years, with 131 Indiana bat captures (18 new and 113 recaptures). Eastern small-footed bat numbers (34 captures) were 55% higher than any other year post-WNS. A fall 2018 survey has been conducted and will be reported on in the final report for W-71-R-2.

- Consultants from EcolSciences volunteered to do acoustic monitoring outside the abandoned Manunka Chunk railroad tunnels in Warren County, NJ, to follow up on a Sept 2015 observation by ENSP of a *Myotis* bat flying at the northern tunnel entrance. To our knowledge, this tunnel has never been documented as a bat hibernaculum. Acoustic monitoring was done outside the southern tunnel entrance (lower risk of vandalism) from late Sept through mid-Nov 2017. The files showed several hundred calls each of big brown bats and little brown bats into November, as well as incidental records of Eastern red bats and other migratory species. One auto-classifier program, Kaleidoscope Pro, identified 18 calls as Indiana bat, but a second program, SonoBat, identified them as little browns.

- Following up on the fall acoustic survey at the Manunka Chunk tunnels, the ENSP and contractors performed an internal survey on March 16, 2018, in attempt to confirm and quantify hibernating bats. We observed 14 big brown bats within the first 500 ft of the west tunnel (approximately one-quarter of the total length of both tunnels), but were not able to survey other areas due to deep water and unstable/broken-down conditions. No little brown bats were observed in the accessible section.

- We also visually surveyed the entire mile-long interior of the Pattenburg tunnel for hibernating bats on Feb 28, 2018. This tunnel was documented as a bat hibernaculum in the 1990s, with a complement of species hibernating there (including Northern long-eared bats). It had not been surveyed internally recently, though Myotis bats were

recorded during one night of acoustic surveillance by the ENSP two years prior. We observed 50 big brown bats hibernating within the tunnel.

Data Management
- We continued entering bat data from consultant reports into GIS shapefiles for entry into ENSP's Biotics database. We will detail the total number of entries, due by the end of the year, in our final report.
- Land Use/Land Cover justification write-ups are in progress for seven bat species will be completed by the end of the project period. The justifications, based on extensive literature reviews, will provide the framework for ENSP's Landscape Project mapping of these species.

Conclusions:
- Maternity colonies of WNS-affected bats seem to be stabilizing, although our sample size of known-occupied roosts is small and trends have varied at different colonies.
- Bridges have been an untapped resource for our summer bat monitoring efforts. New coordination between our agency, the US Fish and Wildlife Service and the NJ Department of Transportation will enhance our documentation and understanding of bats roosting in bridges.
- The large drop in little brown bat numbers at Hibernia Mine between 2017 and 2018 (hibernation seasons) is not likely attributed to WNS, based on recent trends and the lack of symptomatic late-winter bats. It is possible that the new gated opening confused bats or made them cautious of their familiar hibernaculum. Our disturbances to the bats during hibernation surveys may also have altered the habits of some.
- The disparity between new male and female little brown bats in Hibernia was the highest this year since our first banding year (2010; 1 year post-WNS) when the ratio was 78% males. This suggests that either WNS or our disturbance takes a greater toll on females, or that the subtle decrease in temperature or unfamiliar appearance of the mine entrance this year did not favor them.
- Several little brown bats from Hibernia Mine were re-sighted for the first time in six or more years, indicating that their absence from one survey (or many!) does not imply that they have perished. Bats may be making use of an alternate hibernaculum unknown to us, or roosting in parts of the mine that we cannot access.
- While acoustic surveys detected *Myotis* bats outside of two abandoned railroad tunnels during spring/fall, only big browns were seen hibernating inside the tunnels. Further surveillance will be needed to confirm these sites as hibernaculum for *Myotis* bats, if that is in fact the case.
- Radio-transmitters >3 years old were not reliable and should be replaced/refurbished every other year.
- Little brown bats were mist-netted for the first time since 2015, showing that healthy individuals remain on the landscape and that acoustic scouting is a valuable way to pre-screen sites and target areas with high likelihood of presence. Likewise, healthy and reproductive northern long-eared bats remain on the landscape, including in lesser-quality forested stream habitats like those found in NJ's Inner Coastal Plain physiographic region.

Recommendations:
- Continue annual, biweekly summer emergence counts at Little Brown Bat colonies - and other colonies of interest - to help ascertain trends in WNS-affected bat populations. Follow up on our one known little brown bat bridge colony to determine if observer error contributed to the low 2018 counts, or if perhaps bridge maintenance activities may have occurred recently and impacted that bats or their use of the structure.
- Survey and document additional bridge colonies via NJDOT inspections. Follow up on all reports of bats in bridges with emergence counts to determine colony sizes and species, and seasonal arrival and departure phenology as possible.
- Resume 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.
- Use results of the NABat stationary monitoring program to focus netting efforts for species of interest/concern, like the Northern Long-eared Bat, Tri-colored Bat and Indiana Bat, in order to confirm the species' presence, radio-track bats to their roosts, and locate colonies for further monitoring.
- Adopt a policy of surveying hibernating bat colonies less frequently (i.e., every 3-5 years) to limit our potential for unintended impacts.