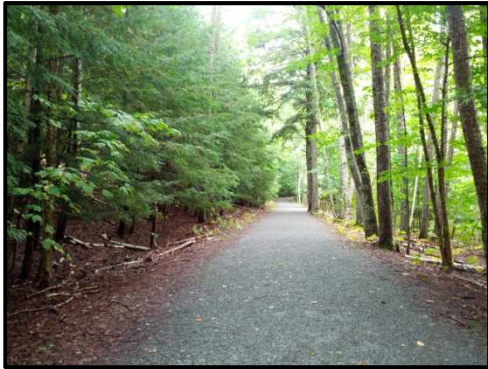


EFFECTS OF WHITE-NOSE SYNDROME ON THE BATS OF ACADIA NATIONAL PARK

A comparison of mist-net capture results pre-WNS and post-WNS



Submitted by:
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Submitted to:
National Park Service; Acadia National Park

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EFFECTS OF WHITE-NOSE SYNDROME ON THE BATS OF ACADIA NATIONAL PARK

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The Biodiversity Research Institute (BRI) is a 501(c)3 non-profit organization located in Gorham, Maine. Founded in 1998, BRI's mission is to assess emerging threats to wildlife and ecosystems through collaborative research, and to use scientific finding to advance environmental awareness and inform decision makers.

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FRONT PHOTO CAPTIONS: *Top left: In daylight the Hemlock Road looks similar to most trails at ANP but by nightfall it serves as a bat super-highway. Bottom left: A rare Myotis leibii waits for the sun to set, wedged in its crevice roost on top of Dorr Mountain. Photos: Timothy Divoll.*

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EXECUTIVE SUMMARY

White-nose syndrome (WNS) was detected at Acadia National Park (ANP) in the winter of 2011-12 in one bat species: the little brown bat (*Myotis lucifugus*). Several individuals were either found dead or observed exhibiting odd behaviors such as daytime flight. This is suggestive of a nearby hibernaculum infected with the fungus that has caused mass mortalities in this and other cave roosting bat species. To assess the potential impact of WNS on Acadia's bat population, we compared capture rates and ease of capture for each species using data before WNS was detected in the park compared to after detection. Based on summer capture results scaled for effort three seasons before and one season after apparent infection with WNS in one species, no major declines in the summer population were noticed. We did, however, notice an increase in abundance and ease of capture of red bats (*Lasiurus borealis*). This is consistent with patterns observed in other WNS impacted areas. The current explanation for this is that, because this species does not hibernate in caves, they are less susceptible to WNS, and thrive on increased available prey. Effectively, they fill the ecological void left by mass mortalities of *Myotis* species. We recommend continued mist-netting in an effort to recapture individuals banded before WNS at ANP and monitor population trends. Of most importance is locating maternity roosting sites and winter hibernacula sites of all *Myotis* species present: little brown (*M. lucifugus*), northern long-eared (*M. septentrionalis*), and eastern small-footed (*M. leibii*). Protection of critical habitat is essential in maintaining viable bat populations and a fully-functional ecosystem at ANP.

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INTRODUCTION

Recent issues such as white-nose syndrome (WNS) and wind power development have had undoubted effects on bat populations in northeastern North America. A lack of baseline knowledge of bat abundances and spatiotemporal patterns makes it challenging at best to understand what to consider, how to manage, and how to conserve bat populations. The causative agent of WNS, *Geomyces destructans*, is a fungus causing mortality by infection of bats during hibernation causing them to awaken, burn precious energy to groom and then exit caves in winter to search for food (Reeder et al. 2012). Most die when they cannot find prey in winter, precisely the justification for storing extra fat and hibernating through the winter. This disease has killed over 5 million bats in North America since 2006 (Blehert 2012) and is considered one of the greatest environmental challenges temperate bats face, alongside wind power development (Boyles et al. 2011). This fungus was first detected in Maine in the western mountains in winter 2010-11 and a year later at (ANP) in winter 2011-12 (Figure 1). Currently, only little brown bats (*Myotis lucifugus*) appear to be affected at this location, based on dead or dying bats found on Mount Desert Island and submitted to the National Wildlife Health Laboratory for confirmation of the disease by histological analysis (B. Connery, pers. comm.). Without a known hibernacula location and the absence of dead bats of other species, susceptibility of these other species at ANP remains unknown. Of most concern are eastern small-footed bats and northern long-eared bats, both relatively abundant at ANP and both recently petitioned for listing as Federally Endangered (Mattesson 2010).

Based on experience in New York state, biologists from the New York Department of Environmental Conservation believe that bats found dead on the landscape indicate a hibernaculum very close in proximity (Carl Herzog, pers. comm.). Stable isotope analyses suggest that some species such as eastern small-footed and northern long-eared bats may never leave the park, both hibernating and spending summers at ANP (Divoll 2012). Since we do not know where hibernacula at ANP are situated, we used summer mist-net data as an index of relative bat abundance pre-WNS and post-WNS onset to determine if the disease has impacted local populations one year after detection at ANP.

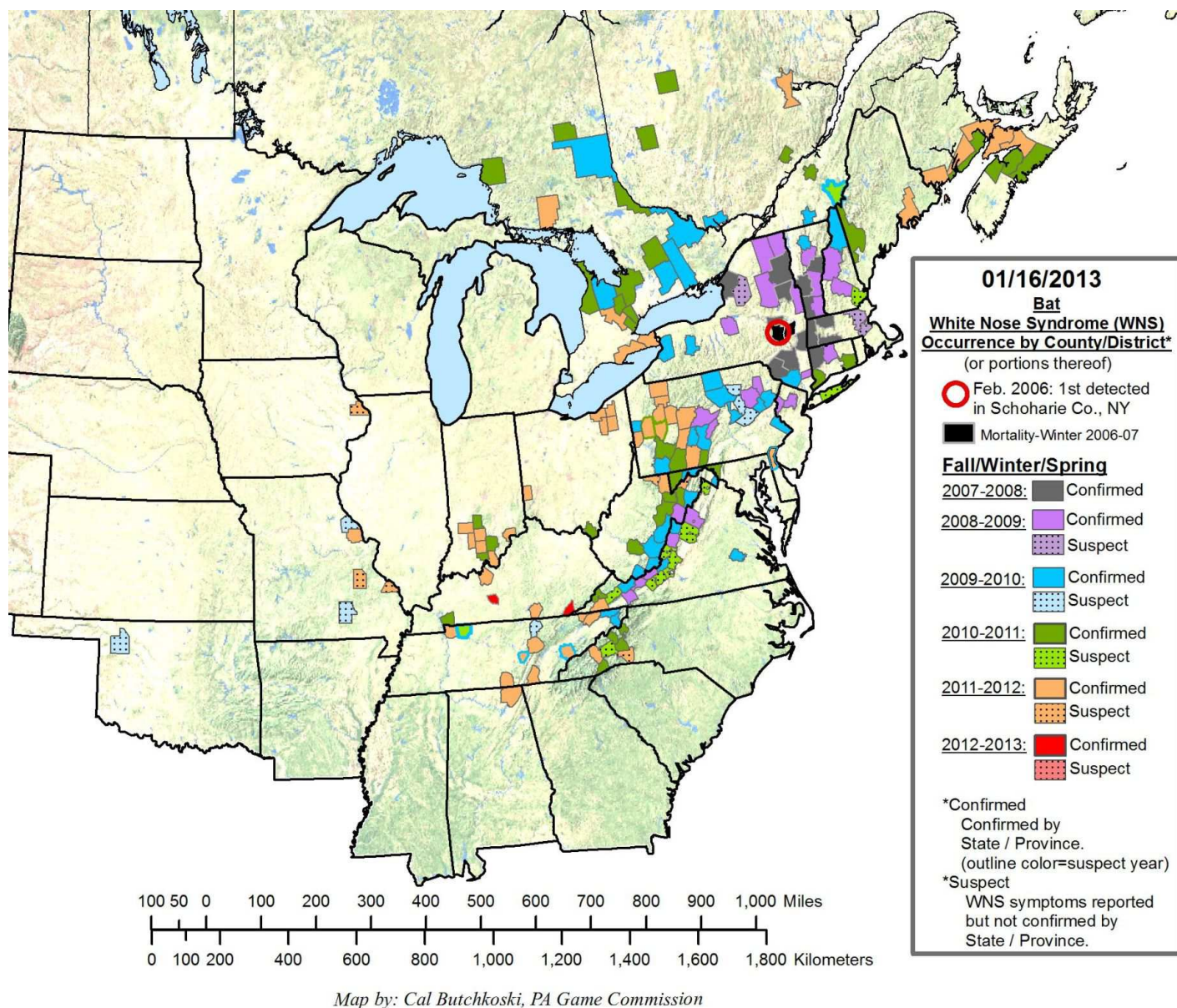


Figure 1. The current known occurrence of WNS across eastern North America, as of January, 2013.

STUDY AREA

Historic parklands and national parks are important areas that provide foraging habitat for bats (Glendell & Vaughn 2000, Loeb et al. 2009). We surveyed bats in 2009, 2010 and 2011 at Acadia National Park, Maine, which comprises 15,233 ha of protected land in eastern coastal Maine. Three tracts of land make up the majority of the park: Mount Desert Island, Isle au Haut, and Schoodic Peninsula. These areas contain marshes, old growth forest, mixed forest, ridges, lakes and ponds, and carriage roads with approximately 20% of this area classified as wetland habitat (Calhoun et al. 1994). We used Mount Desert Island (MDI) as one study site to determine variation in the population through the seasons including 14 trapping locations on the island to stay mobile and maximize nightly captures based on wind, moon, and fog patterns, which can affect capture rates (Morrison 1978; Fig. 2). These 14 locations were situated on park lands and conservation easements in mixed forest dominated by mature eastern hemlock (*Tsuga canadensis*), northern white cedar (*Thuja occidentalis*), spruce (*Picea spp.*), poplar (*Populus spp.*), American beech (*Fagus grandifolia*), birch (*Betula spp.*), and maple (*Acer spp.*). Locations were at low elevation (2 - 122 m) and the average distance to the closest water source was 0.53 km (Table 1). Different sites, particularly on the east side of the island, offered topographic protection from moonlight and/or wind depending on the moon phase and wind direction.

Table 1. Descriptions of bat mist-net locations at Acadia National Park, Maine, 2009 - 2012.

Trapping location	Latitude	Longitude	Elevation (m)	Distance to water (km)	Habitat Type
Amphitheater bend	44.323	-68.2716	112	1.07	forested carriage road
Bubble Pond	44.3375	-68.2357	122	0.34	forested carriage road
Cedar Swamp Mtn.	44.3246	-68.2842	78	0.27	forested carriage road
Eagle Lake South	44.3493	-68.2484	106	0.19	forested carriage road
Gilmore Meadow	44.3617	-68.2696	75	0.22	forested carriage road
Hio Rd.	44.2547	-68.3367	12	0.31	forested carriage road
Jordan Pond Cliff	44.3306	-68.26	111	0.24	forested carriage road
Lurvey Spring Rd.	44.3044	-68.3355	41	1.01	forested carriage road
Marshall Brook Rd.	44.2725	-68.3521	7	0	forested grass road, tidal creek
Murphy's Lane	44.3486	-68.1843	23	0.17	forested road bed
Pooler property	44.4207	-68.3215	2	0	forested grass road, tidal creek
Stonebarn property	44.4179	-68.3069	5	3	forested grass road, tidal creek
Hemlock Rd.	44.3632	-68.2074	15	0.15	forested carriage road
Valley Cove	44.3037	-68.316	34	0.38	forested carriage road

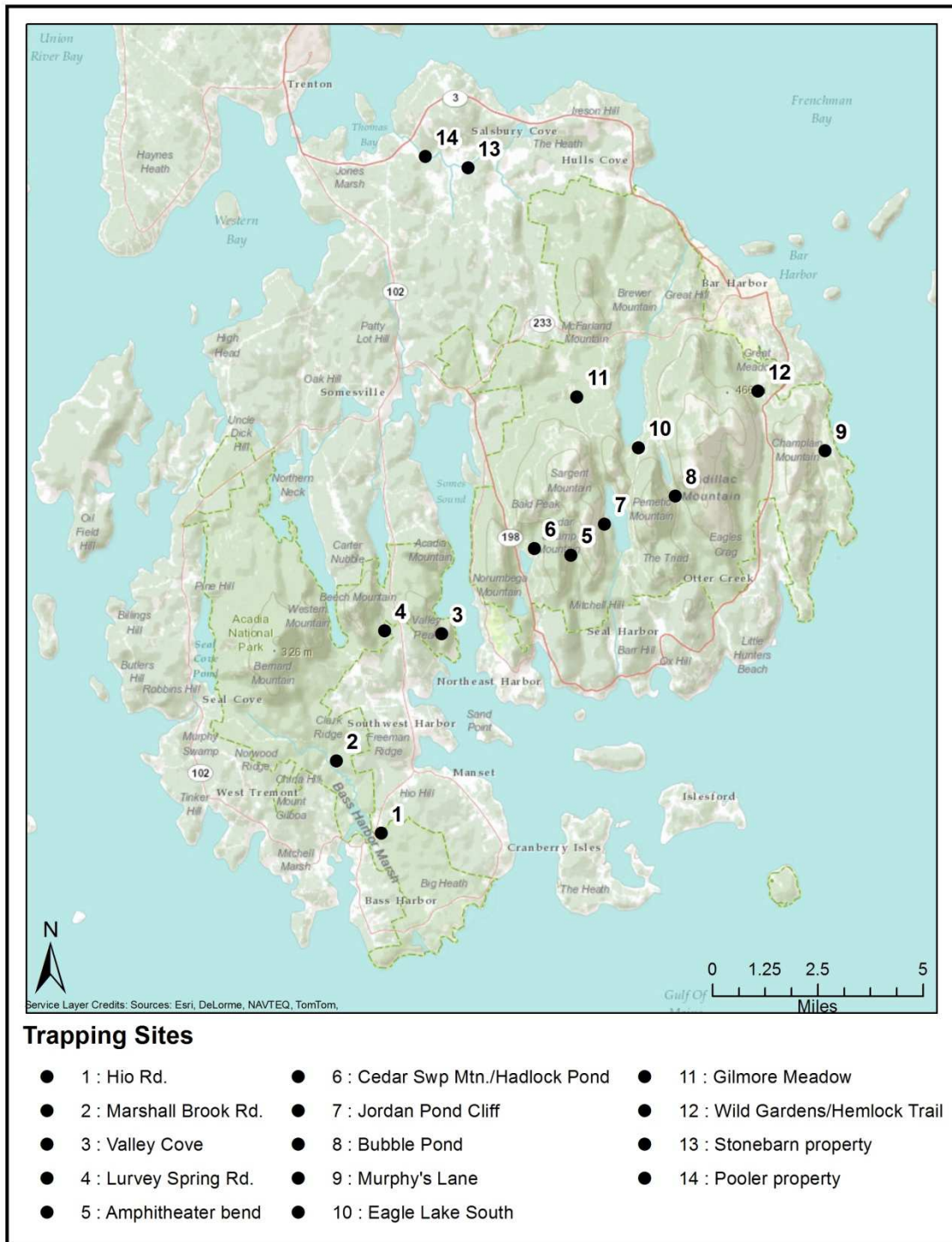


Figure 2. Locations of bat mist-netting sites on Mount Desert Island at Acadia National Park, Maine, 2009 - 2012.

METHODS

To determine differences in species diversity at ANP each month, mist netting surveys were conducted at 14 sites using Triple High Forest Filter systems (Bat Conservation and Management, Carlisle, PA) hung with Avinet (Dryden, NY) bat specific mist-nets (38mm mesh, 4 shelves, 2.6m x 6 to 18m). A pilot effort in the months of May, June, August, and September of 2009 was conducted to determine access to and capture success of mist-netting sites. Site selection was based on weather patterns that can affect capture rates such as wind direction, moon phase, and temperature (Geluso & Geluso 2012) each night to predict which sites would be darkest, least windy, and warmest. We also netted at different sites each night, since bats may become trap-shy at net locations used on consecutive nights (Winhold & Kurta 2008). A limiting factor of mist-netting is that some species can detect nets with echolocation and sight when there is a fair amount of moonlight or light pollution, allowing them to actively navigate around and above nets with one or both senses.

Based on successful netting efforts in 2009 we mist-netted 1- 5 nights per week from the second week of April through the end of September 2010. In 2011, netting only occurred in July and August, and results were compared to capture rates in previous years. Regardless of sampling year, the same sites were used under the same netting protocol. Two triple high mist-net systems (7.8 m tall) were placed over roads or streams with appropriate lengths to fully cover the travel corridor (6 - 18 m), adding single high nets at the edges where appropriate. Nets were opened for at least 45 minutes and up to 6.5 hours each night and closed if weather inhibited capture or kept open as long as one bat had been captured within the previous half hour. Following MacCarthy et al. (2006), to maximize capture rates each night, nets were checked every 10 minutes when possible to reduce both amount of disturbance at the net and risk of bats chewing their way out of nets. Due to uncertainties in spread of white-nose syndrome and permitting requirements, we followed USFWS Bat Decontamination Protocols (USFWS 2012) to reduce any chance of researcher assisted spread. All bat handling followed Sikes et al. (2011) and was reviewed by the University of Southern Maine's IACUC. All bats captured were identified to species and banded so that each was uniquely identifiable upon subsequent recapture. Individuals were then aged (Kunz & Anthony 1982), sexed, measured (forearm length

in mm), and weighed (g). All were assessed for degree of wing scarring, which may correlate with prior exposure to white-nose syndrome (Reichard & Kunz 2009).

RESULTS

Differing levels of effort were invested each year, depending on funding and resource availability. To account for these differences, each month that sampling occurred from 2009 through 2012, was compared in terms of Units of Effort (UOE) where 1 UOE is equal to 1m² of mist-net or harp trap left in the same location for 1 hour (UOE = m²/h). This allows comparison of bats captured by month, scaled for the amount of effort.

Table 2. Monthly capture abundances without consideration of hours of sampling per month. Total captures each month were heavily influenced by the effort expended and no inferences should be made about abundance trends without consideration of effort. Re-captured bats (n = 24; n = 11 eastern small-footed; n = 7 little brown; n = 6 northern long-eared) are not included in these totals so that totals represent true individual bats.

	little brown	northern long- eared	eastern small- footed	red	big brown	hoary	Total
May 2009	14	7	1	0	0	0	22
June 2009	97	36	21	0	0	0	155
August 2009	143	36	16	2	1	2	200
September 2009	10	5	7	0	0	0	22
April 2010	0	4	17	0	0	0	21
May 2010	16	14	21	0	0	0	51
June 2010	46	41	19	0	0	0	106
July 2010	86	33	9	3	0	0	131
August 2010	116	58	12	5	0	0	191
September 2010	10	10	3	0	0	0	23
July 2011	5	5	4	1	2	0	17
August 2011	71	29	16	4	0	0	120
May 2012	2	4	1	0	0	0	7
August 2012	32	16	14	10	0	0	72
Total	648	298	162	25	3	2	1138

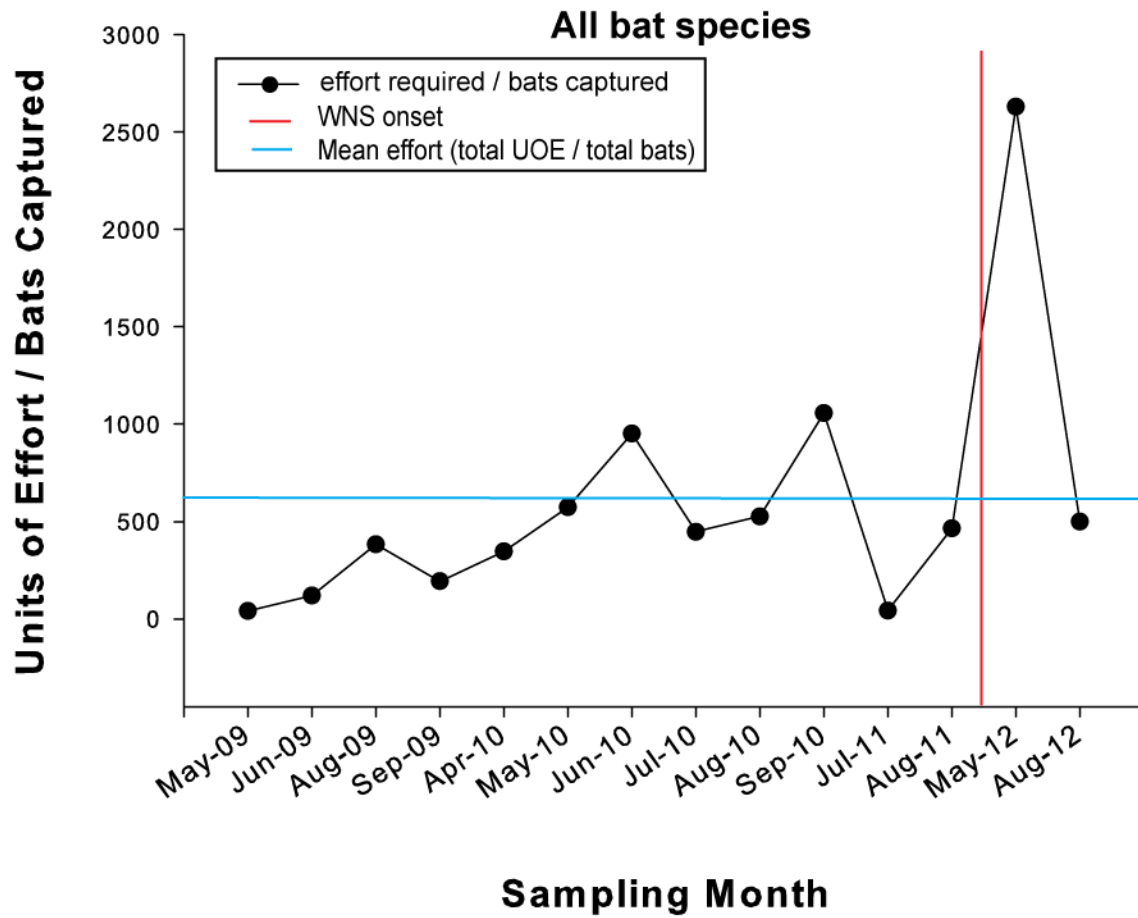


Figure 3. Units of Effort required to capture one bat on average by month of sampling. Blue line indicates the mean effort required across all sampling months to capture 1 individual bat. Red line indicates first detection of WNS at Acadia National Park in the winter of 2011-2012.

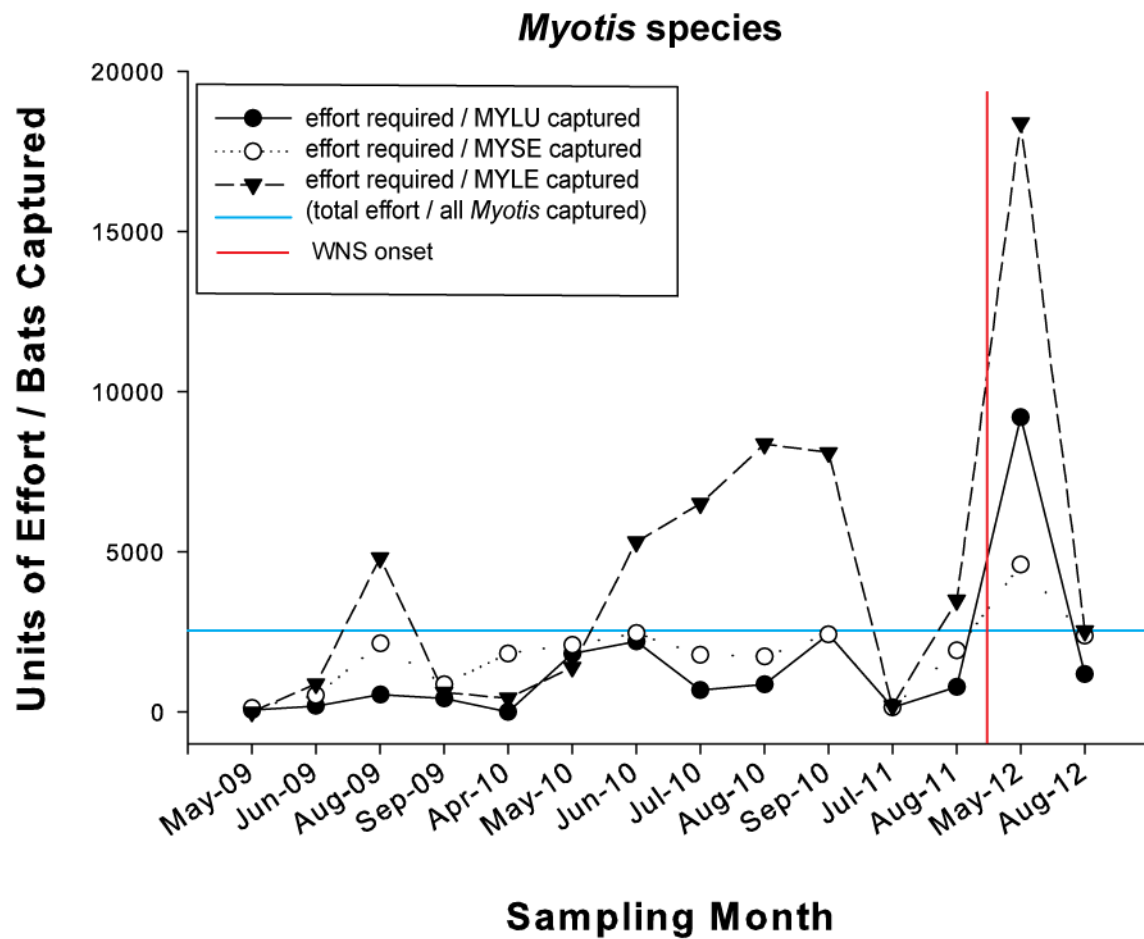


Figure 4. Units of Effort required to capture one bat of the *Myotis* genus on average by month of sampling. Blue line indicates the mean effort required across all sampling months to capture 1 individual bat in the *Myotis* genus. Red line indicates first detection of WNS at Acadia National Park in the winter of 2011-2012. Species codes: MYLU = *Myotis lucifugus*, little brown bat; MYSE = *Myotis septentrionalis*, northern long-eared bat; MYLE = *Myotis leibii*, eastern small-footed bat.

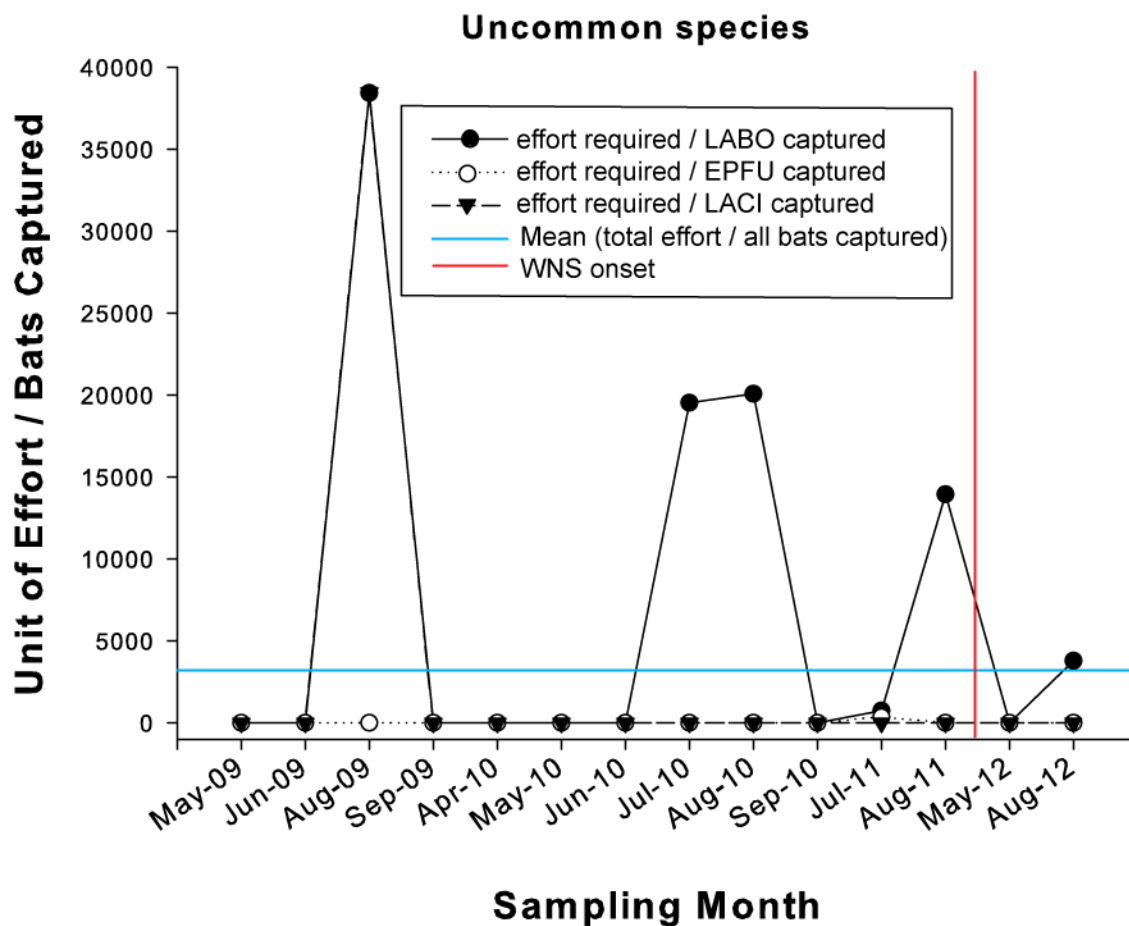


Figure 5. Units of Effort required to capture one bat in the uncommon guild (uncommon within our sampling). Blue line indicates the mean effort required across all sampling months to capture 1 individual bat. Red line indicates first detection of WNS at Acadia National Park in the winter of 2011-2012. Species codes: LABO = *Lasiurus borealis*, red bat; EPFU = *Eptesicus fuscus*, big brown bat; LACI = *Lasiurus cinereus*, hoary bat.

DISCUSSION

Estimations of ease of capture are likely biased by the amount of effort related to weather conditions. Months that very little effort were invested were prone to low capture rates when weather was not favorable for the duration of sampling. This was the case in May 2012, and resulted in lower overall capture results since it was cold and rainy for the entire sampling period despite putting forth at least the same amount of effort per night when compared to previous sampling periods. Because May 2012 was the first sampling period after detection of WNS in little brown bats, we anticipated a decline for at least that species. We did only capture two little brown bats, out of seven total bats for that month (Table 2). However, since we do not know whether the bats found dead in the winter at ANP are the same bats that comprise part of the

summer population, the apparent lack of little brown bats in May 2012 cannot be explained fully by WNS. Captures of other species in May 2012 were also lower than previous May sampling periods. All *Myotis* species were captured in similar abundances per effort in August 2012 when compared to August sampling periods of previous months (Fig. 4).

Overall Captures

Contrary to many post-WNS areas in the northeast, ours captures have been dominated by little brown bats followed by northern long-eared and eastern small-footed (Table 2). This has been of great interest to members of the NorthEast Bat Working Group (NEBWG) over the past few years as many have seen significant reductions of *Myotis* captures in their studies closer to the epicenter and origin of WNS, Albany, NY. ANP became infected later than many parts of the northeast (Fig. 1) so summer declines may still be lagging winter population declines. In large states such as New York and Pennsylvania, biologists have also seen increases in big brown and red bat captures, (Carl Herzog & Cal Butchkoski, NEBWG 2013), which is consistent with our data for red bats only.

Perhaps the best gauge of overall bat capture pre- and post-WNS is the month of August. This month is post juvenile volancy so young of the year are available for capture and naive. We also sampled consistently each year in August. Based on this month alone (Fig. 3), it took about the same amount of effort to catch 1 bat on average, even after WNS was detected at ANP.

Myotis species

Within *Myotis* species, little brown and northern long-eared bats remained as easily captured in August regardless of year. Eastern small-footed bats were comparatively harder to catch, except in 2012. This was likely influenced by our attempts to capture this species specifically for a separate radio telemetry study. Though we have little post-WNS capture data, it appears that one year following WNS detection at ANP, *Myotis* species have not experienced significant declines but the amount of effort to catch the same number of these species has generally increased (Fig. 4). This may be a slow indication of WNS impacts or bats may have learned how to avoid mist-nets after four years of sampling. It will be interesting to monitor this consistently in consecutive years, given the unknown susceptibility of northern long-eared bats and eastern small-footed bats. Reduced summer captures in New York state lagged a couple of

years behind mortalities seen in winter hibernacula (Al Hicks, pers. comm.) We do not yet have baseline data on hibernacula in Hancock County, Maine, so the summer capture frequencies will be an important estimator of population abundance until hibernacula are located and can be monitored.

Of particular interest are the numbers of eastern small-footed bats and northern long-eared bats captured at ANP in light of their potential listing as Endangered. Eastern small-footed bats are less common than northern long-eared bats and aggregations are usually detected at a maternity colony or winter hibernacula; in contrast our captures are from summer foraging. The number of captures at ANP ($n = 162$) suggest this is one of the largest concentrations of this species known to date, comparable to other reported concentrations: 118 roosting in a man-made dam at Surry Lake, NH (J. Veilleux, pers. comm.), 47 hibernating in a railroad tunnel in Maryland (Johnson & Gates 2008), 61 roosting in natural talus in West Virginia (Johnson et al. 2011), and 33 roosting in an old wooden cabin at high elevation in North Carolina (O'Keefe & LaVoie 2010). At this time, we do not know if eastern small-footed bats or northern long-eared bats are affected by WNS at ANP.

Other uncommon species

The lack of big brown and hoary bat captures make it challenging to infer or conclude anything about these two species in relation to WNS. Hoary bats are not commonly captured but big brown bats are a very common species found roosting in man-made structures throughout its range and captured frequently at all sites in the northeast, excluding ANP (BRI, unpublished). Many researchers throughout the northeast have seen significant increases in big brown and red bat captures since WNS has caused declines in local *Myotis* populations (NEBWG meeting, Albany, NY, 2013). The consistent lack of big brown bats at ANP cannot be explained and appears to be a true anomaly. In 2001, Atkins & Glanz reported that big brown bats comprised 26% of their total captures. Their work was concentrated around man-made structures where this species roosts whereas we sampled at travel and foraging corridors only.

Our red bat captures are consistent with findings in other states. Though we only captured this species in July and August each year, it took successively less effort each year to catch red bats (Fig. 5). This may be an early indication that red bats are in fact filling the niche of *Myotis*

spp. that have succumbed to WNS and we haven't sampled long enough post-WNS onset to detect a lack of *Myotis*.

Recommendations

To better understand the impacts of WNS on Acadia's bats, it is imperative to locate critical summer roosting habitat, specifically maternity roosts, in conjunction with equally critical winter hibernacula. Both maternity roosts and hibernacula are vulnerable habitat that safeguard populations through recruitment and survival. Because our bats are banded there is great opportunity to track individuals post-WNS. In the winter of 2011-12, nearly 100 little brown bats were either found dead or observed flying during the day on Mount Desert Island (B. Connery, pers. comm.). It is evident that a hibernaculum is nearby and it should be located and subsequently monitored using similar methods as those used in New York, Pennsylvania, and West Virginia. It is the general consensus among northeastern bat researchers that all northeastern hibernacula are about saturated with WNS and winter surveying should now have greater benefits than impacts (NEBWG meeting, Albany, NY, 2013).

Because of potential species listings on the Endangered Species List, pregnant and/or lactating female *Myotis* bats should be tracked using radio telemetry to locate maternity roosts in an effort to protect this critical habitat. Further, standard mist-netting in at least August each year should be continued and those data used in models to estimate population abundances, survival, site fidelity, etc. With greater than 1100 individual bats banded, there is a high potential for more recapture occurrences. Since we have several years of pre-WNS capture data, recaptures in post-WNS years are extremely valuable to better understand life histories of post-WNS bats and related needs associated with the conservation of these species.

We also recommend further stable isotope sampling of bats at ANP to include isotope sampling of their prey items. This will help determine whether individuals reside year-round at ANP or if populations converge in the fall to hibernate as the summer population may be comprised of individuals hibernating solely at ANP, entirely hibernating elsewhere, or a mix of bats hibernating in many locations.

Further, it will be important for ANP to develop a long-term monitoring strategy to incorporate recording of echolocation signals with full-spectrum ultrasound detectors. In combination with mist-netting, acoustic methods add value to inventories and are a cost-effective

way to monitor bat populations in all seasons. Though there are significant uncertainties in reliably identifying echolocation calls to the species level, full-spectrum acoustic methods are very useful in monitoring overall bat activity and, at a minimum, distinguishing *Myotis* species (high frequency emitters) from other lower frequency emitting species.

Finally, the surprising absence of big brown bats at ANP should be investigated on park lands as well as neighboring private lands that may have current or historic man-made roosts (including sites surveyed by Atkins & Glanz in 2001). All other projects that BRI has worked on throughout the northeast have offered big brown bats as an easy capture. Most memorable are some sites in north-central Pennsylvania where the habitat is very similar to that available at ANP. Large state forests miles from man-made structures offered plenty of big brown bats but this was not the case at similar trapping sites within ANP.

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