Second Guessing the Maximum Likelihood Estimator Values for Bat Surveys

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Abstract: The U.S. Fish and Wildlife Service allows acoustical surveys and automated identification software to determine the presence of the endangered northern long-eared bat (*Myotis septentrionalis*) and Indiana bat (*Myotis sodalis*). Analytical software is required to assess presence probability on a site-night basis using a maximum likelihood estimator (MLE) that accounts for interspecific bat misclassification rates. The current standard for occupancy is a returned MLE P-value < 0.05 at the nightly level irrespective of the number of files identified as either northern long-eared bats or Indiana bats. These MLE P-values can vary based on presence of other bat species with similar calls and the relative proportions of all species recorded. Accordingly, there is concern that with few nightly northern long-eared bat or Indiana bat recordings or the presence of large numbers of high-frequency bats, false-negative findings from a swamping effect could result. Using data collected in 2020–2021 by the U.S. Fish and Wildlife Service to set nationwide acoustic monitoring guidelines, we examined the relationship of returned software MLE P-values from 4873 site-nights of acoustic detector data relative to nightly counts of northern long-eared bats and Indiana bats, overall counts of other high-frequency bats, and habitat cover type. For both northern long-eared bats and Indiana bats, nights with one or more echolocation pass files identified as either species but above the MLE P-value threshold largely occurred where nightly counts of the target species was <15 and their proportion to the count of high-frequency bat species was low. We followed this analysis with a simulation using a known call library and observed similar patterns. Accordingly, with few nightly echolocation passes, *post-hoc* visual assessment following automated software identification easily could be undertaken. Evidence of swamping by other high-frequency species causing positive file identification creating false-negative or false-positives of northern long-eared bats and Indiana bats was not apparent at nightly counts of either species > 10.

Key words: acoustic sampling, acoustic swamping, echolocation pass count, *Myotis septentrionalis*, *Myotis sodalis*

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After the advent and subsequent spread of white-nose syndrome (WNS) in the eastern United States, the U.S. Fish and Wildlife Service (USFWS) has shifted its reliance from mist-netting surveys to acoustical surveys for determining the presence or probable absence of the Federally Endangered northern long-eared bat (*Myotis septentrionalis*) and Indiana bat (*M. sodalis*; Armstrong et al. 2022, USFWS 2022). Current USFWS guidelines for acoustical monitoring acceptance specify use of automated bat identification software that employs a maximum likelihood estimator (MLE) scoring of software confidence of species presence on a nightly basis (Ford et al. 2023). Whereas all commercially available bat identification software programs provide a file-by-file call identification, assumed presence must account for known species misclassification rates (Britzke et al. 2002), i.e., high overlap of Indiana bats with little brown bats (*M. lucifugus*), to move from an ambiguous determination of presence of a given species to one with higher certainty (Nocera et al. 2019). Because of the regulatory and land management implications for false northern long-eared bat or Indiana bat presence, when not actually identified via physical capture (Vermont Fish and Wildlife Department 2009, Ford et al. 2016, Silvis et al. 2016, Schroder and Ward 2022), the USFWS has set a conservative nightly MLE threshold of $P < 0.05$ for accepting the presence of both these species (USFWS 2022). The MLE scoring at the nightly level is sensitive to the software user's input of possible species which may have different combinations of confusion matrix misclassification rates as well as to the admixtures of individual species files identified and the ratios of species noted therein (Britzke et al. 2013, Nocera et al. 2019). However, this

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stringent MLE scoring to prevent false positive outcomes could come at the cost of greater false negatives. For example, in many parts of the post-WNS landscape, one or two Indiana bat echolocation call files may not reach the USFWS MLE threshold in the presence of an equal or slightly greater number of little brown bat files or other high-frequency (>35 kHz) species such as eastern red bats (*Lasiurus borealis*; Britzke et al. 2011), resulting in false-absence determinations. Conversely, encountering high rates of acoustic activity near large, colonial day-roosts of little brown bats and gray bats (*M. grisescens*) or in areas with numerous eastern small-footed bats (*M. leibii*) conceivably could produce potentially significant MLE values for both false-negative or false-positive file identifications of northern long-eared bats and Indiana bats (Britzke et al. 2002, Janos 2013, Kaiser and O'Keefe 2015, Nocera et al. 2019).

Since 2017, the USFWS and numerous municipal, state, federal, and private organization cooperators have conducted summer acoustical sampling to develop metrics for the necessary level-of-effort (LOE) for regulatory clearance purposes. These surveys occurred within the historical distribution of the northern long-eared bat and Indiana bat and in close proximity to contemporary maternity colonies where presence is known (Barr et al. 2021, Armstrong et al. 2022). From data collected in 2020–2021, Ford et al. (2023) showed that when restricted to nightly counts with an MLE $P < 0.05$ for northern long-eared bats and Indiana bats, nightly echolocation passes were significantly greater at sites with confirmed maternity activity than sites simply within the historic distribution. Logically, these values provide a body of evidence that suggests acoustic results have the potential to be used as a screening tool to not only establish presence but also identify potential maternity colony locations in future survey efforts. Ford et al. (2023) used a conservative USFWS MLE threshold ($P < 0.05$), which excluded 56% and 51% of site-nights where individual northern long-eared bat and Indiana bat echolocation files were identified, respectively. However, assessments of the conditions and characteristics of when northern long-eared bat and Indiana bat echolocation passes are noted by identification software have not yet been addressed. Questions persist regarding MLE-induced false-negatives, which may occur on nights with low overall and/or target bat activity, or alternatively, from an acoustic "swamping" by high numbers of bat passes of species with overlapping echolocation characteristics that might cause MLE *P*-values to be errantly above the USFWS threshold when present or below the threshold when not present.

Using acoustic data from 12 states, collected during 2020–2021 (Armstrong et al. 2022), we modeled MLE *P*-values at known maternity colony areas based on pass counts of northern long-eared bats and Indiana bats when nonsignificant (MLE $P > 0.05$) presence statistics were returned. We predicted that low (<10) nightly pass counts of northern long-eared and Indiana bats would result in nonsignificant MLE determinations and therefore false-negative outcomes, largely irrespective of their ratio to other high-frequency bats. Conversely, we predicted that MLE uncertainty would increase when the ratio of northern long-eared bats and/or Indiana bats was low relative to high-frequency bats, even if nightly counts were higher (>10). Lastly, based on the findings of Ford et al. (2023), we predicted that identification swamping effects would be most associated with riparian areas where overall bat species richness and activity are highest.

Methods

We conducted acoustic surveys at 20 sites in 12 states (Alabama, Arkansas, Kentucky, Indiana, Illinois, Missouri, New Jersey, Ohio, Tennessee, Virginia, West Virginia, and Wisconsin) where maternity colonies of northern long-eared bats and Indiana bats were known to occur. These sites spanned the Appalachian Plateau, Central Lowlands, Coastal Plain, Interior Low Plateau, Piedmont, and Ozark Plateau physiographic provinces (Figure 1). For a more detailed study site description see Ford et al. (2023).

In these 12 states, we deployed acoustic detectors at 20 sites ($n = 64$ detectors) from 15 June–15 August 2020 and 15 May–15 August2021 to support the USFWS Range-wide Indiana Bat and Northern Long-eared Bat Survey Guidelines (USFWS 2022). The sites were selected based on recent (<5 yr) post-WNS records of maternity activity or proximity (8 km) to currently known maternity colonies where biologists generally would accept software results without subsequent visual vetting (Armstrong et al. 2022). Following the methods described by Barr et al. (2021), at each site, we placed 1–2 detectors in each of three broad cover types: forest, forest-field edge, and forested riparian following the site placement guidelines outlined by the USFWS guidelines (USFWS 2022). At each site, we cable-locked detectors to trees and mounted microphones on 3-m tall poles approximately 2–3 m from the bole of the tree. All detectors deployed were Wildlife Acoustic SM4 ZC with SMM U2 omni-directional microphones (Wildlife Acoustics Inc., Maynard, Massachusetts) except Ouachita-St. Francis National Forest in Arkansas where we used Anabat SD2s with "Stainless" directional microphones (Titley Scientific, Columbia, Missouri). We replaced detector batteries and downloaded data cards at 6-wk intervals at each site. Each detector was set to default settings per USFWS recommendations (USFWS 2022).

Following data collection and collation, we used the 4.2.0 classifier of Kaleidoscope (v. 5.1.0, Wildlife Acoustics) at the "0" setting to identify bat passes to species, record nightly pass counts, and calculate species-specific MLE probability of presence of known or potentially present bat species at each site (USFWS 2019). We used signal detection parameters of 8–120 kHz frequency range, 2–500 ms pulse length, 500 ms inter-syllable gap, and 5 pulses for species assignment (Ford et al. 2023). We proceeded without *post hoc* visual echolocation pass assessment because this identification package had been shown to be 100% accurate with regard to eliminating false negatives of northern long-eared bats and Indiana bats and 80–90% accurate with regard to eliminating false positives for both species (USFWS 2019). Additionally, we had high confidence in knowing the true status of maternity colony activity for both bat species from when these data were collected (Ford et al. 2023). For analyses, we retained all nights without precipitation at each site and detector location, as determined by site-specific or nearest Meteorological Terminal Aviation Routine records (Iowa Environmental Mesonet 2021). We also required that at least one nightly echolocation pass for an individual detector be identified as either northern long-eared bats, Indiana bats, or both, regardless of MLE *P*-value. We used a generalized linear model with a Poisson distribution and log-link function in SAS 9.4 (PROC GENMOD; SAS Inc. 2020) to assess the relationships of returned nightly MLE *P*-values for northern long-eared bats and Indiana bats, respectively, with: 1) the absolute count by detector night for either species; 2) the ratio of either northern long-eared bats or Indiana bats nightly echolocation passes to the sum of all high-frequency bat passes recorded on that night (eastern red bat, southeastern bat [*Myotis austroriparius*], gray bat, eastern small-footed bat, little brown bat, northern long-eared bat, Indiana bat, and tricolored bat [*Perimyotis subflavus*]); and 3) cover type. Because we anticipated that the ratio covariate would positively influence the MLE *P*-value response at low and high ratios, we entered it as a quadratic term. Following our test of field data, we created 800 simulated site-nights from the known bat species echolocation call library that is maintained to test the accuracy of automated identification software by creating the conditions observed from field data in terms of low to high counts of northern long-eared bats and Indiana bats and low to high ratios of counts therein relative to other high-frequency bat species (USFWS 2019). Our analysis of simulated data was the same as with field observations though without the inclusion of a cover type covariate. We checked each model for goodness-of-fit and over- and under-dispersion by examining residual plots.

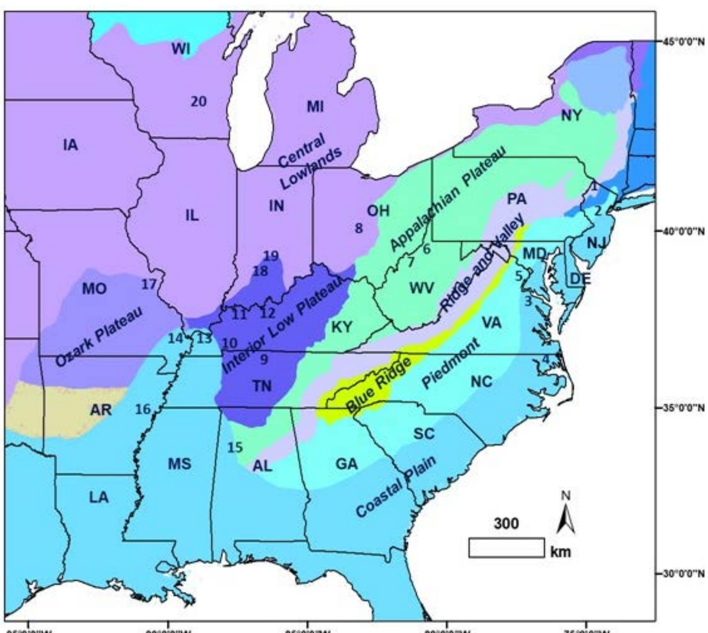

Figure 1. Acoustic survey sample sites (see text), 2020–2021 in the eastern U.S. across physiographic provinces (colors) by northern long-eared bat (*Myotis septentrionalis*) maternity colony (MYSE) and/or Indiana bat (*Myotis sodalis*) maternity colony (MYSO), 1. Wallkill National Wildlife Refuge (NWR), New Jersey (MYSE, MYSO), 2. Great Swamp NWR, New Jersey (MYSE), 3. Fort A.P. Hill Military Reservation (MR), Virginia (MYSO), 5. North River Gameland, North Carolina (MYSE), 5. Prince William Forest Park/Marine Corps Base-Quantico, Virginia (MYSE,), 6. Louis Wetzel Wildlife Management Area (WMA), West Virginia (MYSE), 7. The Jug WMA (MYSE), 8. Battelle Darby Metro Park, Galloway, Ohio (MYSO), 9. Wilson County Artificial Roost, Tennessee (MYSO), 10. Fort Campbell MR (MYSO), 11. Yellowbank WMA, Kentucky (MYSE, MYSO), 12. Fort Knox MR (MYSE, MYSO), 13. Ballard WMA, Kentucky (MYSE, MYSO), 14. Cypress Creek NWR, Illinois (MYSE, MYSO), 15. Oakmulgee WMA, Alabama (MYSE, MYSO), 16. Ouachita-St. Francis National Forest, Arkansas (MYSO), 17. Shaw Nature Center, Missouri (MYSO), 18. Beanblossom Bottoms Nature Preserve, Indiana (MYSE, MYSO), 19. Morgan-Monroe State Forest, Indiana (MYSE, MYSO), 20 Governor Dodge State Park, Wisconsin (MYSE).

Results

Over 2020–2021, for northern long-eared bats, we retained 2208 rain-free nights across 12 sites where maternity colonies were known present and at least one nightly echolocation pass was identified (Table 1), whereas for Indiana bats, we retained 2865 rain-free nights across 14 sites (Table 2). Mean nightly echolocation passes of northern long-eared bats were higher in forest and riparian cover types than in edge cover types when the MLE *P*-value was <0.05 (Table 1). However, mean nightly echolocation passes were low across all cover types when the MLE *P*-value was >0.05. Indiana bat activity was highest in the riparian cover type when the MLE *P*-value was <0.05, and similar to northern long-eared bats, also low across all cover types when the MLE *P*-value was >0.05 (Table 2). Nightly counts of all high-frequency bats were highest in riparian cover types when the MLE *P*-value was <0.05 for the target species (Tables 1 and 2). For both northern long-eared bats and Indiana bats, predicted MLE *P*-values were negatively related to the overall nightly echolocation pass count for either species as well as their respective ratios to the nightly count of all high-frequency bat echolocation pass counts (Tables 3 and 4; Figures 2 and 3). Higher MLE *P*-values were observed where northern long-eared bats were identified in edge cover types as opposed to forest and riparian cover types (Figure 2), whereas the forest cover type was most likely to display this condition compared to edge and riparian cover types for Indiana bats (Figure 3).

For both species, the predicted MLE *P*-value was >0.05 most often where each species' nightly echolocation pass counts were low and those identifications occurred in the context of far larger observed numbers of other high-frequency species. For northern long-eared bats, this species swamping occurred where the nightly count of northern long-eared bats was <10 and northern long-eared bat echolocation pass counts consisted of approximately 20% or less of the nightly total of all high-frequency bats (Figure 2). Results for Indiana bats were more variable, whereby at sites with nightly echolocation pass counts < 10, identified Indiana bat echolocation passes did not reach the MLE *P*-value < 0.05 threshold where the ratio to other high-frequency bats was less than 40% (Figure 3). Uncertainty for low Indiana bat count numbers increased where the species constituted ratios >90% of the entire high-frequency bat observations (Figure 3). For both species, nightly echolocation pass counts > 15 generally met the MLE *P*-value threshold irrespective of either target species counts, the ratio of those to all high-frequency bats, or cover type (Figures 2 and 3). Although model fit was less good, simulated data results followed the same trend as with observed data in that once either nightly counts of northern long-eared bats and Indiana bats reached > 10, the MLE *P*-value threshold was met and there was no strong evidence that high ratios of other high-frequency bat species relative to northern long-eared bats or Indiana bats would create false negative scenarios using the USFWS MLE acceptance standard (Tables 5 and 6; Figures 4 and 5) . Similarly, with the simulated data, uncertainty was greater when counts of either species were <5.

Table 1. Mean nightly echolocation passes of northern long-eared bats (*Myotis septentrionalis*) and all high-frequency bats (see text) at maternity colony areas (*n* = site-nights) in the eastern U.S., 2020–2021 by survey site, cover type (edge, forest, and riparian), and nightly maximum likelihood estimator (MLE) *P*-value (< 0.05 or > 0.05) of pass confidence from automated identification software.

		Northern Long-eared Bat			All High Frequency Bats		
	n	Mean	SE	Range	Mean	SE	Range
MLE < 0.05							
Edge	195	5.88	0.47	1–50	54.94	3.32	1–222
Forest	427	11.99	0.89	1–200	43.18	2.48	1–380
Riparian	420	22.85	2.19	1–507	174.47	13.91	1–2260
MLE > 0.05							
Edge	321	1.70	0.07	1–8	67.90	6.49	1–1,019
Forest	319	1.74	0.07	1–8	67.86	5.41	1–887
Riparian	526	2.63	0.11	1–16	124.34	6.37	1–1205

Table 2. Mean nightly echolocation passes of Indiana bats (*Myotis sodalis*) and all high-frequency bats (see text) at maternity colony areas (*n* = site-nights) in the eastern U.S., 2020–2021 by survey site, cover type (edge, forest, and riparian), and nightly maximum likelihood estimator (MLE) *P*-value (< 0.05 or > 0.05) of pass confidence from automated identification software.

		Indiana Bat			All High Frequency Bats		
	n	Mean	SE	Range	Mean	SE	Range
MLE < 0.05							
Edge	346	15.14	0.93	1–154	86.46	4.16	1–548
Forest	499	15.10	0.75	1–134	76.99	3.31	1–652
Riparian	646	48.20	4.92	1–1251	166.60	9.68	1–2260
MLE > 0.05							
Edge	460	2.20	0.08	1–11	59.89	3.40	1–514
Forest	481	2.20	0.09	1–17	82.87	7.27	1–1,072
Riparian	481	3.47	0.20	1–38	95.31	6.65	1–962

Table 3. Generalized linear model parameter estimates for predicted maximum likelihood estimator probability values of northern long-eared bat (*Myotis septentrionalis*) echolocation pass confidence from automated identification software at maternity colony areas (*n* = 2208 site-nights) in the eastern U.S., 2020–2021 by nightly count of northern long-eared bat echolocation passes, ratio of northern long-eared bats to other high-frequency bats (see text), and survey site cover type.

Parameter	*β*	SE	Wald χ^2	*P*
Intercept	0.32	0.08	17.53	0.0090
Count	–0.22	0.02	85.08	< 0.0001
Ratio	–11.91	1.05	127.44	< 0.0001
Ratio × Ratio	9.92	1.09	83.29	< 0.0001
Cover type[1]				
Edge	–0.27	0.10	7.98	0.0005
Forest	–0.09	0.10	0.79	0.3754

1. Riparian was reference condition.

Table 4. Generalized linear model parameter estimates for predicted maximum likelihood estimator probability values of Indiana bat (*Myotis sodalis*) echolocation pass confidence from automated identification software at maternity colony areas (*n* = 2865 site-nights) in the eastern U.S., 2020–2021 by nightly count of Indiana bat echolocation passes, ratio of Indiana bats to other high-frequency bats (see text), and survey site cover type.

Parameter	*β*	SE	Wald χ^2	*P*
Intercept	0.34	0.08	16.95	< 0.0001
Count	–0.23	0.02	172.38	< 0.0001
Ratio	–6.88	0.67	107.10	< 0.0001
Ratio × Ratio	5.58	0.83	45.27	< 0.0001
Cover type[1]				
Edge	–0.08	0.08	0.81	0.3684
Forest	–0.25	0.09	7.53	0.0061

1. Riparian was reference condition.

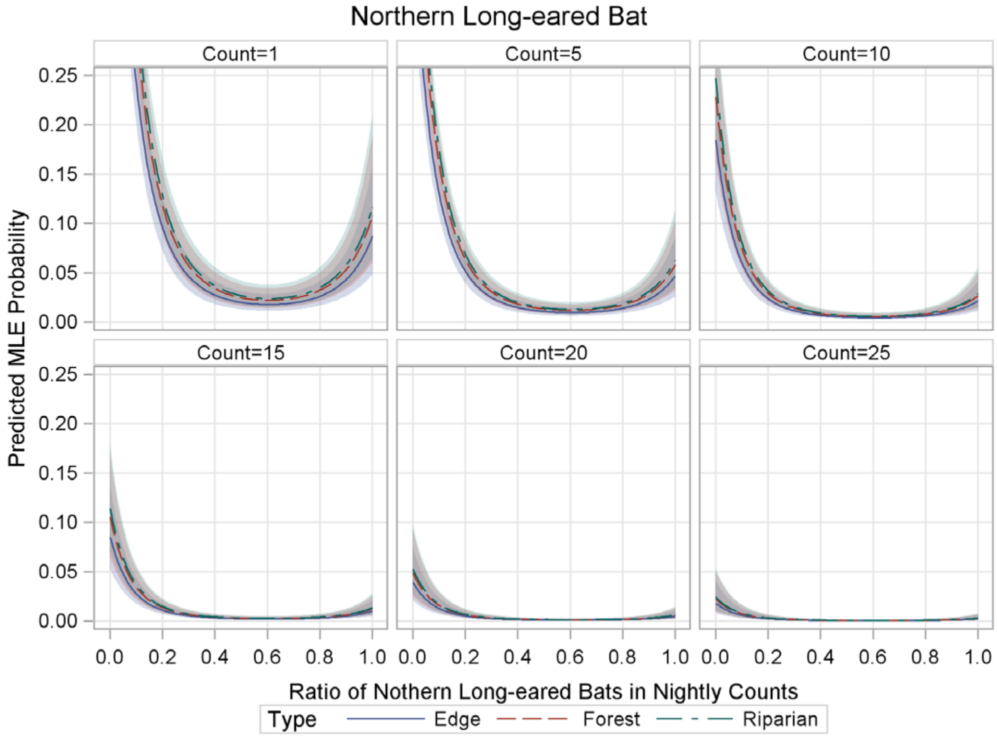

Figure 2. Mean and 95% confidence interval for predicted nightly maximum likelihood (MLE) *P*-values of northern long-eared bat (*Myotis septentrionalis*; $n = 2{,}208$ site-nights) echolocation pass confidence from automated identification software in the eastern U.S., 2020–2021 by nightly count of northern long-ear bat echolocation passes, ratio of northern long-eared bats to other high-frequency bats, and survey site cover type where at least one northern long-eared bat was identified at the echolocation pass file level.

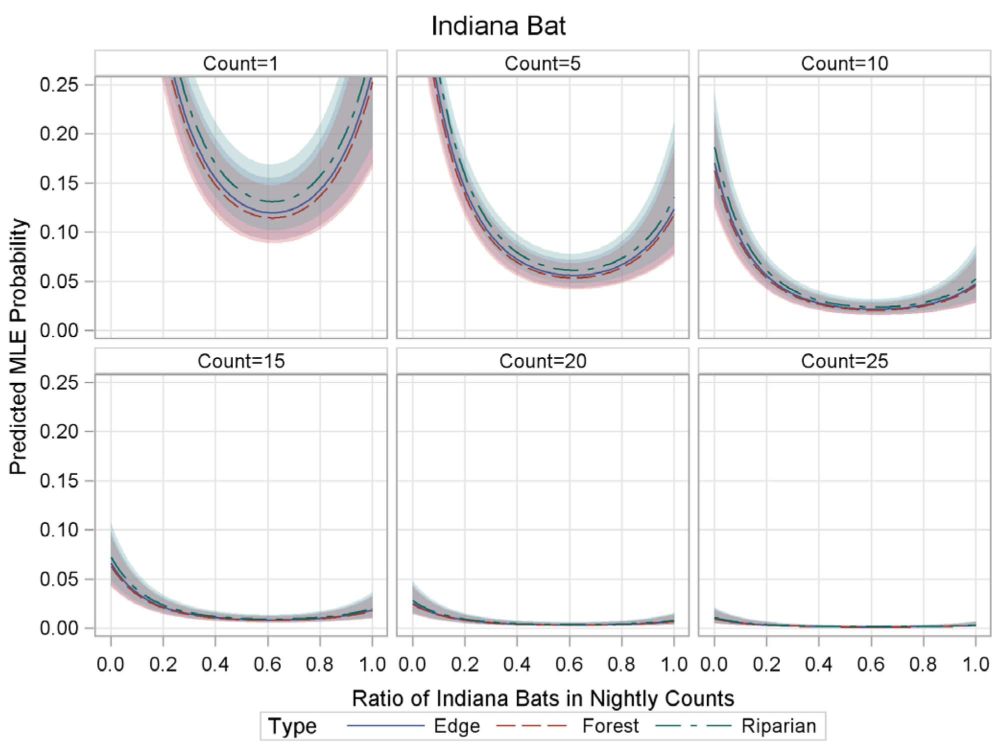

Figure 3. Mean and 95% confidence interval for predicted nightly maximum likelihood (MLE) *P*-values of Indiana bat (*Myotis sodalis*; $n = 2{,}865$ site-nights) echolocation pass confidence from automated identification software in the eastern U.S., 2020–2021 by nightly count of Indiana bat echolocation passes, ratio of Indiana bats to other high-frequency bats, and survey site cover type where at least one Indiana bat was identified at the echolocation pass file level.

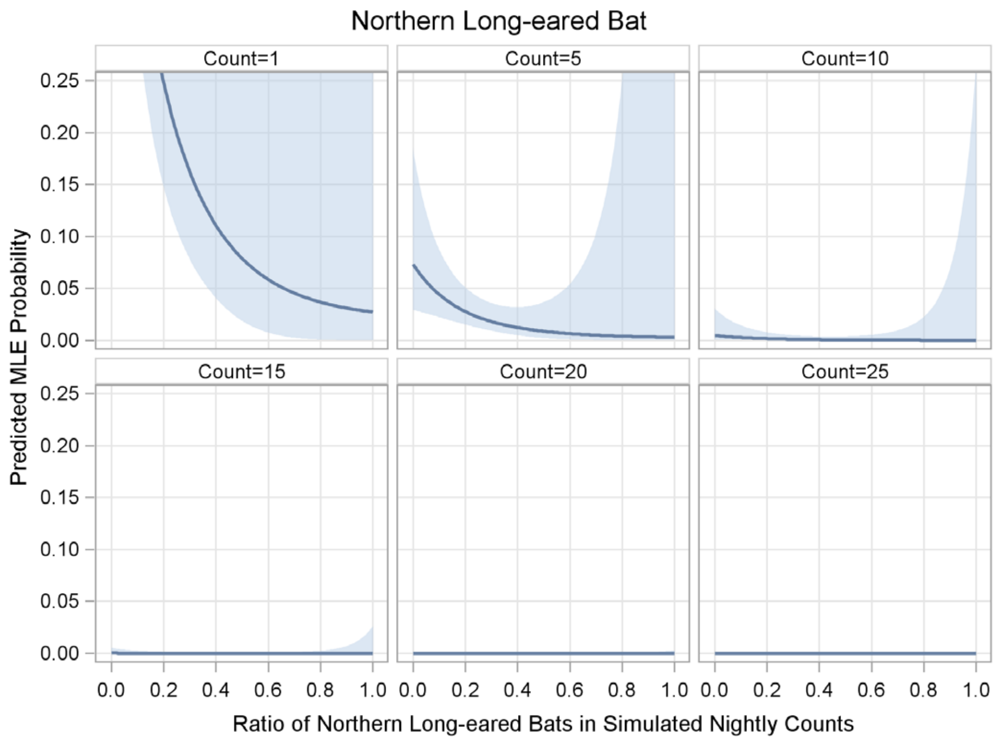

Figure 4. Mean and 95% confidence interval for predicted nightly maximum likelihood (MLE) *P*-values of northern long-eared bat (*Myotis septentrionalis*; *n* = 800 site-nights) echolocation pass confidence from automated identification software by simulated nightly count and ratio of northern long-eared bats to other high-frequency bats.

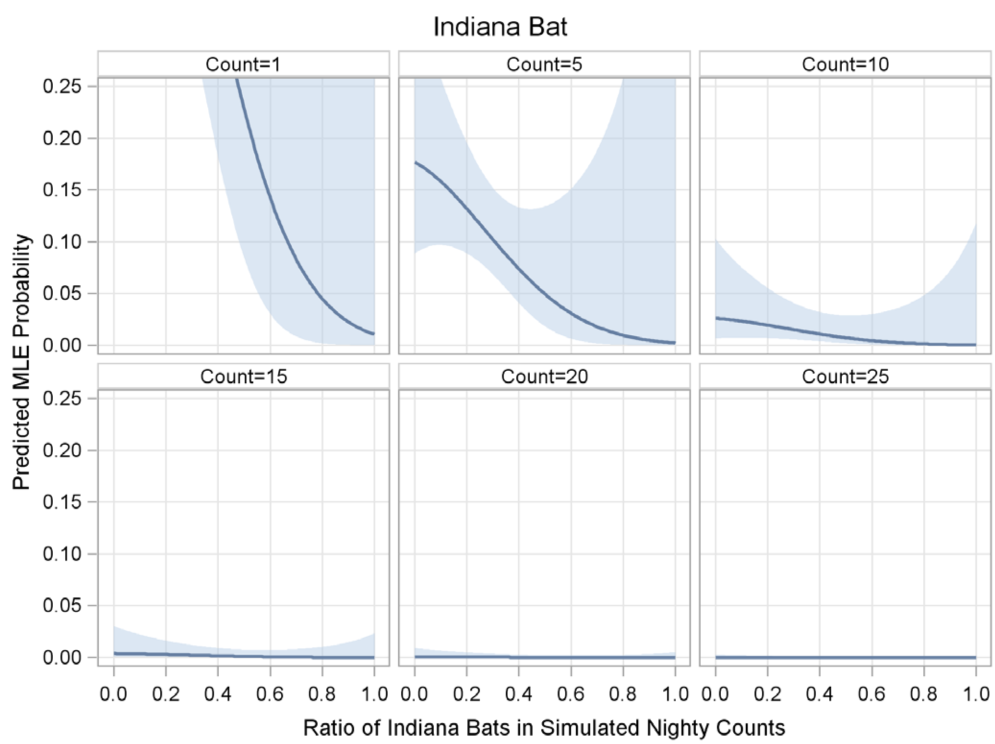

Figure 5. Mean and 95% confidence interval for predicted nightly maximum likelihood (MLE) *P*-values of Indiana bat (*Myotis sodalis*; *n* = 800 site-nights) echolocation pass confidence from automated identification software by simulated nightly count and ratio of northern long-eared bats to other high-frequency bats.

Table 5. Generalized linear model parameter estimates for predicted maximum likelihood estimator probability values of northern long-eared bat (*Myotis septentrionalis*) echolocation pass confidence from automated identification software from 800 simulated nightly counts and ratio of northern long-eared bats to other high-frequency bats.

Parameter	β	SE	Wald χ^2	P
Intercept	0.17	0.10	3.15	0.0761
Count	–0.38	0.07	30.51	< 0.0001
Ratio	–0.65	1.82	0.79	0.3748
Ratio × Ratio	–3.7	4.17	0.79	0.3748

Table 6. Generalized linear model parameter estimates for predicted maximum likelihood estimator probability values of Indiana bat (*Myotis sodalis*) echolocation pass confidence from automated identification software from 800 simulated nightly counts and ratio of Indiana bats to other high-frequency bats.

Parameter	β	SE	Wald χ^2	P
Intercept	0.13	0.08	3.10	0.0783
Count	–0.54	0.10	31.92	< 0.0001
Ratio	–5.51	2.39	5.31	0.0212
Ratio × Ratio	2.38	5.03	0.22	0.6355

Discussion

Confidence in USFWS acoustic monitoring protocols for northern long-eared bats and Indiana bats rests on the assumption that identified presence of either species at the nightly level is accurate. Although false-positives may result in unnecessary, but presumably beneficial conservation actions, false-negatives may lead to a lack of needed conservation measures (Ford et al. 2023). As such, two components of the USFWS's acoustic monitoring program seek to guard against false-positives and false-negatives within the context of assessing northern long-eared and Indiana bat presence at survey sites at the nightly level. First, to be considered present, the collective of northern long-eared bats or Indiana bats identified by automated software must display a MLE P-value ≤ 0.05 nightly (USFWS 2022). This restrictive α-level guards against a preponderance of false-positive designations. Secondly, automated identification software approved by the USFWS for monitoring northern long-eared bats and Indiana bats must return no false-negatives in 20 randomized tests and no more than 20% false-positives thereby adding additional confidence in accuracy (USFWS 2019).

In field settings, as demonstrated by our study, northern long-eared bats and Indiana bats individual echolocation passes clearly could be identified as such without reaching the nightly MLE P-value < 0.05 trigger. This uncertainty likely is due to other species being errantly identified as either northern long-eared bats or Indiana bats, as expected given misclassification rates (Nocera et al. 2019, Ford et al. 2023). For example, at our sites where we knew maternity colonies of one or both target species occurred and hence animals were locally abundant relative to most of the post-WNS landscape (Ford et al. 2023), positive identifications, but without sufficient relative numbers to overcome cross-species misclassification rates, did occur at the nightly level. However, in no instance did this occur over any multiple-night duration relative to the 2020–2021 USFWS required acoustical LOE (USFWS 2022). Conversely, automated software returned northern long-eared bat determinations from cluttered forested survey sites on the Eastern Shore of Virginia, where northern long-eared bats are exceedingly rare, occasionally meeting the nightly MLE P-value < 0.05 (Barr 2018), that were later qualitatively identified as eastern red bats.

Our results provide little evidence for a swamping effect except when nightly counts of the target species were very low in both the field collection dataset and our simulated dataset with known echolocation calls. However, the uncertainty associated with few recordings, presumably males or non-reproductive females as posited by Ford et al. (2023) suggests that target species in some instances may not occur in sufficient numbers to overcome misclassification rates with high probability. Contrary to our predictions, the speculated swamping phenomenon did not occur or at least did not show a clear trend relative to riparian cover types. This suggests that sampling riparian cover types may provide useful information about the Indiana bat but also the more upland forest obligate northern long-eared bat and other WNS-impacted species without as much risk of species misclassification as originally believed (Ford et al. 2005, Gorman et al. 2022). Although the Endangered Species Act does not distinguish between males and non-reproductive females versus maternity colonies of northern long-eared bats and Indiana bats (Ford et al. 2023), concerns about false-negatives stemming from rejecting a file-level identification that does not meet the MLE P-value standard and subsequent lack of conservation action remain valid. Our study indicates that this potential event generally occurs when few passes of the target bat species are recorded, typically on single nights, whereby qualitative visual examination of spectrograms may quickly mitigate false-negative error of solely relying on a non-significant MLE P-value.

Nonetheless, we urge caution in broadly applying our findings. For example, we examined the relationships of MLE P-values to nightly echolocation counts of northern long-eared bats and Indiana bats, their relative proportion of other high-frequency bats and cover types with only one of several approved automated software programs/versions. Moreover, we only used the "balanced" 0 sensitivity setting as opposed to the more sensitive or specific identification settings in Kaleidoscope Pro. Whether these relationships we observed are true for other approved versions of this or any other identification software or setting thereof are unknown. Results also could vary based on both the potential bat species selected for software to consider as possibly present, because misclassification rates change for and among bat species depending on the assemblage selection. For example, identification accuracy for Indiana bats would increase if little brown bats, when known to be absent at a site, were not selected for inclusion during software analysis. Still, because Nocera et al. (2019) only found strong agreement at the nightly level regarding species presence or absence using the USFWS MLE *P*-value threshold, as opposed to actual individual file agreement, additional testing with additional field datasets and simulations using known bat echolocation call libraries seems warranted.

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