Bat Assessment Guidance for Wind Energy Facilities in Nebraska

Eastern Red Bat (*Lasiurus borealis*). Photo by Keith Geluso.

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CONTACTS

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OVERVIEW

Developing Nebraska's abundant wind resources can be balanced with maintaining biodiversity by avoiding, minimizing, and mitigating the impacts of wind energy development and operation. A series of statewide, non-regulatory guidance documents have been created to assist wind energy developers achieve this balance. **These guidance documents do not replace coordination or consultation with the Nebraska Game and Parks Commission (NGPC) and the U.S. Fish and Wildlife Service (USFWS).** All of the documents are based on the best available science and will be updated when new information for recommendations becomes available.

Guidance Documents and Tools

State

Guidelines for Avoiding, Minimizing, and Mitigating Impacts of Wind Energy on Biodiversity in Nebraska (http://snr.unl.edu/renewableenergy/wind/tools.asp#stateguidelines)

Nebraska's Biodiversity and Wind Energy Siting and Mitigation Map (http://snr.unl.edu/renewableenergy/wind/tools.asp#map)

Avian Assessment Guidance for Wind Energy Facilities in Nebraska (http://snr.unl.edu/renewableenergy/wind/tools.asp#avian)

Bat Assessment Guidance for Wind Energy Facilities in Nebraska (http://snr.unl.edu/renewableenergy/wind/tools.asp#bat)

Whooping Crane Operational Contingency Plan (http://snr.unl.edu/renewableenergy/wind/tools.asp#contingency)

Federal

U.S. Fish and Wildlife Service Land-Based Wind Energy Guidelines (http://snr.unl.edu/renewableenergy/wind/tools.asp#fedguidelines)

USFWS Eagle Conservation Plan Guidance: Module 1 – Land-based Wind Energy (v2) (http://snr.unl.edu/renewableenergy/wind/tools.asp#eagles)

OBJECTIVE

This document provides recommendations for pre- and post-construction surveys and data analysis that can help avoid or minimize bat fatalities at wind energy facilities in Nebraska. The specific objectives are to: 1) determine bat activity patterns before and after the development of wind energy facilities; 2) evaluate the bat fatalities associated with operation of wind energy facilities; and 3) provide reliable information for siting and operation of current and future wind energy facilities in Nebraska.

TAKE HOME POINTS

- **Consult** early and often with the NGPC and the USFW (Contacts).
- **Feather wind turbine blades** as a standard practice at all Nebraska wind energy facilities.
- At least **one year** of pre- and post-construction acoustic surveys are recommended.
- At least **two years** post construction mortality surveys are recommended.
- Data collection and analysis should be conducted by a **trained bat biologist**.
- **Sharing data** is recommended to help enhance recommendations for operational mitigation and siting.

INTRODUCTION

Evaluating bat fatalities at wind energy facilities became a priority in 2003 in the United States and continues to be a priority today. A review of bat fatalities at wind energy facilities across North America found that 21 of the 45 species of bats found in the U.S. were reported to have been killed at facility sites (Arnett et al. 2008). It is estimated that between 650,000 to more than 1,300,000 bats were killed at wind energy facilities from 2000-2011 in the U.S. and Canada (Arnett and Baerwald 2013). In 2012 alone, it is estimated that 880,000 bats were killed at U.S. wind energy facilities when 51,630 megawatts were installed (Smallwood 2013). Fatalities of migratory hoary bat (*Lasiurus cinereus*), eastern red bat (*Lasiurus borealis*), and silver-haired bat (*Lasionycteris noctivagans*) accounted for about 80% of all bat fatalities observed in the Midwest (Arnett et al. 2008) and all are seasonal migrants in Nebraska (Freeman et al. 1997). In areas where Mexican free-tailed bats (*Tadarida brasiliensis mexicana*) regularly occur, they make up a significant portion of fatalities observed. Other species of bats found in Nebraska that have been observed dead at wind energy facilities in the U.S. are the big brown bat (*Eptesicus fuscus*), little brown myotis (*Myotis lucifugus*), northern long-eared bat (*Myotis septentrionalis*), tri-colored bat (*Perimyotis subflavus*), and Brazilian free-tailed bat (Arnett et al. 2008). Concerns about the potential bat fatalities at wind energy facilities in Nebraska prompted the development of more detailed state-wide guidance.

Nebraska has a diverse mix of resident and migratory bat species (Appendix A). Because of the diversity of habitats found throughout Nebraska, there is no place in the state where all 13 bat species occur together. In the Nebraska Natural Legacy Project State Wildlife Action Plan (Schneider et al. 2011), there are seven bat species listed as either Tier I or Tier II At-Risk Species. Fringed myotis (*Myotis thysanodes pahasapensis)* is identified as Tier I, a species that is globally or nationally most at-risk of extinction. Townsend's big-eared bat (*Corynorhinus townsendii)* and long-legged myotis (*Myotis volans*) are both listed as Tier II and are classified as State Critically Imperiled (S1). Evening bat (*Nycticeius humeralis)* and northern long-eared bat are listed as Tier II and are classified as State Vulnerable (S3). Northern long-eared bat, tricolored bat, and little brown myotis were identified as Tier I candidate species in 2012 based

on their global ranking. In May 2015, the northern long-eared bat was listed as threatened under the Endangered Species Act (ESA) and therefore, it automatically was listed under the Nebraska Nongame and Endangered Species Conservation Act (NESCA).

Consulting early and often with the NGPC and USFWS is highly recommended. Under NESCA and ESA, Nebraska has a nexus for reviewing commercial wind energy facilities which require a permit from the Nebraska Power Review Board and/or may impact listed species. Even if listed species may not be present in the area of the proposed wind energy facility, coordinating with NGPC and USFWS is recommended, especially due to the recent and proposed ESA listings of bat species. **Prior to beginning surveys, it is highly recommended that you consult with the NGPC and the USFWS and that you review in detail the document *Guidelines for Avoiding, Minimizing, and Mitigating Impacts of Wind Energy on Biodiversity in Nebraska*** (http://snr.unl.edu/renewableenergy/wind/tools.asp#stateguidelines). To schedule a meeting, contact agency representatives listed in the Contacts section.

This document is intended to provide a brief review of the state of the science on impacts of wind energy on bats, recommendations for pre- and post-construction surveys, guidelines for reporting survey results, and a basic overview of the bats found in Nebraska. This document will be updated based on current research findings and as needed to be in accordance with USFWS recommendations and/or if a nationwide protocol that meets or exceeds the following recommendations is developed.

Recommendations in this document were compiled from the current Nebraska bat guidelines, conversations with bat experts, information gathered from conference presentations, bat guidelines from other states, and the document *Comprehensive Guide to Studying Wind Energy/Wildlife Interactions* (Strickland et al. 2011).

Suggested Timeline

After wind development site has been determined and At least 1 year prior to the spring before project construction.	Review *Guidelines for Avoiding, Minimizing, and Mitigating Impacts of Wind Energy on Biodiversity in Nebraska* and *Nebraska's Biodiversity and Wind Energy Siting Map*. Contact agency personnel and submit project information (e.g., location, footprint, approximate number and types of turbines, estimated construction time, etc.). Request information about survey needs for proposed project. A meeting and/or site visit may be needed. Develop survey methods and send them to agency staff for review before 1 February and incorporate agency comments into survey protocols by 1 March.
Spring, Summer, and Fall—at least 1 year prior to project construction.	Conduct recommended acoustic surveys for bat presence.
Upon completion of bat acoustic surveys and no less than 6 months prior to project construction.	Submit pre-construction survey report. Discuss operational mitigation (curtailment) with agency personnel.
Wind Energy Facility Project Construction	
At all times.	Program wind turbines to feather blades below cut-in speed.
Spring, Summer, and Fall— at least 1 year following project construction.	Conduct recommended acoustic surveys for bat presence.
Year-round — at least 2 years following project construction.	Conduct recommended post-construction mortality surveys, including scavenger removal and searcher efficiency trials and carcass surveys.
Submit final reports to agency personnel within 6 months of completing all post-construction surveys.	

BATS & WIND ENERGY DEVELOPMENTS

Avoid, Minimize, Mitigate

Bats may be more susceptible to wind energy than other wildlife species due to their life history strategies.

1. Bat populations are impacted by small loses. Bats have slow reproductive rates and are long-lived. Most bats give birth to only one or two pups per year and can live up to 20+ years. If adults of reproductive age are removed from the population (e.g., killed by wind turbines), it can take years to replace them.

2. Bats with varying life history strategies are impacted differently by wind energy. Nebraska has both resident and migratory bats which use may use habitat differently and may require different recommendations to minimize impacts. Because migratory bats travel from wintering to summering areas, they increase their likelihood of encountering wind energy facilities and having collisions with wind turbines in Nebraska and throughout their migratory route. Although migrating bats may only be in an area for a very short period of time, because they often migrate in groups, collisions with turbines can often result in the death of a number of individuals.

3. Bats are challenging to study and monitor because of their nocturnal behavior. Unlike birds, little is known about bat migration and basic bat ecology in many areas.

Site-specific studies and research are necessary to guide siting and operational mitigation useful for avoiding, minimizing, and mitigating potential negative impacts of wind energy on bats.

Siting

By avoiding key bat habitats, such as roosting areas (e.g., forested areas, buildings, quarries, large trees), hibernacula, maternity colonies, or frequently visited locations (e.g., water sources), during the siting of a wind energy development, the potential impact to bats may be reduced.

The *Nebraska's Biodiversity and Wind Energy Siting Map* delineate areas where potential adverse impacts of wind energy on biodiversity, including wildlife concentrations, in Nebraska are most likely to occur and the subsequent level of mitigation that will likely be recommended. The *Map* is based on a variety of other maps and GIS layers, some of which were developed specifically for use in the *Map*. Known bat hibernacula and wetland and natural lands map layers are examples of some of the layers used to help guide siting and mitigation for bats.

Operational Mitigation

Curtailing wind turbine operations is currently the most effective way to reduce bat fatalities at wind energy facilities. Curtailing or modifying operations can be done by increasing the cut-in speed and/or feathering (i.e., changing the pitch angle) the wind turbine blades below cut-in speeds. In general, the number of bat fatalities at wind energy facilities is greatest during low

wind speeds (Arnett et al. 2008); therefore, not operating wind turbines at lower wind speeds can minimize bat-turbine collisions.

Recent studies have determined the effectiveness of increasing the cut-in speed and feathering wind turbine blades in reducing bat fatalities. In one study, feathering wind turbine blades below cut-in speeds of 3.5, 4.5, or 5.5 meters/second (m/s) resulted in 36.3, 56.7, or 73.3% mean fatality reduction (Good et al. 2011). In a review of operation mitigation studies, at least a 50% reduction in bat fatalities were observed for most studies when turbine cut-in speed was increased by 1.5 m/s above the manufacturer's cut-in speed (Arnett et al. 2013). In one study conducted in Canada, an increase in the cut-in speed from 4.0 meters/second (m/s) to 5.5 m/s resulted in a 60.0% reduction in bat fatalities (Baerwald et al. 2009). During a two year study in which cut-in speeds were increased to 5.0 m/s and 6.5 m/s, bat fatalities were reduced 44-93% with an approximate annual power loss of ≤ 1% of total annual output (Arnett et al. 2010).

Feathering of the turbine blades is strongly recommended as a standard practice at all Nebraska wind energy facilities.

Increasing cut-speed to 5.0 m/s is recommended during fall migration and in areas where northern long-eared bats could be present to minimize fatalities.

The dates and times when curtailment most effectively reduces bat fatalities can be determined on a site-by-site basis by correlating temporal patterns in nightly bat activity and environmental variables and fatality patterns. Multiyear surveys can help refine this time period. Determining these targeted dates and times can also minimize the loss of power production.

Surveys and Data Sharing

Proper identification of important bat habitats and bat activity patterns are vital to minimizing impacts on bats and can be aided by surveys and data sharing. Historically, data collected during pre- and post-construction studies have not been widely available, and therefore have not contributed to the broader understanding of wind turbine siting and operations that minimize impacts to bats. Sharing pre- and post-construction survey data that has been gathered with a scientifically rigorous study design will help to inform project-specific decisions and contribute to the overall understanding of bat interactions with wind energy development.

The recommendations in this document should be used to guide the study design. The NGPC and the USFWS can advise on specific and currently accepted survey protocols; an ideal time to discuss bat survey protocols is at the first consultation meeting. It is recommended that a detailed survey protocol tailored to the site be provided to NGPC and USFWS for review at least ***three months*** prior to the initiation of surveys.

BAT ASSESSMENT SURVEYS

Goal

Identify locations and operation strategies that avoid or minimize bat fatalities at wind energy facilities located in Nebraska.

Objectives

There are three main objectives for conducting bat assessment surveys. The first objective is to collect data prior to construction. These data can determine the potential species of bats present, their relative use of a site, and whether additional studies would be appropriate. The second objective is to collect post-construction data to determine on-going bat use of the project area and fatalities that are occurring during operation. These data can be used to determine which species are most vulnerable to wind turbine collisions and what factors (e.g., wind speed, temperature) contribute to fatality events. The third objective is to use this information to develop and implement operational plans that are the most effective in reducing fatalities while minimizing loss of power generation.

For the purpose of assessing bat presence and fatalities at wind energy facilities in Nebraska, stationary acoustic and mortality surveys are recommended. Capture surveys (Appendix C), visual surveys, and the use of radar to detect bats are encouraged as research.

Surveyor Qualifications

Accurately sampling for bat presence/absence is a specialized skill that requires training and experience. It is recommended surveyors submit a document outlining their qualifications including education, training, and previous experience sampling for bats to the NGPC and the USFWS. Specific experience analyzing acoustic data and conducting field studies for bats should be highlighted.

Acoustic Surveys

Acoustic surveys can be conducted by placing ultrasonic acoustic detector at appropriate locations throughout the wind energy development site. While any detector can be used, the same type of detector should be used at all sampling stations throughout the study site and for both pre- and post-construction surveys.

It is recommended that a detailed survey protocol tailored to the site be provided to NGPC and USFWS for review ***three months*** prior to the initiation of surveys.

Survey Timing

It is recommended that stationary acoustic surveys include the spring migration period through the fall migration period (April 1 to November 15). Detectors should be set to record from 0.5 hours before sunset to 0.5 hours after sunrise. **A minimum of one year of pre- and two years of post-construction surveys are recommended.**

Sampling Locations

Appropriate acoustic detector locations are imperative to gathering high quality data and accurately quantifying species level activity. Acoustic sampling locations should be distributed throughout the proposed wind energy development site. Sampling in all habitats is recommended because habitat use during bat migrations is not well defined. The number of sampling locations should be scaled to the size of the proposed wind energy development site.

Detector Set-up

Having detectors at multiple heights can improve the detection of the bat species in the area (Collins and Jones 2009). Both low and high frequency bat species are at risk of collision with wind turbines and a sampling design that most effectively surveys for both is important. Detectors placed at the height of the rotor-swept area more effectively capture low frequency bat activity (Weller and Baldwin 2011) while detectors placed closer to the ground detect high frequency bat activity. Therefore, at each sampling station, detector/microphone placement is recommended at near ground level (~10 meters) and at the height of the rotor-swept area. To collect data at rotor-swept height and nearer the ground, detectors can be placed on meteorological (met) towers. Installing equipment for securing an acoustic detector at the appropriate height on a met tower before raising the tower enables the surveyor to easily add an acoustic detector at a later time if the project proceeds. If the number of met towers at the site is insufficient to gather meaningful bat acoustic data, raising temporary towers is recommended.

Preparing Equipment

The accuracy of data collected by acoustic detectors can be greatly compromised if proper equipment, settings, or monitoring is not used. Listed below are potential technical problems and suggestions to minimize data collection loss. It is important to check equipment regularly to ensure that it is functioning properly.

1. Cable: No detection of bat calls can be a result of the cable resistance impeding data transfer or cable failure. Test the cable connecting the microphone and acoustic detector to ensure it will successfully transmit data; test the cable at the greatest length that will be used to connect the detector and microphone.
2. Battery: For some detectors, as the battery charge decreases, the detection area decreases. By maintaining a constant or near-constant battery charge, the detection area is maintained and data collected on different nights will be more comparable. High and low temperatures can also dramatically decrease expected battery life. To maintain battery charge, a solar panel and external batteries can be used.
3. Weather-proofing: Cases designed to keep the microphone dry can result in signal loss or degradation. Test the weather-proofing design to establish the amount of call loss occurring and modify case to minimize call loss (e.g., Britzke et al. 2010).
4. Microphone placement: Microphones should be mounted to maximize area covered and minimize interference from echo, clutter, and reflected noise.
5. Calibrate detectors: Detectors should be calibrated at least once a year.

6. Test microphone functionality regularly to assure the sensitive electronics within have not been compromised.

Data Collection

The following information should be recorded for ***each microphone***:

- Detector information:
    - Brand name
    - Model number
    - Recording format
        - Zero-crossing
        - Full-spectrum (WAV, WAC (0,1,2, etc.), sampling rate)
    - Setting (e.g., sensitivity, gain/trigger level, high pass filter, threshold)
- Microphone information:
    - Type
    - Brand name
    - Model number
    - Height above ground recorded in meters
- Location (GPS coordinates) recorded in decimal degrees (DD) to four decimal places (00.0000°, -00.0000°)
- Collection dates and times:
    - Dates of attempted data collection (mm/dd/yyyy – mm/dd/yyyy)
    - Number of nights of successful data collection for which the detector recorded for >90% of the survey night
    - Dates of successful data collection
    - Sunset time (civil, nautical, astronomical, manually set)
    - Time data collection begins and ends (hh:mm – hh:mm; 24hr format; CDT/MDT or hh:mm before or after sunset/sunrise)

Data Analysis

Use of auto-classifiers to identify bat calls and reporting the most accurate classification of the bat call is recommended. If calls cannot be classified to species, designating an appropriate phonic group (i.e., high/low frequency) is recommended. Quantify and report all call classifications including unidentifiable calls. If species of concern or status are determined by automatic classifiers, visual confirmation by an experienced bat biologist is highly recommended.

- Bat presence data:
    - Summary of sampling period
        - Total number of passes
        - Time of passes

        - All bat species identified
        - Number of unidentified passes
    - For each identified bat species
        - Total number of passes
        - Dates identified (Julian date)
        - Number of passes/date
        - The time of passes for each date
        - Nightly number of passes/hour (standardized to detector-hours before or after sunset)
- Environmental data:
    - Wind speed (meters/second) and direction during the time period when passes are recorded
    - Relative Humidity
    - Ambient temperature (°F) – high and low temperature for the day
    - Moon phase (http://aa.usno.navy.mil/data/docs/RS_OneDay.php)
    - Precipitation (nearest weather station)
    - Barometric pressure

Estimating Occupancy

Bat activity recorded with acoustic detectors can be correlated to environmental variables and modeled to predict bat presence which could be useful in determining when curtailment of operations may be needed (see Weller and Baldwin 2011 and http://www.fs.fed.us/psw/topics/wildlife/bat/batwind.shtml). Developing a model for the wind energy development site is recommended especially for species of concern.

Mortality Surveys

It is recommended that mortality surveys be conducted for **two years** following the wind energy facility becoming operational. *Studies should be designed to incorporate the most current techniques and statistically sound analyses*. General recommendations for estimating fatalities are available in the *Guidelines for Avoiding, Minimizing, and Mitigating Impacts of Wind Energy on Biodiversity in Nebraska*.

Scavenger Removal and Searcher Efficiency Trials

To more accurately estimate actual bat mortality, scavenger removal and searcher efficiency trials should be incorporated into the mortality surveys. These trials should be conducted with fresh bat carcasses when possible; frozen carcasses can be used, but do not produce as accurate of results in the scavenger removal trials. Because detectability and scavenging rates differ between birds and bats, bird trials should not be used as a proxy. Additionally, efficiency and

removal trials based on species groups (e.g., myotine, lasiurian) can assist in refining total mortality estimates for each species group.

The frequency of the mortality surveys should be informed by the results of the scavenger removal and searcher efficiency trials. Both trials should be conducted in a variety of habitats, during all seasons, and under any condition that may influence the results of the trials. For each season, daily carcass searches are recommended until the scavenging rate is identified and if high numbers of bat fatalities are occurring. Daily mortality surveys can be correlated with environmental variables which can help determine when curtailment can be most effective in reducing bat fatalities. If there are a high number of bat and bird fatalities at specific turbines or the wind energy facility as a whole, the carcass removal rates may change as scavengers learn to target the new food source. Likewise, as the seasons change, different scavengers may be present on the wind farm. Therefore, scavenger removal trials should be conducted seasonally, at a minimum, to determine if the carcass removal rate has changed and the frequency of the mortality surveys should be adjusted accordingly. Searchers should be tested for efficiency every season, if the habitat has been altered, or other circumstances arise. Ultimately, how often mortality surveys need to be conducted to accurately estimate mortality at a wind turbine site or wind energy facility will depend on a combination of the number of bat fatalities, searcher efficiency, and carcass removal by scavengers, which will be unique to the site and may change over time.

Carcass Surveys

The carcass survey method selected should fit the site. One common method is to survey along set transects, within a set radius around the turbine, looking for carcasses within 2-3 meters on each side of the transects. The area of the search plot should be based on the most current methods. The rate at which the transect is walked should be similar for all searchers at each turbine location. The type and height of vegetation should be recorded. Another method is to search the turbine pad and a portion of the road for carcasses. The area of the turbine pad and road section should be recorded for each turbine. To use this method, a correction coefficient needs to be calculated by fully searching a given number of turbines within the wind energy site. Other survey methods can be used as well.

Ideally, carcass searches would be conducted on all of the turbines at the wind energy site. If only a portion of the turbines is going to be surveyed with the transect approach, it is recommended that at least 25% of the turbines be searched within 80 meters around the base of the turbines. If the pad/road method is used, all of the turbines should be searched and a more thorough search of a portion of the turbines should be conducted.

All bat carcasses found should be recorded and a probable cause of death determined. The information recorded should include:

- Location (GPS coordinates) recorded in decimal degrees (DD) to four decimal places (00.0000°, -00.0000°)
- Distance (meters) and bearing (magnetic, DD)
- Vegetation and cover type and height (meters)
- Collection date and time:
    - Date of data collection (mm/dd/yyyy)
    - Time found (hh:mm; 24hr format; CDT/MDT)
- Bat carcass information:
    - Species (scientific name)
    - Sex
        - Female
        - Male
        - Unknown
    - Reproductive Status
        - Pregnant
        - Post-reproductive
        - Non-reproductive
        - Unknown
        - Scrotal
    - Age
        - Adult
        - Juvenile
    - Photograph(s)
        - No
        - Yes – identification information
    - Tissues sampled
        - No
        - Yes
            - type (hair, wing punch, swab, etc.)
        - identification information
    - Condition of carcass
        - Intact
        - Scavenged
            - Suspected culprit
            - Level/degree of dismemberment
    - Possible cause of death

Carcasses are valuable sources of information. The carcass should be photographed and the location plotted on a map of the project site. It is recommended that carcasses be bagged and labeled with a unique identifier and frozen if it is not going to be used for scavenger removal or

searcher efficiency trials. Carcasses of rare or at-risk species should be retained as vouchers and provided to the NGPC or USFWS for verification and deposition in an approved repository. To advance bat ecological research, tissue and hair samples can be collected (Appendix B)..

It is recommended that a detailed survey protocol tailored to the site be provided to NGPC and USFWS for review ***three months*** prior to the initiation of surveys.

Estimating Fatalities

The statistical analysis should include the observed number of carcasses, searcher efficiency, non-removal rates (from scavenger removal trials), and correction coefficient (if using pad/road method). If daily searches have been conducted, observed fatalities can be correlated with environmental variables. The Fatality Estimator (Huso 2012) is recommended and available at http://pubs.usgs.gov/ds/729/. Evidence of Absence software (Dalthorp 2014) for estimating bird and bat fatalities at wind farms and designing search protocols is available at http://pubs.usgs.gov/ds/0881/.

Reporting

Four reports of the survey findings should be submitted to the NGPC and the USFWS:

1) a pre-construction acoustic survey report,
2) a post-construction acoustic survey report,
3) an interim mortality survey to be submitted after the first year of facility operation, and
4) a final report with mortality survey results and a comparison of pre- and post-construction acoustic survey results.

All reports should include introduction, methods, results, and discussion/conclusion and should clearly describe sampling design, field methods, and analyses in enough detail that the survey could be replicated. The interim report can be in an abbreviated format but should provide all data pertinent to assessing the survey objectives; this report will be used to help identify issues and provide greater ability to address any problems before continuing data collection. **The goal of the reports is to clearly explain the who, what, where, when, why, and how of the surveys; what was learned during the field studies is what is important.**

Included in **all** reports should be:

1) Project name and location (GPS coordinates, county or counties, closest city).
2) Aerial photo and/or map with project boundaries and acoustic detector locations indicated.
3) Surveyor(s) name and qualifications.
4) References and citations for methods and analyses.

Included in the **Acoustic Survey** reports should be:

Equipment Information (details listed in Acoustic Sampling Data Collection section):

1) Detector information
2) Microphone information
3) Location
4) Collection dates
5) Number of attempted and successful nights of data collection during acoustic surveys. A success rate of **85%** of collection nights recommended.
6) Description of microphone location and orientation.

Bat presence:

1) Graphical presentation of the number of passes/date at each site, microphones by height, and for the entire project for:
    a. Each identified species
    b. All identified species combined
2) Graphical presentation of the number of passes/hour for dates with the top 20% of bat activity for each site and for the entire project for:
    a. Each identified species
    b. All identified species combined
3) Correlation between bat species presence and environmental variables (moon phase, wind speed, etc.)

Call Classification/Data Analysis:

1) Format of data analyzed (zero-crossing, full-spectrum)
2) Data converter used (if any)
3) Filter(s) used and applicable setting (e.g., min# pulses per call, sensitivity of classifer, species, considered, etc.)
4) Software or classifer used
    a. Classification output
5) If method differs for different species, explain why.

Data

Comments and Additional Information

Included in the **Mortality Survey** reports should be:

Survey Information:

1) Survey strategy
    a. Transects within a given radius
    b. Pad and road searches

    c. Other
2) Search plot characteristics
    a. Radius and distance between transects (meters)
    b. Pad and road area
    c. Other
3) Selected turbines
    a. Number of turbines searched
    b. Proportion of total number of turbines at the site
    c. Habitat type at each selected turbine
    d. Selection process (random, fixed)
4) Aerial photo showing areas/transects searched
5) Starting and ending dates of searches
6) Periodicity and dates of searches
7) Total number of searches

Carcass Information:

1) Basic information outlined in the Carcass Survey section.
2) Graphical presentation of total bat fatalities:
    a. Per turbine number
    b. Distance from turbine (meters)
    c. Timing (date)
    d. Summary of possible causes of death

Searcher Efficiency Trials:

1) Name of surveyor
2) Date
3) Number placed
4) Number found
5) Percent found
6) Estimates of searcher efficiency for different seasons and habitat/cover type

Scavenger Removal Trials:

1) Number of carcasses placed
2) Number of days carcasses persisted
3) Carcass removal rates for different seasons and habitat/cover type

Statistical Analysis:

1) Estimator used
2) Comments

Results described in text and table format

1) Observed fatalities
2) Adjustments
    a. Unsearched/Unsearchable area
    b. Searcher efficiency
    c. Carcass removal by scavengers
    d. Total

Data

Comments and Additional Information

OPERATIONAL MITIGATION

Even with well-designed and executed pre-construction surveys, there is the potential for unanticipated bat fatalities associated with the operation of wind turbines at a location. Bat activity data collected during both pre- and post-construction and daily bat fatality data can be used to target windows of time that pose the greatest threat of collision for a bat species.

If bat fatalities are occurring at one or multiple wind turbine locations, operational mitigation, including curtailment during high risk periods, may be recommended. The NGPC and USFWS should be consulted to determine if and when operational mitigation is recommended. **Because operational mitigation may be recommended at the site, it is recommended that the approximate amount of time needed to effectively minimize bat fatalities through curtailment be considered in the power purchase agreement.**

Feathering turbine blades when wind speeds are less than the speed at which electricity generation begins can greatly reduce bat fatalities. It is highly recommended that all turbines be programmed to feather blades when they are not producing electricity. **It is also recommended that this operating practice be included in the power purchase agreement.**

RESEARCH NEEDS

The potential synergistic impacts of wind energy development and white-nose syndrome on bats could negatively impact Nebraska bats. To help protect bats and their habitats from the potential impacts of wind energy development we need more knowledge of bat migration patterns, daily movements, and habitat use in Nebraska. By identifying bat activity patterns and important bat habitat we will be better equipped to recommend operational mitigation and placement of wind turbines to minimize bat fatalities and the alteration of important bat habitat. Data acquired though pre- and post- construction monitoring and contributed to the state-wide database is needed to be able to conduct analysis and determine the appropriate recommendations.

In an effort to learn more about bat distribution and migration in Nebraska, a number of grant-funded bat research projects have been initiated in the Nebraska Cooperative Fish & Wildlife Research Unit at the University of Nebraska – Lincoln. Information on these projects can be found at: http://snr.unl.edu/renewableenergy/wind/research.asp#bat.

The NGPC and the USFWS are interested in working with other stakeholders on a collaborative solution to identifying bat movement and migration patterns and important bat habitat.

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APPENDIX A: THE BATS OF NEBRASKA

The information for the bat species listed below has been compiled from the Bat Conservation International, Inc. (BCI) species profile website (http://www.batcon.org/resources/media-education/species-profiles), NatureServe (http://www.natureserve.org/explorer/index.htm), *Nebraska's Flying Mammals* (Freeman et al. 1997), and local expert input. Use of photos was granted by BCI and Keith Geluso. Maps are either from the BCI website or based on current literature with the reference listed under Residence. Maps should be used for reference purposes only. Conservation statuses listed are from the Nebraska Natural Legacy Project for At-Risk Species and NatureServe Rounded Global Status.

Big Brown Bat (*Eptesicus fuscus*)

CONSERVATION STATUS: Global – Secure (G5).

RESIDENCE: Year-round resident throughout Nebraska. Two subspecies occur in the state and populations overlap in areas of Nebraska.

ECOLOGY: Hibernates from early November to April in caves, hollow trees, rock quarries, mines, cellars, storm sewers, or buildings where temperatures remain above freezing. In the summer, females give birth to one or two young, roost in hollow trees, rock crevices, or buildings, and form nursery colonies that average 100 bats. Males may join colonies or remain solitary.

HABITAT: Riparian, forests (mixed, hardwood, or conifer), semi-open habitats including cities. Common in dwellings.

SPECIAL CONCERNS: white-nose syndrome; wind energy.

SPECIES CODE: EPFU

ACOUSTIC PROPERTIES: Low frequency

Eastern Red Bat (*Lasiurus borealis*)

CONSERVATION STATUS: Global – Secure (G5).

RESIDENCE: Mostly migratory; some populations are non-migratory.

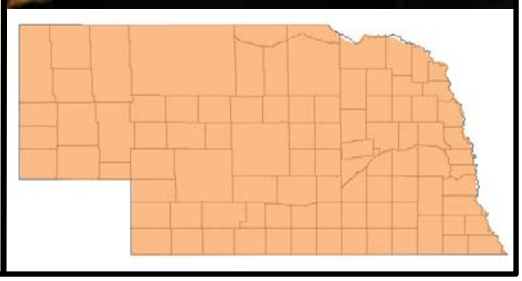
ECOLOGY: Solitary species. Females give birth in late May or June to two to five young (most commonly four for Nebraska's latitude). Range in color from orange red to rusty red and are often mistaken for dead leaves or fruit of the trees they roost in.

HABITAT: Riparian, forested and wooded areas, urban areas.

SPECIAL CONCERNS: One of the most common species found dead beneath wind turbines.

SPECIES CODE: LABO

ACOUSTIC PROPERTIES: High frequency



Evening Bat (*Nycticeius humeralis*)

CONSERVATION STATUS: Nebraska Tier II, State Vulnerable (S3); Global – Secure (G5).

RESIDENCE: Migratory; across southern and eastern Nebraska from May through September. Map based on Serbousek and Geluso 2009.

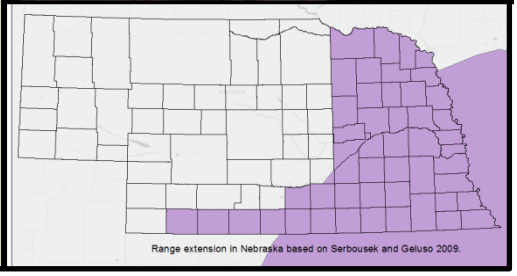
ECOLOGY: Females give birth to twins in the summer and form nursery colonies that can be found in hollow trees and buildings or behind the loose bark of trees. Only adult females and young have been reported in Nebraska.

HABITAT: Riparian, forested and wooded areas interspersed with cultivated areas.

SPECIAL CONCERNS: None.

SPECIES CODE: NYHU

ACOUSTIC PROPERTIES: High frequency



Fringed Myotis (*Myotis thysanodes pahasapensis*)

CONSERVATION STATUS: Nebraska Tier I, State Critically Imperiled (S1); Global –Imperiled (G4T2)

RESIDENCE: Year-round residents in the upland forest habitats in the western portion of Nebraska including the Wildcat Hills, Pine Ridge, and Pine Bluffs areas. Map from Panella 2012.

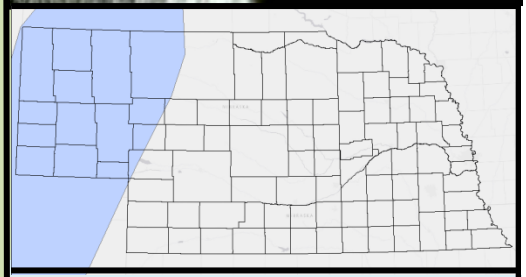
ECOLOGY: Females give birth to one young in the summer and form nursery colonies.

HABITAT: Riparian, conifer and mixed woodlands, grasslands, urban/suburban.

SPECIAL CONCERNS: Disturbance of roost sites, habitat alteration, overexposure to toxic insecticides.

SPECIES CODE: MYTH

ACOUSTIC PROPERTIES: Low frequency



A Species Conservation Assessment (Panella 2012): http://outdoornebraska.gov/wp-content/uploads/2015/09/NLP_Assessment_FringedMyotis.pdf

Hoary Bat (*Lasiurus cinereus*)

CONSERVATION STATUS: Global – Secure (G5).

RESIDENCE: Migratory; found in Nebraska from May through October.

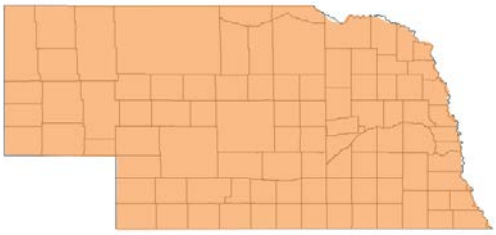
ECOLOGY: Solitary species; prefers to roost alone or as a family group (females with young) in trees or other vegetation. Females give birth in late May or June to twins.

HABITAT: Riparian, forested and wooded areas.

SPECIAL CONCERNS: One of the most common species found dead beneath wind turbines.

SPECIES CODE: LACI

ACOUSTIC PROPERTIES: Low frequency



Little Brown Myotis (*Myotis lucifugus*)

CONSERVATION STATUS: Nebraska Provisional Tier I; G3 - Vulnerable.

RESIDENCE: Year-round residents in the eastern quarter and northwestern corner of Nebraska.

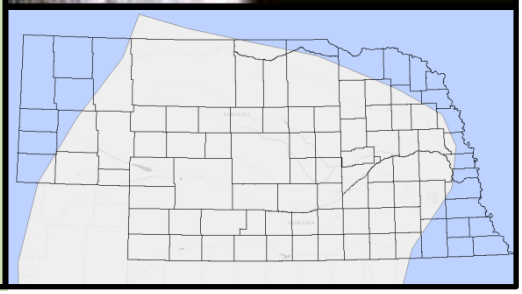
ECOLOGY: Females give birth to one young from May to early July and form nursery colonies of hundreds to thousands. During the winter, bats in the eastern portion of the state hibernate in rock quarries along the Platte River.

HABITAT: Wide range of habitats, use human-made structures.

SPECIAL CONCERNS: Wind Energy; White-nose syndrome.

SPECIES CODE: MYLU

ACOUSTIC PROPERTIES: High frequency



Long-legged Myotis (*Myotis volans*)

CONSERVATION STATUS: Nebraska Tier II, State Critically Imperiled (S1); Global – Secure (G5).

RESIDENCE: Year-round residents in the Pine Ridge area and along the Nebraska – Wyoming border.

ECOLOGY: Females give birth to one young in the summer and form nursery colonies that can be found in tree cavities, under loose bark, in buildings, and in rock crevices. During the winter, they hibernate in caves and mines.

HABITAT: Riparian, conifer and mixed woodlands and forests.

SPECIAL CONCERNS: None.

SPECIES CODE: MYVO

ACOUSTIC PROPERTIES: High frequency

Northern Myotis (*Myotis septentrionalis*)

CONSERVATION STATUS: Federal and State Threatened; Global - Imperiled (G3).

RESIDENCE: Year-round residents in eastern Nebraska and the Niobrara and Republican River corridors. Map based on Benedict 2004.

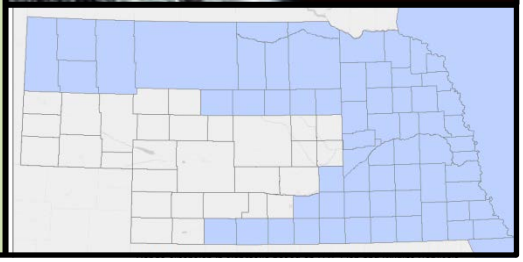
ECOLOGY: Females give birth to one young in May and form nursery colonies ranging from a few individuals to about 50. From October to March, northern myotis hibernate in caves and mines. During the summer days, they roost under loose tree bark, shutters, or wood shingles.

HABITAT: Riparian, conifer and mixed woodlands and forests, urban areas.

SPECIAL CONCERNS: Wind energy; white-nose syndrome.

SPECIES CODE: MYSE

ACOUSTIC PROPERTIES: High frequency



Mexican Free-tailed Bat (*Tadarida brasiliensis mexicana*)

CONSERVATION STATUS: Global – Secure (G5).

RESIDENCE: Migratory and probably rare visitors to Nebraska. It may be just exploring its range. Map based on Genoways et al. 2000.

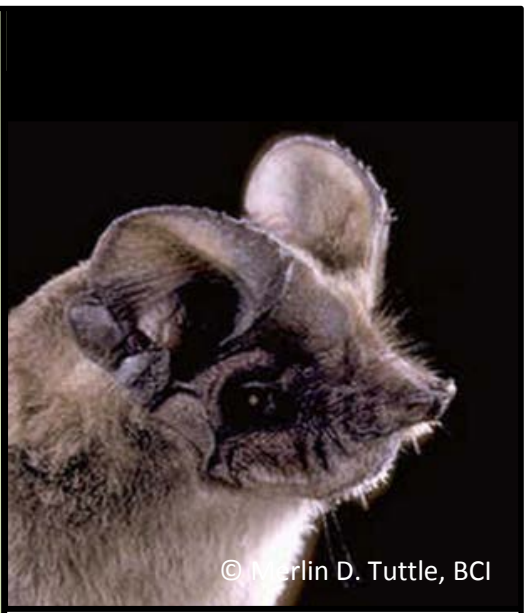
ECOLOGY: In portions of their range, females gather by the millions in caves to give birth and raise a single young. Winter group sizes are much smaller.

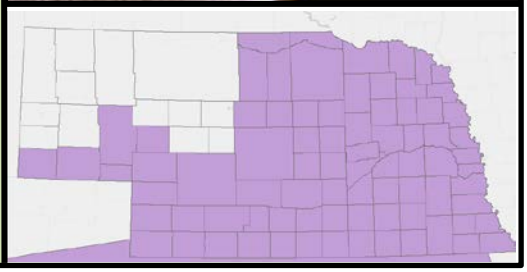
HABITAT: Riparian, semi-open to open habitats including urban areas.

SPECIAL CONCERNS: Wind energy.

SPECIES CODE: TABR

ACOUSTIC PROPERTIES: Low frequency





Silver-haired Bat (*Lasionycteris noctivagans*)

CONSERVATION STATUS: Global - Secure (G5).

RESIDENCE: Mostly migratory; some populations are non-migratory.

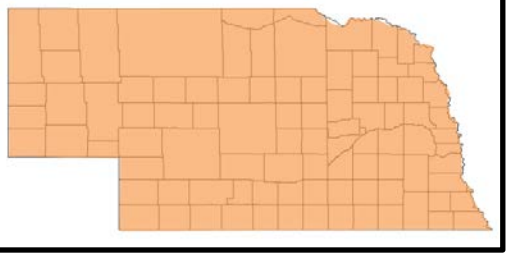
ECOLOGY: Females give birth to twins in the summer. During the summer, silver-haired bats roost in a variety of places including behind loose tree bark, in small cavities, open sheds, garages, outbuildings, and piles of lumber. Unlike other bats, they are known to hibernate in forested areas.

HABITAT: Riparian, conifer, mixed, and hardwood woodlands and forests.

SPECIAL CONCERNS: One of the most common species found dead beneath wind turbines.

SPECIES CODE: LANO

ACOUSTIC PROPERTIES: Low frequency



Townsend's Big-eared Bat (*Corynorhinus townsendii*)

CONSERVATION STATUS: Nebraska Tier II State Critically Imperiled (S1); Global - Vulnerable (G4).

RESIDENCE: Only one Townsend's big-eared bat has been documented in the state at a house below the Pine Ridge cliffs, in the northwestern corner of Nebraska. Non-migratory species.

ECOLOGY: Females give birth to one young in June or July and form nursery colonies in mines, caves, or buildings; males are solitary roosters. Hibernate in caves and mines in the winter.

HABITAT: Riparian, conifer, mixed, and hardwood woodlands and forests, grassland, cliffs.

SPECIAL CONCERNS: Sensitive to disturbance at their roosting sites; population declines throughout much of the U.S.

SPECIES CODE: COTO

ACOUSTIC PROPERTIES: Low frequency

Tri-colored Bat (*Perimyotis subflavus*)

CONSERVATION STATUS: Nebraska Provisional Tier I, State Critically Imperiled (S1); Global - Vulnerable (G3).

RESIDENCE: Year-round residents of Nebraska. Map based on Geluso 2005.

ECOLOGY: Females give birth to twins in the late spring or early summer. During the winter, they hibernate in limestone quarries; in the summer they most likely roost in quarries, trees, and other vegetation.

HABITAT: Riparian, conifer, mixed, and hardwood woodlands and forests, grassland, cliffs.

SPECIAL CONCERNS: Wind energy; white-nose syndrome.

SPECIES CODE: PESU

ACOUSTIC PROPERTIES: High frequency

Western Small-footed Myotis (*Myotis ciliolabrum*)

CONSERVATION STATUS: Global - Secure (G5).

RESIDENCE: Year-round residents found primarily in northwestern Nebraska along the Niobrara and White rivers.

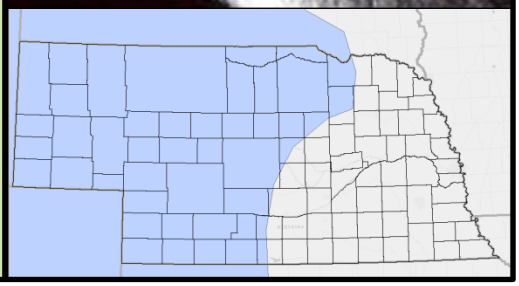
ECOLOGY: Females give birth to one young in the summer. In the summer, they can be found living under strips of bark and in rocky cliffs, rock outcroppings and crevices, and buildings. During the winter, they hibernate in caves and mines.

HABITAT: Riparian, conifer, mixed, and hardwood woodlands, grassland, cliff faces/talus.

SPECIAL CONCERNS: None.

SPECIES CODE: MYCI

ACOUSTIC PROPERTIES: High frequency



APPENDIX B: COLLECTING TISSUE OR HAIR SAMPLES

Genetic and stable isotope data from tissue or hair samples can be used by researchers to look at genetic diversity, geographic structure of populations, migratory habits, and more. Samples can be collected from live bats captured during mist netting or harp trapping surveys or from dead bats found during mortality surveys. Prior to collecting samples, check with NGPC to determine if a state Scientific and Education Permit is required and USFWS to determine if federal endangered species recovery permit is needed. The American Museum of Natural History (AMMH) Division of Vertebrate Zoology is accepting donations of bat tissue and hair samples. The AMMH will pay shipping charges for accepted donations and will provide vials for storing samples. For more information on donating to AMMH including wind punch and hair sampling protocols, visit http://research.amnh.org/vz/mammalogy/batdonation.

APPENDIX C: CAPTURE SURVEYS

Conducting capture surveys may not be necessary at every wind energy development site, but may be recommended by the NGPC and the USFWS following the initial season of acoustic sampling. Capture surveys conducted in areas where listed species may be present will require a Scientific and Education Permit from the NGPC and Recovery Permit from the USFWS and the use of approved protocols.

It is recommended that a detailed survey protocol tailored to the site be provided to NGPC and USFWS for review ***three months*** prior to the initiation of surveys.

To advance bat ecological research, tissue and hair samples can be collected and donated to the American Museum of Natural History or other approved repository. For more information see the Collecting Tissue or Hair Sample (Appendix B).

Survey Considerations

Survey Timing

The preferred time for surveys will be selected to most accurately cover the period of concern based on the acoustic survey data.

Potential Sampling Locations

- Water sources – streams, ponds, stock tanks
- Roosting areas – trees, buildings, mines, cliff/rock crevices

Data Collection and Analysis

The following information should be recorded for ***each survey date***:

- Mist net(s)
    - Mesh size
    - Length and width
    - Height deployed
    - Number of nets
    - Other
- Location (GPS coordinates) of each net/trap recorded in decimal degrees (DD) to four decimal places (00.0000°, -00.0000°)
    - Habitat(s) where deployed
- Collection date and times:
    - Date of data collection (mm/dd/yyyy)
    - Official sunset time (hh:mm; 24hr format; CDT/MDT)
    - Time netting/trapping began and ended (hh:mm – hh:mm; 24hr format; CDT/MDT)
- Capture information for each bat:
    - Species (scientific name)

- Sex
  - Female
  - Male
  - Unknown
- Reproductive Status
  - Pregnant
  - Lactating
  - Post-lactating
  - Non-reproductive
  - Unknown
  - Scrotal
- Age
  - Adult
  - Juvenile
- Morphometric Measurements (mm)
  - Forearm
  - WNS wing score
- Photograph(s)
  - No
  - Yes – identification information
- Time of capture (24-hour clock - hh:mm- hh:mm) (CDT/MDT)
- Tissues sampled
  - No
  - Yes
    - Type (hair, wing punch, swab, etc.)
  - Identification information

- Environmental data:
  - Wind speed (meters/second) and direction during the time period when passes are recorded
  - Relative Humidity
  - Ambient temperature (°F) – high and low temperature for the day
  - Moon phase (http://aa.usno.navy.mil/data/docs/RS_OneDay.php)
  - Precipitation (nearest weather station)
  - Barometric pressure

White-Nose Syndrome Precautions

White-nose syndrome (WNS) is caused by the fungus *Pseudogymnoascus destructans* (pd.). It was first discovered in New York in 2007 and since then has devastated populations of hibernating bats across half of the U.S. and Canada. More recent discoveries of WNS have been

identified further west in North America and there are concerns that bat populations across the country could be in danger of contamination.

WNS can be transmitted via bat-bat contact or by humans carrying the fungus from a contaminated cave on clothing, footwear, or other equipment. It is important to reduce the risk of spreading WNS to uncontaminated areas by properly decontaminating gear between cave visits or bat surveys that involve handling bats, or entering roost areas or hibernacula.

Visit the WHITE-NOSE SYNDROME Decontamination webpage for recommended protocols (http://www.fws.gov/midwest/Endangered/mammals/BatDisinfectionProtocol.html).

Bats that are captured during surveys should be examined for WNS. Winter/spring signs include excessive or unexplained mortality at/near hibernaculum, visible fungus on wings, muzzle, and/or ears of live or fresh dead bats, and abnormal behaviors such as daytime activity. For more information, visit the USGS National Wildlife Health Center Case Definitions for WNS website (http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/). If WNS is suspected, follow the USGS submission guidelines at: http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/USGS_NWHC_Bat_WNS_submission_protocol.pdf.

Capture Survey Reports

Included in the **Capture Survey** reports should be (details above in Capture Surveys Data Collection Section):

Survey Information:

1) Survey method
    a. Mist net
    b. Harp trap
    c. Other
2) Equipment specifications
3) Survey specifics

Bat presence:

1) Capture information for each bat
    a. Species
    b. Sex
    c. Reproductive status
    d. Age
    e. Morphometric measurements
    f. Reference photos

    g. Times of capture
    h. Genetic material sampled (if applicable)
    i. Environmental data
2) Summary of capture information for each species
3) Graphical presentation of the total number of bats/date:
    a. Each identified species
    b. All identified species combined
4) Graphical presentation of the total number of bats/hour:
    a. Each identified species
    b. All identified species combined

Data

Comments and Additional Information