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North American Bat Monitoring Program (NABat) Mobile Acoustic Transect Surveys Standard Operating Procedure 2—Field Season and Survey Preparation

Chapter 2 of
Section C, Collection of Data Associated with the North American Bat Monitoring Program (NABat), of
Book 2, Collection of Environmental Data

Techniques and Methods 2–C2

U.S. Department of the Interior
U.S. Geological Survey

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Conversion Factors

U.S. customary units to International System of Units

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
mile, nautical (nmi)	1.852	kilometer (km)
yard (yd)	0.9144	meter (m)

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:
°C = (°F –32)/1.8.

Abbreviations

SOP	standard operating procedure
NABat	North American Bat Monitoring Program
GIS	geographic information system
GPS	Global Positioning System

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By Jaclyn Martin,[1] Jason Rae,[2] MacKenzie Hall,[3] Emily Ferrall,[4] Han Li,[5] Bethany Straw,[1] and Brian Reichert[1]

Abstract

This document is the second of three standard operating procedures providing instructions and considerations for conducting mobile acoustic surveys along road transects to collect bat acoustic data following the North American Bat Monitoring Program (NABat) protocol and sample design. This standard operating procedure focuses specifically on considerations for establishing the field survey season and preparing to conduct mobile acoustic transect surveys. Intended audiences for this document include those in charge of facilitating surveys within their region (for example, state or provincial mangers and NABat regional hub coordinators), project leaders or survey coordinators responsible for setting up and organizing NABat mobile transect monitoring for their organization or area, and field staff preparing to conduct surveys within the field.

Introduction

This standard operating procedure (SOP) describes step-by-step procedures and considerations necessary to prepare for conducting mobile acoustic transect surveys, from establishing field season parameters and the frequency and timing for the field survey season, to preparing equipment and addressing survey logistics. Figure 1 illustrates the workflow for the field season and the timing of survey preparation.

Frequency and Timing of Surveys

Surveys should occur during the summer maternity season, after maternity colonies are fully formed and females have completed spring migration, and prior to juveniles becoming volant. As a general recommendation, the period between June 1 through early to mid-July allows for favorable weather conditions, while excluding most migrants and allowing surveys to be completed before juveniles are dispersed on the landscape. However, these dates should be used for reference only and may not be appropriate in every region. Exact dates of migration and volancy will vary by region, elevation, and species, therefore, it is important to account for location-specific variability in climate and species composition when determining the survey period. During the survey season, each mobile transect should be completed twice, with both runs of a single transect occurring within the same week. Surveys in subsequent years should occur within 1–2 weeks of the original survey date to maintain consistency in both the bat's life cycle stage and the overall weather conditions. If conducting stationary acoustic surveys in the same year and within the same sampling grid, the timing of mobile transect surveys should overlap with that of stationary surveys whenever possible. Additional mobile transects may be run outside of the recommended survey period for local monitoring efforts if desired; these data may still be submitted for inclusion into the NABat database.

[1]USGS

[2]Wildlife Conservation Society Canada.

[3]New Jersey Division of Fish and Wildlife Endangered and Nongame Species Program.

[4]Georgia Department of Natural Resources.

[5]Department of Biology at the University of North Carolina at Greensboro.

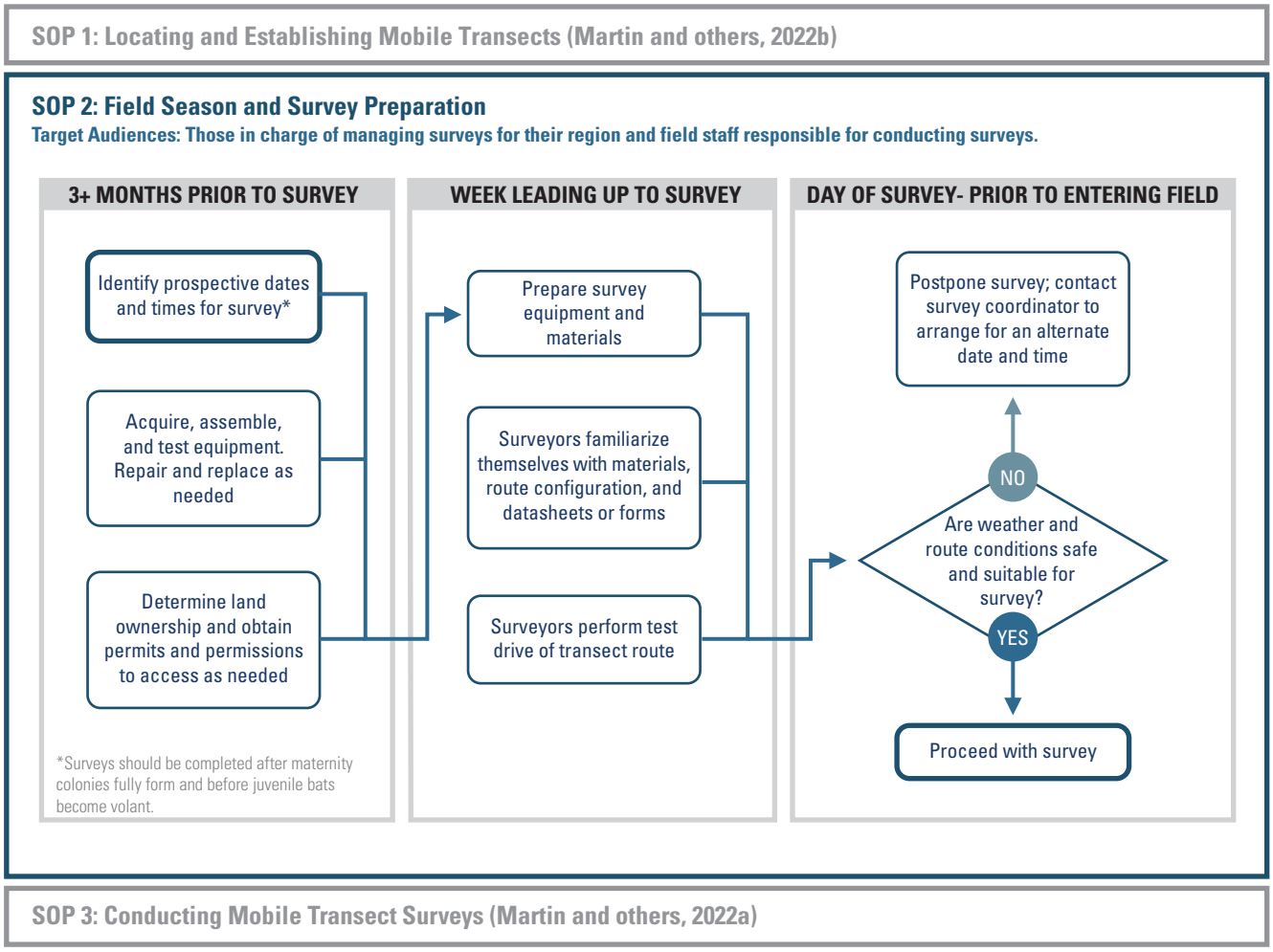

Figure 1. Summary of the workflow for field season and survey preparation, as detailed in this report. (SOP, standard operating procedure; +, or more)

Environmental Conditions

Inclement weather can influence bat activity, and therefore, the rate at which bats can be detected. Ideally, surveys should be conducted on nights that are clear of clouds and lack wind. Depending on local conditions, consider scheduling surveys early in the season to avoid inclement weather that may be more likely to occur in late summer; this precaution will also provide greater flexibility in the event a survey must be postponed. Consider postponing surveys if any of the following conditions are present or forecasted during the survey period:

- *Temperatures below 50 degrees Fahrenheit (°F).*—Bat activity is influenced by ambient temperature and is severely decreased below 50 °F (Barclay, 1982; Grinevitch and others, 1995 Agosta and others, 2005; Brooks, 2009). This threshold may vary based on local conditions within the survey area. Note that this temperature guidance only applies to the survey night when the survey is being conducted, and it is independent of the nightly low if it falls outside the survey period.
- *Rain.*—Rain may deter bat activity and has the potential to pool in and around the microphone, damaging the microphone and impacting the functionality of equipment. Raindrops hitting the microphone will also contribute to noise and will reduce sound transmission. In locations that have a history of rain most nights within the survey period, surveying in light rain is permissible, as some research suggests that bat activity is less impacted in light rain (Scanlon and Petit, 2008). However, if windshield wipers are required to maintain visibility while driving, then there is too much rain to complete the survey, and it must be postponed. Additionally, water should not pool on roads nor create slippery conditions, and equipment must be protected from water damage. In most cases, surveys should not be conducted during any amount of rain.

- *Dense fog.*—If visibility while driving is obscured by dense fog, postpone the survey for a later date for your own safety.
- *Wind speed in excess of 6 miles per hour (mph).*—Bat activity is impacted by local wind speed conditions, generally decreasing as wind speeds increase, particularly above 6 mph (Reynolds, 2006; Cryan and Brown, 2007; Martin and others, 2017). Very high winds may also increase the occurrence of ambient noise, potentially obscuring bat calls or resulting in additional noise files.
- *Smoke.*—Postpone surveys in the case of heavy smoke from wildfires or other causes if conditions pose a threat to field staff (for example, poor air quality, inaccessible routes, low visibility, proximity to flames, high risk of falling debris, and so forth.). Long lasting fires may persist throughout the survey window and prevent staff from conducting surveys for the duration of the season. If smoke is present but conducting surveys is deemed safe, make note of the conditions when collecting survey metadata.
- *Road closures.*—Sections of the road may be closed and inaccessible due to factors such as construction, weather, or vehicle accidents.
- *Excessive traffic.*—Be aware of increased traffic on weekends or during special events and holiday periods. While it may be advantageous to schedule surveys during holidays to offer volunteers additional opportunities to participate, it is important to avoid transect routes where heavy evening traffic is likely.

In the event one or more of these conditions is unavoidable, make note of the condition and any other relevant observations on the datasheet.

Survey Start Time

Surveys should be conducted during peak activity times for bats within your study area to maximize detection of echolocating bats. For most locations, peak activity times occur early in the night within approximately two hours after sunset. The exact start time for a mobile transect survey is highly dependent on the location of the study area and behavior of the local species assemblage. For more precise guidance on determining an exact survey start time for your area, consult with your regional NABat hub or state coordinator. Once a start time has been determined, it is imperative that replicates of the same transect begin at the same time, both within and between years, whenever possible. The following are suggestions to consider when determining the start time for your survey:

- Identify the timing of the beginning of nautical twilight or end of civil twilight and beginning of astronomical twilight for your study area. Anticipated twilight phases for a particular area and date can be found on some mobile weather apps, or websites such as https://thetimeandplace.info or https://www.timeanddate.com/sun. In general, the beginning of nautical twilight coincides with the start of emergence for many species, however, certain species, such as those in the *Myotis* genera, are more likely to emerge later in the evening. Once emerged from their roosts, bats may not be fully dispersed amongst the landscape until closer to the beginning of astronomical twilight. The timing of dispersion depends on the species and conditions in the study area.
- When calculating start time, consider that starting the survey too early may result in missing species that have not yet emerged or dispersed on the landscape, while starting too late runs the risk of missing the peak of activity.
- If feasible, performing capture surveys, running trial transects, and placing a stationary detector along the proposed route prior to the survey dates is recommended. Doing so can aid in determining the most effective start time by providing information on species activity and detection rates
- If the determined start time coincides with the start or end of an evening twilight phase, hub or survey coordinators should include a printed copy of the Sun Graph (https://www.timeanddate.com/sun), or a similar document depicting start and end times for the various twilight phases for the month for their area, in the detector package as a quick reference for surveyors.

Equipment

This section lists the equipment needed, the types of detectors available, and guidance on how to choose a detector and microphone combination that suits your survey needs. Prior to the survey, confirm that you have all necessary equipment and materials and are prepared to complete your mobile transect route(s). For guidance on recommended equipment and common detector types, refer to table 1 and additional information in this section.

Choosing a Detector and Microphone

A list of acceptable acoustic detectors and microphone options are provided in table 2 below. This list is subject to change as technology advances and is provided for information purposes only. The NABat Coordinating Office does not recommend any commercial resource over another. Contact the NABat Coordinating Office (https://www.nabatmonitoring.org/our-team) or your local or regional coordinator if you have questions about an acoustic detector not on this list.

Detector and Microphone Considerations

There are a variety of bat detectors available for use during mobile acoustic transect surveys, with improvements to existing detectors and new models being released as technology advances. Acceptable models for mobile surveys include zero-cross frequency division or full-spectrum direct recording detectors. The detector must be able to provide a time and date stamp and location information (waypoint) for each acoustic file that is recorded. Furthermore, it is critical to understand the specifications and limitations for the detector you are using and consider these when programming the detector's sensitivity and settings. See the "Preparing for Mobile Transect Surveys" section for more information on preparing equipment for mobile transect surveys. Additional consideration should be given when deciding between a directional or omnidirectional microphone. Because omni-directional microphones receive sound from all directions, they have a larger sampling volume and the ability to record bats in every direction from the microphone. Consequently, omnidirectional microphones may be more likely to pick up noise that is generated from or reflected off the top of the vehicle. Additional noise can reduce the quality of recordings by generating unwanted noise files and distorting recorded bat calls (Parsons and Szewczak 2009). In contrast, a directional microphone, either by design or with the addition of housing or a shield, has a sampling volume that is mainly directed towards the front of the cone shaped microphone. This shape often results in the microphone having a greater range of detection, allowing it to detect bats from farther away (Limpens and McCracken 2004). One example of where this feature may be important is for surveys targeting high flying species such as the hoary bat. While there are advantages to using a directional microphone, and their use is recommended, omnidirectional microphones can still be successful in collecting high quality recordings. If resources allow, the hub or survey coordinator may wish to perform test surveys to compare detection rates between the two types of microphones to establish the most appropriate option for their organization.

Table 1. Equipment checklist for conducting one mobile transect survey.

[GPS, Global Positioning System; NABat, North American Bat Monitoring Program]

Item
Detector
Microphone, including cable if separate from detector
Car mount for securing equipment to top of vehicle
Ultrasonic calibration tool (optional, can be used to test microphone sensitivity)
Memory cards
Batteries (rechargeable recommended)
Battery charger if using rechargeable batteries
GPS unit, including cable and power cord if not built into the detector
Map (print or digital) with route guidance
Datasheet and pencil or a mobile device with access to the mobile field data collection application and NABat digital mobile metadata form
Folder or binder to store and organize completed datasheets if using paper copies
Emergency contact information for the hub or survey coordinator or appropriate staff
Car sign or magnet reading, "Slow Vehicle—Survey in Progress" or similar (optional, recommended for safety purposes)
Flashlight, headlamp, or red light

Table 2. List of acoustic detectors and associated relevant details.

[EMT, echo meter touch: EMT2, echo meter touch, model 2; mic, microphone; kHz, Kilohertz]

Device	Source	Manufacturer	Notes
Echo Meter Touch 2 Pro	For iOS Operating Systems: https://www.wildlifeacoustics.com/products/echo-meter-touch-2-pro-ios For Android Operating Systems: https://www.wildlifeacoustics.com/products/echo-meter-touch-2-pro-android	Wildlife Acoustics	Budget option. The EMT2 Pro is recommended for research purposes over the EMT2 or earlier versions of the EMT. The EMT2 Pro mic element features improved signal-to-noise ratio above 60 kHz when compared to the standard model. Available for use with iOS or Android users.
Song Meter SM4BAT FS	https://www.wildlifeacoustics.com/products/song-meter-sm4bat	Wildlife Acoustics	Requires purchase of a microphone. Microphone can be omnidirectional or directional with the addition of a directional horn placed on the microphone. The full spectrum mode should be used.
D500X	https://batsound.com/product/d500x-ultrasound-detector-recorder/?currency=USD	Pettersson	Requires purchase of external microphone.
Anabat Swift	https://www.titley-scientific.com/us/anabat-swift-passive-bat-detector.html	Titley Scientific	Requires purchase of external microphone. Omnidirectional and directional microphones available.
Anabat Express	https://www.titley-scientific.com/us/anabat-express-2-114.html	Titley Scientific	Requires purchase of externalmicrophone. Omnidirectional and directional microphones available.
Anabat Walkabout	https://www.titley-scientific.com/us/anabat-walkabout.html	Titley Scientific	Requires purchase of a directional, external microphone.

Preparing for Mobile Transect Surveys

Approximately Three Months Prior to Survey Date:

1. Locate and establish mobile transect routes. Follow guidance provided in SOP 1 (Martin and others, 2022b).
2. Prepare and test equipment:
    A. Test all equipment to verify functionality and update firmware as needed. Rub or snap fingers in front of the microphone to confirm it detects and registers sound. Calibrate the microphone following guidance from the detector's manufacturer. Additionally, an external ultrasonic calibration tool can be purchased and used to test the sensitivity of ultrasonic microphones, however, while this is recommended, it is entirely optional. Troubleshoot as needed. Depending on the car mount system and whether a microphone extension cable is needed (for example, if the detector is to be kept inside the vehicle), confirm that the cable is long enough to connect the microphone to the detector while performing the survey.
    B. Construct or buy a vehicle mount:
        i. Mounts can be purchased from a manufacturer or constructed from simple materials. Requirements for the mount setup will depend on the equipment being used and the vehicle used to survey. The mount must be secure enough to hold the equipment in place on top of the vehicle while the vehicle is moving at 20 mph. A detector with a built-in microphone and Global Positioning System (GPS) can be secured as a single unit within a container and anchored to the center of the vehicle rooftop. Detectors with external microphones can be secured in a microphone clip and attached to the vehicle with a mount (for example, a suction cup mount; figs. 2 and 3). An extension cord can be used to attach the detector to an external GPS unit and a smart device to collect data (fig. 4). Magnetic mounts will not work on vehicles with aluminum roofs. Refer to guidance in SOP 3 (Martin and others, 2022a) for more information on setting up equipment.
        ii. Order new equipment or repair existing equipment as needed. Allow for 3 or more months for new equipment to arrive or repairs to be made. Whenever possible, use the same microphone type, detector or detector type, and settings for each replicate of a transect within years. Be sure to document changes in equipment.
3. Obtain research permits:
    A. Depending on land ownership within the survey area, a permit may be necessary to access and perform surveys along all or parts of a transect. Some example locations where permits could be required

are within national parks or fee-regulated areas and on Tribal lands, U.S. Forest Service lands, and university reserves. The hub or survey coordinator is responsible for obtaining required permits at least 3 months in advance of the survey season. A copy of the permit should be provided to field staff to have on hand during the survey night.

B. If no permit is required, notify the relevant field office of the land owner or managing organization of your survey plans and timeline.

4. Contact private landowners:

A. If the survey area requires use of private roadways, contact the landowner for permission to access and perform surveys. Perform a test run of the route during the day, prior to the actual survey date. In the United States, tax lot maps can be used to identify private landownership. These maps can be found through the county tax assessor's website for each state. Other resources may exist in some regions.

One Week Prior to Survey Date

1. Obtain equipment from the hub or survey coordinator or from previous surveyors if sharing equipment during the survey season.

Figure 2. Example of an Anabat SD2 external microphone mounted to a vehicle and oriented at a 45-degree angle. Image courtesy of Han Li with the Department of Biology at the University of North Carolina at Greensboro.

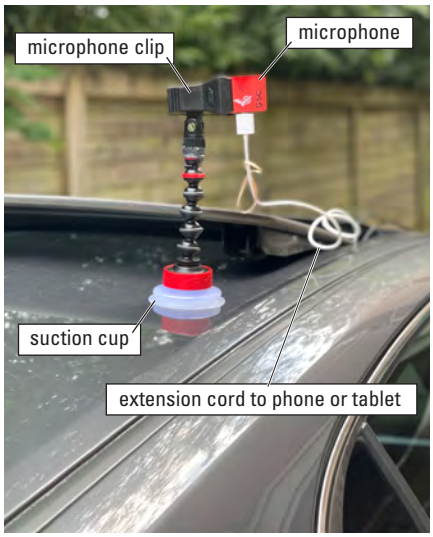

Figure 3. Example of a microphone clip and suction cup mount used to mount the Echo Meter Touch 2 Pro to a vehicle. Image is courtesy of Han Li with the Department of Biology at the University of North Carolina at Greensboro.

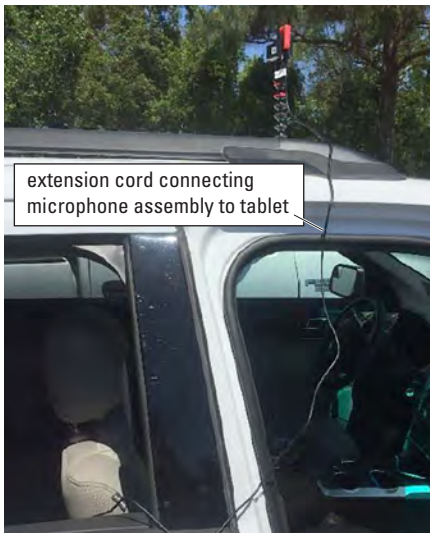

Figure 4. Example of an Echo Meter Touch 2 Pro mounted to the center of a vehicle rooftop using a microphone clip and suction cup mount. The detector is oriented with the microphone pointing up, and the lightening connector points down. It connects to a tablet inside the vehicle using an extension cord that enters the vehicle through a window and attaches to a tablet. Image courtesy of Marissa Liverman with the North Carolina Wildlife Resources Commission.

2. Prepare equipment:

    A. Program the detector to the appropriate location, date, time zone, and audio settings or verify these settings are already in place. It is critical that these settings be consistent for all transects within and between years. Document the settings for each transect in the NABat database. Refer to the "NABat Guide to Acoustic Detector Settings" form, available from https://www.nabatmonitoring.org, for additional guidance on programming various detector models.

    B. Clean the detector with a soft cloth to ensure no dust or other particles are present that may cause damage to the detector's functionality.

    C. Remove old batteries from the acoustic detector, GPS unit (if separate), and any other survey equipment and replace with new or fully recharged batteries (rechargeable recommended). Charging may take several hours. Be gentle with electrical wiring and pay careful attention to positive and negative ends when putting batteries back into equipment. Extra batteries should be kept on-hand in case of an emergency.

    D. Verify that the detector and microphone are picking up and registering sound as expected by rubbing or snapping fingers in front of the microphone. Troubleshoot as needed.

    E. Verify that the detector has the correct number of memory cards of appropriate capacity and that cards are empty. If data are present, notify the hub or survey coordinator or appropriate staff to ensure data have been downloaded to a computer and backed up, then clear the data from the memory card.

    F. If using an external GPS, verify that the time and location settings are consistent with the detector so that the latitude and longitude coordinates can be matched to each acoustic file recorded by the detector. The GPS should be set to the North American Datum of 1983 (NAD83) to ensure location data is compatible with the NABat master sample frame.

3. Confirm that a vehicle is available for the survey and that it is suitable for the driving terrain and in good operating condition. The vehicle must have suitable tires, all-wheel drive or four-wheel drive if needed, working windshield wipers, headlights, and so forth. Additionally, emergency equipment such as jumper cables, a car jack, and a spare tire are recommended.

4. If conducting a route on private, protected, or public lands requiring special access or permission, confirm that a copy of any necessary permits have been obtained and placed in the vehicle for use during the survey night.

5. Review all maps and digital route guidance to familiarize yourself with the starting point, driving route, and end point. Note that the start and end point should be exact and consistent for each transect across survey nights and years.

6. Perform a test drive of the transect route to verify road access and become familiar with the landmarks and turns. If possible, field staff should perform the test drive during the same time of day as the survey. A test drive will help to prevent confusion and increase comfortability of field staff driving the route after dark when visibility is limited. Refer to SOP 3 (Martin and others, 2022a) for more information on performing a test run of the transect.

7. Review the survey datasheet for information required to upload to the NABat database. Alternatively, for mobile transect surveys occurring in a single grid cell, metadata can be recorded digitally and submitted directly to the NABat database using a smart device with access to a mobile field data collection application suitable for NABat mobile surveys. Help is available at https://nabatmonitoring.org or by contacting a member of our user support team (https://www.nabatmonitoring.org/our-team).

Day of Survey (Prior to Entering the Field)

1. Check the hourly weather forecast to verify it is not expected to rain and that temperature and wind conditions remain suitable during your survey window. If rain is unavoidable in your survey area, follow guidance provided in the "Environmental Conditions" section of this SOP.

2. Check road conditions along the transect route to ensure it is accessible without significant detours and is safe to drive. Flooding due to previous weather occurrences, road construction, detours, or vehicle accidents are factors that may impact your route. Refer to your state or region's Department of Transportation website or other local sources for current road conditions.

3. Check local sunset time and record the calculated start time on the survey datasheet or in the mobile field data collection application and input the start time into the Survey123 application if you are using it. Plan to arrive at the starting location 15–20 minutes early to set up, allow the GPS to gain a connection with satellites, begin filling out the datasheet or mobile field data collection application form, and troubleshoot as needed.

4. Make sure the detector and microphone are functioning properly by turning on the unit and rubbing or snapping your fingers in front of the microphone; look for an indicator light or icon if present on the detector confirming that sound is detected by the microphone.

5. If using an external GPS device, verify the time zone and location settings are consistent between it and the detector.

6. Store all equipment in a safe and secure location until you are at the survey location and ready to set up. Equipment should be kept indoors, as opposed to in a vehicle, until just prior to leaving for the survey. If for some reason the equipment must be left unsupervised in a vehicle, for even a short period of time, ensure the vehicle is locked with the windows closed.

Summary

This document is the second of three standard operating procedures providing instructions and considerations for conducting mobile acoustic surveys along road transects to collect bat acoustic data following the North American Bat Monitoring Program (NABat) protocol and sample design.

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