

Standard Operating Procedure #1:

Sampling Design and Site Selection

Version 1.0

In Bat monitoring protocol for the Great Lakes Inventory and Monitoring Network: Version 1.0

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Revision History Log

The following table lists all edits and amendments to this document since the original publication date. Information entered in the log must be complete and concise. Users of this standard operating procedure will promptly notify the GLKN protocol lead and/or project coordinator about recommended and required changes. The protocol lead and/or project coordinator must review and incorporate all changes, complete the revision history log, and change the date and version number on the title page and in the header of the document file.

Previous Version #	Revision Date	Author (with title and affiliation)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
Add rows as needed for each change or set of changes tied to an updated version number					

Contents

	Page
Figures.....	ii
1.0 Introduction.....	1
1.1 Sample Design	1
1.2 Site Selection	3
1.3 Relocating a Site	5
1.4 Site Naming Conventions	5
Literature Cited	7
Appendix A. Illustration of Sample Design.....	9

Figures

	Page
Figure 1. Example of a grid system used to place sample locations on the landscape.	9
Figure 2. Example of creating a replacement sample location.	10

1.0 Introduction

The Great Lakes Inventory and Monitoring Network (GLKN) is implementing a monitoring program to document changes in bat populations in national park units in the upper Midwest. We are using acoustic monitoring as an index for assessing long-term bat population trends in response to ecosystem changes including climate, habitat, and disease such as white-nose syndrome (WNS). The goals of this monitoring program are to assess probable presence and absence of bat species, and to determine relative activity levels of those species for each national park unit over time. This Standard Operating Procedure (SOP) describes the methods to be followed for identifying the sampling locations within each national park unit where bat acoustic monitoring will occur.

1.1 Sample Design

Following the same general procedures as the North American Bat Monitoring Program (Loeb et al. 2015), GLKN utilizes a probabilistic sample design based on the creation of a master sample, as described by Larsen et al. (2008). The successful use of this sample design for bat acoustic surveys was illustrated by Rodhouse et al. (2011). The sampling frame for each park consists of a finite grid of 1-km² cells. For some parks certain areas were excluded from the sampling frame *a priori* based on inaccessibility from roads, trails, or shorelines. Using the Generalized Random Tessellation Stratified (GRTS) algorithm (Stevens and Olson 2004), cells within each park's sampling frame were arranged into an ordered list, referred to as the "master sample". The master sample is both randomized and spatially balanced, as is any subset of the master sample, as long as the GRTS order is preserved. The GRTS process forces sampling to be spread across the geographic extent of the park, to avoid the potential bias of sampling a group of sites that are clumped in close proximity to each other. It also allows the flexibility to add or delete sample sites from year to year if resources or access change.

The cells that will actually be sampled are identified by working through the master sample list in numerical order, starting with Cell #001 for each park. Each cell is assessed for feasibility to determine if it should be included. If a cell is not accessible or has safety concerns that would put future sampling in jeopardy, that cell is omitted and replaced with one that can be sampled every year with confidence. Omitted cells are documented to justify why each cell was excluded.

Our initial goal was to sample a minimum of 15 cells per park. This goal was established based on the number of detector units available, the estimated time required to access and sample each location, and a statistical power analysis (Gruver et al. 2016). The final number of established sites ranges from 18–35 per park. This equates to a range of 3.6%–88.9% (average 20.4%) of cells sampled out of each park's sampling frame.

The cell is defined as the 1-km² area that is selected for sampling. The site is defined as the exact location within the cell where the acoustic recording equipment is placed (see Section 1.2). See Appendix A for an illustration of the sample design. A Site ID is assigned based on the cell's GRTS order number. Naming conventions are detailed in Section 1.4.

Our monitoring program uses an “always revisit design”, meaning that the same sites are sampled each year in approximately the same order and at approximately the same time. This design was chosen because it is statistically superior for assessing long-term trends. Although there is some inherent bias attributable to the decisions made by the person doing the initial site selection, each site will be revisited each year. This consistency allows for a valid estimation of trends over time.

The GLKN sample design is similar in many regards to other acoustic monitoring protocols. A detailed comparison of our protocol to the NABat protocol (Loeb et al. 2015) and NW Bat Hub protocol (Rodriguez et al. 2019) is found in Section 2.5 of the Protocol Narrative.

1.2 Site Selection

When selecting sample sites, the objective is to identify one suitable bat monitoring location within each selected cell. Field crews may use Google Earth or other aerial imagery to scan the landscape within a cell to find potential sample sites. Potential sites are then visited on-the-ground to verify suitability and accessibility. It may take a significant amount of time (hours to days) to identify a quality location for a long-term study site such as this.

Suitable sampling sites will target bats when they are traveling between roosting areas and foraging or drinking areas. Different bat species prefer different habitat types because of their feeding habits, wing morphology, and flight behavior. It is best to select a variety of sites reflecting the different habitats available in the park to increase the diversity of species being monitored.

There are three main factors that will affect the quality of the recorded bat calls: reflection of sound waves, habitat structure, and the number of bats present. The sound waves produced by bats when they echolocate can reflect off of nearby surfaces, such as water or buildings. The reflected sound may cause distortion and the recordings will be harder to identify to species. In regard to bat behavior, it is well documented that bats will alter the echolocation calls they use depending on their physical surroundings, their activity, and the social context (Obrist 1995, Broders et al. 2004, Ratcliffe et al 2004, Gillam et al 2010). For example, a bat may emit different call types in an open field vs. in a forest with dense understory. A bat will also use different call types when traveling vs. when capturing prey. If many bats are in the same area at the same time a bat may adjust its call structure to distinguish itself from conspecifics or it may produce social calls. Finally, when many bats are in the same area it is likely that multiple individuals will be recorded simultaneously, which can make call identification more difficult.

To ensure collection of the highest quality recordings, potential sample sites should meet the following guidelines:

1. Microphone placed at least 5 meters from clutter. Clutter is defined as physical objects that are present in the bat's flight environment, such as tree branches, leaves, buildings, rock/cliff faces, or water surfaces (Loeb et al 2015, Rodriguez et al 2019). Calls recorded in open, uncluttered environments are often more easily identified to species.
2. Microphone placed at least 2 meters off the ground. This will minimize echoes or distortion from sound bouncing off the ground.
3. Microphone placed at least 5 meters from open water. This will minimize echoes or distortion from sound bouncing off the water surface.
4. Equipment placed at least 15 meters from a known bat colony or roost site. This will reduce the chances of recording social calls or recording multiple bats simultaneously.
5. Site selected is a likely bat travel corridor (e.g., cut line, road, trail, forest edge) or foraging area (e.g., wetland) with a suitable position to set up equipment where the microphone can be

aimed toward the targeted sample area. When setting equipment at a linear corridor the corridor from the edge rather than placing it in the middle of the corridor.

6. Equipment placed within 0.25 mile of water when possible. Bats often forage over water or visit water sources to drink. Fast-flowing streams are not as good due to the excessive water noise.

Once selected, the same sampling location should be re-visited each year. Equipment should be set up as consistently as possible from year to year: in the exact same spot, with the same microphone orientation and height, on approximately the same dates.

1.3 Relocating a Site

Occasionally conditions may change at a site—for example if storm damage or flooding occur or if land ownership changes—making it necessary to relocate the site to a new spot within the same cell. However, sites should not be relocated without serious consideration because it will have implications on data analysis. If changes are severe enough that the site must be moved, it is important to document the move and justify why the change was made. This should be documented thoroughly on the datasheet.

If it is only a minor change (≤ 10 meters) we will consider the new site to be sampling the same area as the original site and the Site ID will remain the same. However, if the site is moved more than 10 meters, it is necessary to assign it a new Site ID. Naming conventions are detailed in Section 1.4.

When a site is relocated, only the new site will be monitored in subsequent years. The new site is considered to be a replacement for the original site and the original site is now dropped from sampling.

1.4 Site Naming Conventions

GLKN has established standardized naming conventions for bat monitoring sites to maintain consistency across parks and avoid potential confusion.

Each site will be assigned a Site ID. The Site ID is based on the park's four-letter code, the cell's GRTS order number, and how many locations have been sampled previously within that cell. For example, the first site where bats are monitored within GRTS cell #001 at Sleeping Bear Dunes will have the Site ID SLBE001A. The "001" signifies the cell number and the "A" signifies this is the first site sampled within the cell.

If a site has to be moved for some reason, then the alpha code at the end of the Site ID changes. Continuing our example, the second site within GRTS cell #001 at Sleeping Bear Dunes will have the Site ID SLBE001B.

Park staff may elect to also use a Site Name, recorded on the datasheet. This will typically be a descriptive phrase referencing roads, trails, or other place names to assist staff in identifying the general area where the site is located.

Literature Cited

- Broders, H. G., C. S. Findlay, and L. Zheng. 2004. Effects of clutter on echolocation call structure of *Myotis septentrionalis* and *M. lucifugus*. *Journal of Mammalogy* 85(2):273–281.
- Gillam, E. H., N. I. Hristov, T. H. Kunz, and G. F. McCracken. 2010. Echolocation behavior of Brazilian free-tailed bats during dense emergence flights. *Journal of Mammalogy* 91(4):967–975.
- Larsen, D. P., A. R. Olsen, and D. L. Stevens, Jr. 2008. Using a master sample to integrate stream monitoring programs. *Journal of Agricultural, Biological, and Environmental Statistics* 13(3):243–254.
- Loeb, S. C., T. J. Rodhouse, L. E. Ellison, C. L. Lausen, J. D. Reichard, K. M. Irvine, T. E. Ingersoll, J. T. H. Coleman, W. E. Thogmartin, J. R. Sauer, C. M. Francis, M. L. Bayless, T. R. Stanley, and D. H. Johnson. 2015. A plan for the North American Bat Monitoring Program (NABat). General Technical Report SRS-208. U.S. Department of Agriculture Forest Service, Southern Research Station, Asheville, North Carolina.
- Obriest, M. K. 1995. Flexible bat echolocation: The influence of individual, habitat, and conspecifics on sonar signal design. *Behavioral Ecology and Sociobiology* 36(3):207–219.
- Ratcliffe, J. M., H. M. ter Hofstede, R. Avila-Flores, M. B. Fenton, G. F. McCracken, S. Biscardi, J. Blasko, E. Gillam, J. Orprecio, and G. Spanjer. 2004. Conspecifics influence call design in the Brazilian free-tailed bat, *Taderida brasiliensis*. *Canadian Journal of Zoology* 82(6):966–971.
- Rodhouse, T. J., K. T. Vierling, and K. M. Irvine. 2011. A practical sampling design for acoustic surveys of bats. *Journal of Wildlife Management* 75:1094–1102.
- Rodriguez, R. M., T. J. Rodhouse, J. Barnett, K. M. Irvine, K. M. Banner, J. Lonneker, and P. C. Ormsbee. 2019. North American Bat Monitoring Program regional protocol for surveying with stationary deployments of echolocation recording devices: Version 1.0, Pacific Northwestern US. Natural Resource Report NPS/UCBN/NRR—2019/1975. National Park Service, Fort Collins, Colorado.
- Stevens, D. L., Jr., and A. R. Olsen 2004. Spatially balanced sampling of natural resources. *Journal of the American Statistical Association* 99:262–278.

Appendix A. Illustration of Sample Design

The following figures illustrate how sampling locations for the GLKN bat acoustic monitoring project are established. First, a 1-km² grid is overlaid across the park. Cells are arranged into an ordered list (master sample) using the GRTS algorithm (Stevens and Olsen 2004) (Figure 1). Cells are sampled in consecutive numerical order from this list, starting with Cell #001. In this example, the first sampling site would be in Cell #001 in the upper right corner of the map (only the first few cells are labeled in these figures). The Site ID is assigned using the four-letter code for the park, the three-digit GRTS order number of the cell, and the letter A to signify the first site within this cell. For example, at Apostle Islands National Lakeshore the Site ID would be APIS001A. We will then continue sampling with Cell #002 and Cell #003, assigning the Site IDs of APIS002A and APIS003A, respectively. When we get to Cell #004, we cannot establish a site because the cell falls entirely over water. If this occurs, or similarly if it falls on private property or another inaccessible area, the cell will be eliminated. Then we will continue with Cell #005 and so on.



Figure 1. Example of a grid system used to place sample locations on the landscape.

Follow the procedure described above when establishing sites for the first time. In subsequent years the same sites are resampled in as close to the same location as possible. However, in rare circumstances it may not be possible to resample the same site, for example if it is flooded or no longer safe to access. In such cases, establish a new replacement site, named with the letter B to signify it is the second site within that cell. For example, if the site in cell #002 could not be sampled in the second year, we would establish a new site using the Site ID APIS002B (Figure 2). In subsequent years, APIS002B would be revisited while APIS002A would be dropped from sampling.

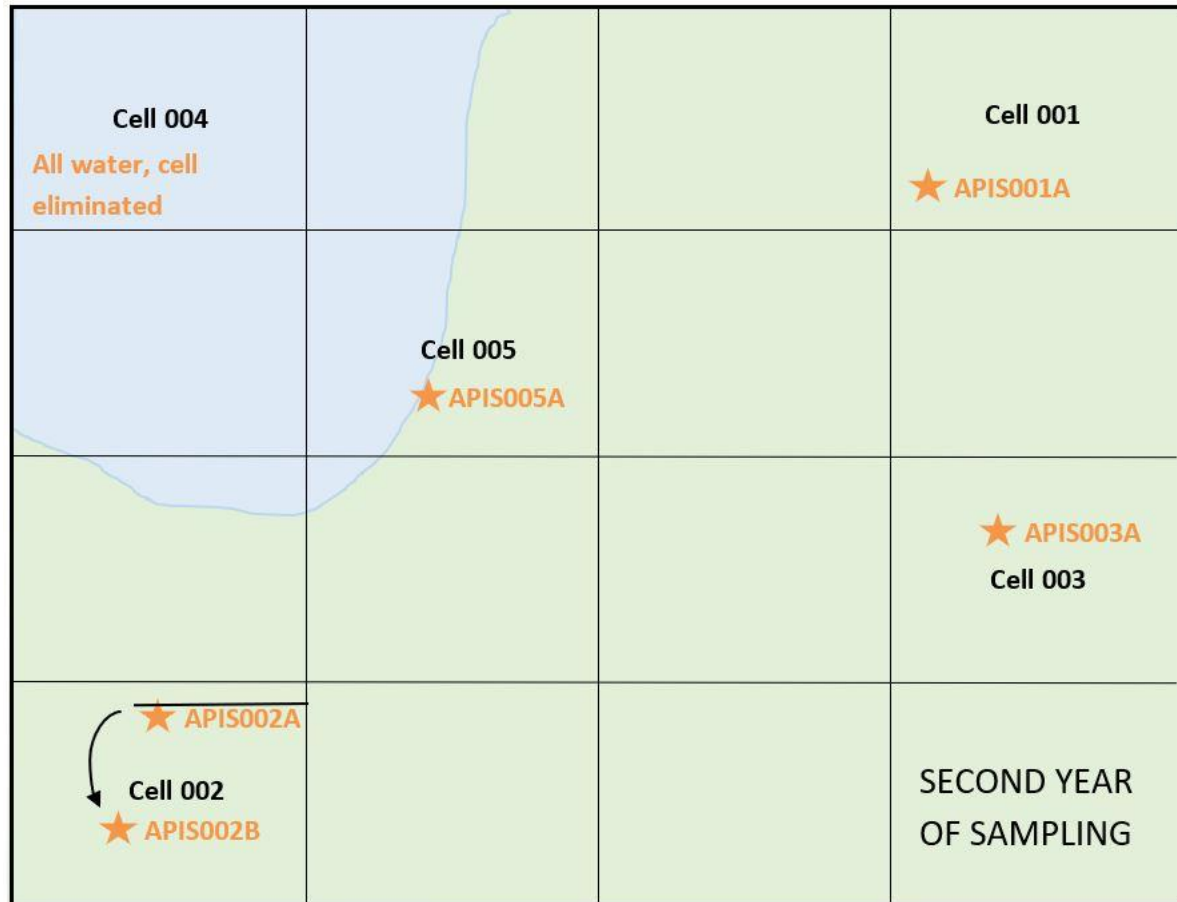


Figure 2. Example of creating a replacement sample location.