



Protocol Implementation Plan for National Parks in the Pacific Northwest: North American Bat Monitoring Program for Surveying Summertime Bat Occurrence with Stationary Deployments of Echolocation Recording Devices

Version 1.0

Natural Resource Report NPS/UCBN/NRR—2024/2639



ON THE COVER

Staff from the Oregon State University-Cascades NW Bat Hub deploy a bat detector in Central Oregon near John Day Fossil Beds National Monument, Oregon.

Oregon State University-Cascades photo used with permission.

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Contents

	Page
Figures.....	vi
Appendices.....	vii
Executive Summary	viii
Target Audience	viii
List of Acronyms.....	ix
USGS-FORT:	ix
Background and Objectives	1
NABat Program	1
Goals and Objectives	1
Monitoring Strategy	3
Sampling Design Overview.....	3
Standard Operating Procedures (SOPs) and Reference Manual	5
Sampling Schedule	5
Sample Units in NPS Parks	6
Idaho Park Units	6
Oregon Park Units	6
Washington Park Units	7
Field Methods	8
Pre-Season Preparations	8
Research Permits	8
Equipment Preparation	8
Training, Calibration, and Consistency	8
Safety.....	9
Locating Survey Sites.....	9
Establishing New Detector Deployment Locations	9
Integrating Local Projects.....	10

Contents (continued)

	Page
Deployment and Data Collection	10
Annual Workload and Field Schedule	10
Field Data Management	11
End of Season	11
Data Management	12
Data Entry	12
Quality Assurance/Quality Control	13
Data Processing	13
Call Auto-Classification and Manual Vetting	13
Databases	13
Local Raw Data	13
NPS Bats Acoustic Survey Database	14
NABat	14
Data Distribution	14
Data Analysis and Reporting	15
Data Analysis and Modeling	15
Data Reporting and Decision Making	15
Protocol Revision	16
Roles and Responsibilities	17
NW Bat Hub	17
NW Bat Hub Steering Committee	18
NW Bat Hub Co-Directors	19
NW Bat Hub Coordinator and Assistant Coordinator	19
NW Bat Hub Data Manager	19
NW Bat Hub Bat Biologist	20
NW Bat Hub Field Crew Leads	20

Contents (continued)

	Page
NW Bat Hub Field Technicians	20
NPS	20
Natural Resources Branch Chiefs/Chief of Resources/Permitters/I&M Program Manager	20
I&M Data Manager	20
Biologists	20
Bio Techs/Interns	20
Interagency Partners and Contributors	21
USGS Statisticians	21
Operational Requirements	22
Facility and Equipment Needs	22
Equipment and Software Procurement	22
Budget	22
Special Considerations	22
Sensitive Locations	22
Literature Cited	23

Figures

	Page
Figure 1. Regional map of the three-state area of NW Bat Hub responsibility with the NPS units and the 30 sample units included in the regional sample.....	4
Figure 2. A workflow schematic that shows the annual cycle of activities that NW Bat Hub and NPS will undertake, collaboratively, with support from the national NABat program in Ft. Collins, CO.	12
Figure 3. An example of annual report content provided by NABat that will be included in a brief annual review of accomplishments and findings provided by the NW Bat Hub to NPS each year.	15
Figure 4. The general organizational structure of NW Bat Hub staff.	18
Figure C1. Map of GRTS sample units at City of Rocks National Reserve.	30
Figure C2. Map of GRTS sample units at Crater Lake National Park.....	31
Figure C3. Map of GRTS sample units at Craters of the Moon National Monument and Preserve.....	32
Figure C4. Map of GRTS sample units at Hagerman Fossil Beds National Monument.	33
Figure C5. Map of GRTS sample units at John Day Fossil Beds National Monument.....	34
Figure C6. Map of GRTS sample units at Lake Roosevelt National Recreation Area.	35
Figure C7. Map of GRTS sample units at Lewis and Clark National Historical Park.....	36
Figure C8. Map of GRTS sample units at Minidoka National Historic Site.....	37
Figure C9. Map of GRTS sample units at Mount Rainier National Park.	38
Figure C10. Map of GRTS sample units at Nez Perce National Historic Park.....	39
Figure C11. Map of GRTS sample units at Northern Cascades National Park and Ross Lake National Recreation Area.	40
Figure C12. Map of GRTS sample units at Olympic National Park.....	41
Figure C13. Map of GRTS sample units at Oregon Cave National Monument and Preserve.....	42
Figure C14. Map of GRTS sample units at Whitman Mission National Historic Site.	43

Appendices

	Page
Appendix A: Glossary of Terms.....	25
Appendix B. List of Monitored Bat Species	29
Appendix C Park Unit Maps with GRTS Sample Units	30

Executive Summary

The Northwestern Hub for Bat Population Research and Monitoring (NW Bat Hub), as part of the North American Bat Monitoring Program (NABat), developed a regional protocol (Rodriguez et al. 2019) to guide multi-agency collaborative implementation of summertime acoustic surveys to track the status and trends of bat populations. See Loeb et al. (2015) and Reichert et al. (2021) for a description of the full NABat plan including winter bat colony counting. The protocol provides guidance specifically for parks in the National Park Service (NPS) North Coast Cascades, Upper Columbia Basin, and Klamath Networks. This protocol implementation plan (PIP) outlines how the protocol will be implemented by NW Bat Hub and National Park staff within this three-network/three-state (Washington, Oregon, Idaho) region. Specific topics for NPS implementation of the protocol that require additional details beyond those outlined by Rodriguez et al. (2019) are the specific NPS requirements for data management, analysis, reporting, and a budget for NPS to contribute to long-term sustainability of the NW Bat Hub and protocol implementation. Surveys will be conducted on and adjacent to NPS lands collaboratively by NPS and NW Bat Hub staff. Roles and responsibilities for protocol implementation will be established prior to each field season depending on staff capacities and interests. This PIP is versionable and it will be updated periodically alongside updates to the protocol itself, and as other operational changes are made. The PIP serves to document why and how NPS will engage as an NABat partner in the Pacific Northwest and with the national NABat program led by US Geological Survey Fort Collins Science Center (USGS-FORT), the role of summertime acoustic monitoring as a way for NPS to meet its vital signs monitoring goals for bats (Garrett et al. 2007), the stewardship of acoustic data by NW Bat Hub and USGS-FORT on behalf of NPS, and the Hub's role as a source of coordinated conservation expertise for NPS and other regional collaborators.

Target Audience

This PIP contains a detailed overview of how the protocol will be used in National Park units in the Pacific Northwest. It is intended for use by NPS and NW Bat Hub coordinators and team leaders, program administrators, field crew leads, and data analysts who need to be conversant in the details of the program. Standard operating procedures that detail the operational-level information can be located in the protocol narrative by Rodriguez et al. (2019).

List of Acronyms

See Appendix A for Glossary of Terms

BatAMP: Bat Acoustic Monitoring Plan

CESU: Cooperative Ecosystem Studies Unit

CONUS: Continental United States

EDA: Exploratory data analysis

FWS: US Fish and Wildlife Service

GRTS: Generalized Random Tessellation Stratified

HERS Lab: Human and Ecosystem Resilience and Sustainability Lab

JHA: Job Hazard Analysis

NABat: North American Bat Monitoring Program

NAS: Network attached storage

NPS: National Park Service

NW Bat Hub: Northwestern Hub for Bat Population Research and Monitoring

ODFW: Oregon Department of Fish & Wildlife

OSU Cascades: Oregon State University-Cascades

PIP: Protocol Implementation Plan

PPE: Personal Protection Equipment

SU: Sample Unit

SOP: Standard Operating Procedure

USGS-FORT: US Geological Survey Fort Collins Science Center

Background and Objectives

Chiroptera (bats) is one of the most speciose and threatened mammalian taxa across the National Park System (Rodhouse et al. 2016). The spread of white-nose syndrome and the expanding footprint of the wind energy industry have presented clear existential threats to many bat populations in the US (O'Shea et al. 2016). Endangered species protections were recently provided or proposed for several previously common and apparently conservation-secure species. Longer-term threats to North American bats include global changes leading to invertebrate declines, drought and aridification, and fire-driven habitat loss (Frick et al. 2019). Monitoring of bat populations for detection of declines and to help guide conservation actions including effectiveness of habitat improvements (e.g., snag and old building retention for summertime bat maternity colonies) is widely recognized as a crucial endeavor by NPS and partners in order to offset bat losses and enhance the resiliency of bat populations.

NABat Program

In 2015, the US Fish and Wildlife Service (FWS) and partners including NPS developed a collaborative plan for NABat to monitor bats across North America (Loeb et al. 2015, Reichert et al. 2021) that created a new opportunity for NPS to contribute to a continental system of information about bat population trends. Implementation of NABat across the Pacific Northwest was catalyzed by collaboration among several federal and state agencies, including NPS, through the creation of the NW Bat Hub housed on the Oregon State University-Cascades (OSU Cascades) campus. The hub concept, described by Reichert et al. (2021), is designed to facilitate NABat implementation and bat conservation activities more generally at regional scales by providing coordination and technical expertise to stakeholders and facilitating top-down and bottom-up information flow (data and guidance). The NW Bat Hub provides economy of scale to NPS and partners which has many benefits.

Goals and Objectives

The goals of the activities outlined in this protocol implementation plan, following the Rodriguez et al. (2019) protocol, are to 1) develop and sustain a high-quality database of species encounter records in the Pacific Northwest, 2) to conduct periodic assessments of extinction and persistence risks of Pacific Northwest bat populations for regional and range-wide conservation decision-making, and 3) contribute monitoring data collected following this protocol annually to the continent-wide NABat Program and data collected outside of the protocol to other bat research and monitoring efforts that arise in future including the Bat Acoustic Monitoring Portal (BatAMP) for study of bat migration.

The NABat plan (Loeb et al. 2015) outlines the general mission, goals, and objectives that guided the development of the Rodriguez et al. (2019) protocol and towards which the activities outlined in this implementation plan are aimed. The specific monitoring objective is to estimate and map at periodic intervals the spatial distribution patterns and changes in distribution patterns over time of bat species using encounter histories made from annual coordinated summertime stationary acoustic surveys conducted within a selection of sample units across the northwestern US. The specific sampling objective is for each monitored species of bat (15 species in the Pacific Northwest), have an 80%

chance (i.e., 20% missed-change error) of having an occupancy-based regional population decline detected, as determined when the upper 95% posterior (credible) interval for the multi-season occupancy model-derived growth rate $\lambda < 1.0$.

More details, conceptual models, and hypotheses about bat population changes can be found in Rodriguez et al. (2019). Recent examples of trend analyses and use of the occupancy model growth rate can be found in Rodhouse et al. (2019) and Udell et al. (2022).

Monitoring Strategy

Sampling Design Overview

The **target populations** for this protocol include the summer (June 1-September 1) populations of bat species, listed in Appendix B, whose ranges include Oregon, Washington, and Idaho. The core focus is on the 15 species that occur across the region. Peripheral species are also of interest but regional rarity will make occupancy analyses less informative due to data sparsity. Note that other analyses such as documenting northward range expansion will be possible.

The **sampling frame** is the regional subset of the continental US (CONUS) NABat grid (Loeb et al. 2015, Talbert and Reichert 2018) comprised of ~7,000 10 km x 10 km **sample units**. These are the units of analysis for modeling bat population status and trends. The **sampling design** is a **spatially-balanced master sample** of the grid that provides a well-dispersed random ordering of all sample units within the region such that any ordered portion (subset) remains well dispersed and statistically robust with respect to the desired scope of inference. The spatial balance of the master sample was achieved with the **Generalized Random Tessellation Stratified** randomization algorithm (GRTS; Stevens and Olsen 2004, Rodhouse et al. 2011, Loeb et al. 2015, Talbert and Reichert 2018). In addition to the random survey, the NABat monitoring program can also accommodate out-of-sample data contributions from sample units that are not strictly in GRTS order. These data can contribute to regional analyses and provide flexibility within the program, allowing participants to survey for bats following the same deployments rules outlined by Rodriguez et al. (2019) in convenient locations (e.g., in co-location with other management activities). These out-of-sample data, referred to as **found data**, may come from NPS units. These found data do not present a worrisome source of spatial bias in the sample as long as they do not overwhelm the core **backbone** randomized sample data. There are strict rules about how much found data is acceptable, but Irvine et al. (2018) examined this with simulation and suggested that found data <30% is unlikely to cause problematic bias, particularly if found data do not introduce outlier conditions. The NW Bat Hub manages the integrity of the sample and must be consulted before adding found data in to the NPS portion of the regional sample.

The minimum target annual **sample size** for this protocol is 180 sample units, divided into ~60 cells per state. To date, achieved sample sizes routinely exceed 200 sample units. There are 30 cells being sampled that overlap with NPS units, comprised of a combination of randomized backbone and found sample units. Additional cells may be added over time but the decision to do so will be made with both the NW Bat Hub and NPS. The current sample of 30 cells being monitored and where they overlap with NPS units are shown in Figure 1. More generally, there are statistical and logistical reasons for the regional target sample size (Banner et al. 2019). This represents ~2.5% of the regional frame which will provide adequate power for detecting occupancy probability declines (Banner et al. 2019) and will provide sufficient flexibility for addressing other kinds of statistical patterns that are relevant to the goals and objectives. Furthermore, this sample size was routinely achieved during several years of pilot testing (Rodriguez 2017, Banner et al. 2018, Irvine et al. 2018). An NPS subset of 30 represents a meaningful contribution to the regional sample from NPS lands, which represent a small proportion of the region.

PNW I & M Units

National Park Service

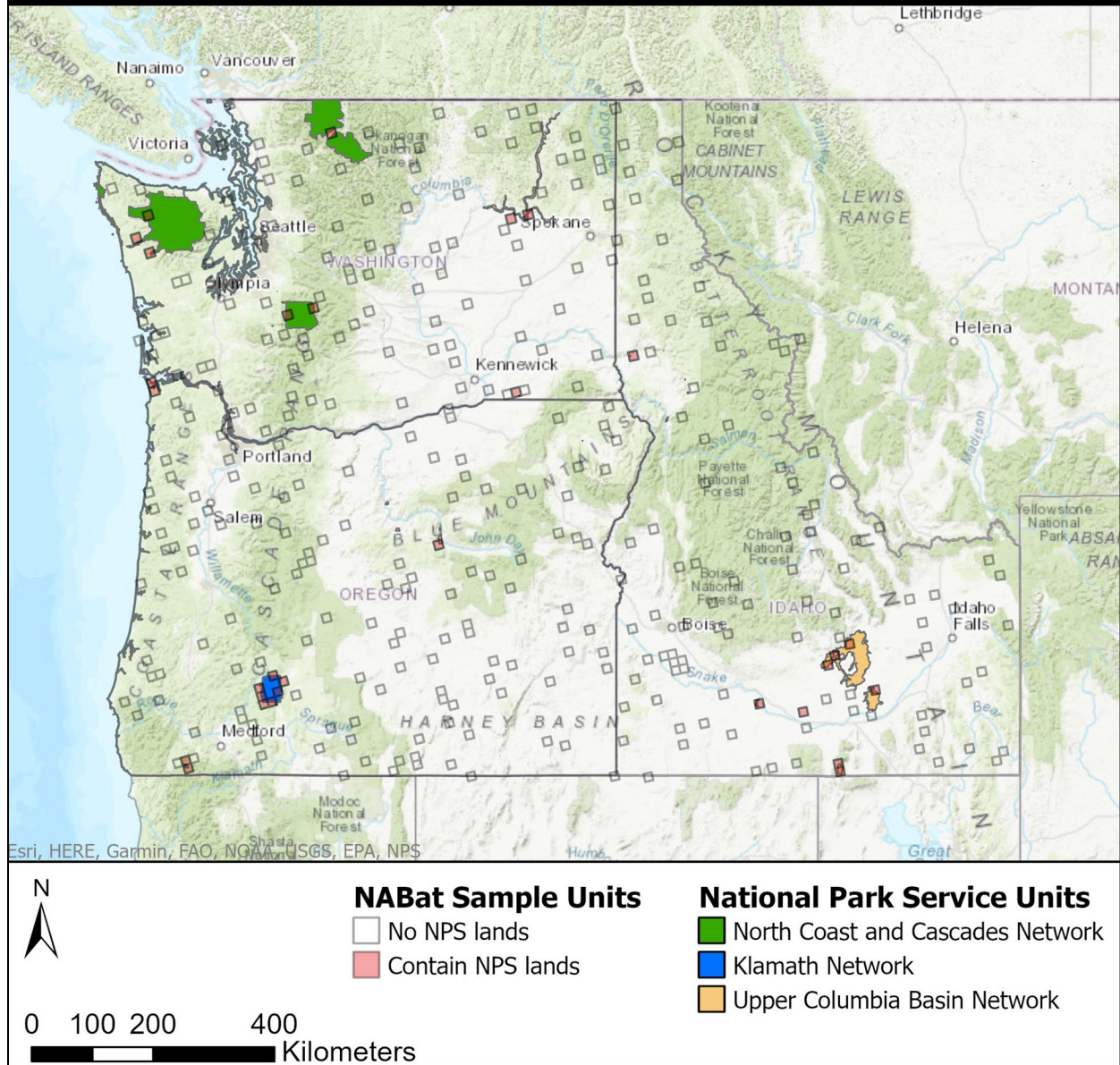


Figure 1. Regional map of the three-state area of NW Bat Hub responsibility with the NPS units and the 30 sample units included in the regional sample.

The **revisit design** for this protocol is for all sample units included in the monitoring program to be surveyed each year, described as an “always revisit” design (Urquhart and Kincaid 1999, McDonald 2003), and which generally confers highest statistical power for detecting temporal trends with statistical models (Urquhart and Kincaid 1999, MacKenzie et al. 2006). The **response (measurement) design** for this protocol will be deployment of **bat detectors** in 4 independent locations (**detector locations** or stations) within each sample unit, each recording free-flying bats over the course of a single night. Locations are placed within each of the 4 grid-cell quadrants, or, when that is not

possible (e.g., due to accessibility constraints), never placed closer together than 1.5 km. The sequence of 4 all-night independent spatial replicate acoustic recording surveys provides the basic single-season **detection history** structure of n rows (e.g., 180) and 4 columns. This structure will enable estimation of **false-negative** and **false-positive detection errors**, although our data management process will pursue removal of false positive errors before modeling following the REMOVE method outlined by Banner et al. (2018), described by Rodriguez et al. (2019) data management and processing and data analysis SOPs.

This is a space-for-time within-season revisit strategy that allows independent single-night replicate survey locations within sample units to represent the larger area for estimating detection probabilities (Kery and Royle 2016:608, Guillera-Aroita 2011, and Srivathsa et al. 2017). This approach differs from Loeb et al. (2015) who proposed each detector record for 4 consecutive nights in order to fit within a typical work week. We found the 4 consecutive nights to be serially autocorrelated and non-independent, and found the single-night approach to be logistically and statistically satisfactory (Wright et al., 2016, Banner et al., 2019, Rodhouse et al. 2019). By reducing the nights per location, we are able to achieve a much larger sample size (more sample units surveyed) by reducing the time spent in each sample unit. Detection probabilities for the majority of the 15 species of bats in the Pacific Northwest have been consistent and sufficient (~40%) with the single-night approach.

Over time, each additional summer season of monitoring will add 4 additional columns so that, after accounting for imperfect detection, the sample unit turnover (i.e., sample unit (re)colonization γ , extinction ϵ , and survival Φ) in occurrence can be estimated.

The inference (analytical) design for this protocol uses a detection history matrix for each bat species with dimensions n rows and $4 \times j$ seasons columns (alternatively $n \times 4 \times j$ array) to fuel a multi-season occupancy model, following methods developed by MacKenzie et al. (2006) and Royle and Dorazio (2008), and NABat-specific advancements by Rodhouse et al. (2015), Wright et al. (2016), Banner et al. (2018), Irvine et al. (2018), Banner et al. (2019), and Rodhouse et al. (2019). Emphasis will be on estimation and mapping of two key parameters, ψ and λ (ψ_T/ψ_{T-t}), derived from the rate parameters γ and ϕ (Banner et al. 2019). Spatial (e.g., mean sample unit forest cover) and temporal (e.g., Julian date of survey night) covariates will be included in both detectability and occurrence probability component models. A formal statistical power analysis for this protocol, including inclusion of several important candidate model covariates (especially % forest cover), was conducted by Banner et al. (2019). We consider this strategy as informative for a baseline level of a richer integrated multi-method (and multiple lines of evidence) conservation science program.

Standard Operating Procedures (SOPs) and Reference Manual

Standard Operating Procedures (SOPs) and a field reference manual are published by NW Bat Hub separately and are available from the NPS Data Store:

<https://irma.nps.gov/DataStore/Reference/Profile/2265548>.

Sampling Schedule

Each summer a target sample of ≥ 180 sample units will be surveyed across the 3-state region. Such a large sample requires the participation of multiple agency partner field contributors in addition to

NW Bat Hub field crews. Typically each state will be surveyed by a single NW Bat Hub two-person team, supplemented by contributions from partners. In National Parks across the region, there are 30 sample units targeted for annual survey (see Appendix C). The NW Bat Hub coordinator will ensure that adequate qualified field personnel are assembled and prepared prior to each field survey event. It is the NW Bat Hub's responsibility to reach out to parks on an annual basis to coordinate activities and park entries and obtain the appropriate research permits (see *Research Permits*). To conduct surveys at backbone sample units in a given state, one Bat Hub crew is required to complete acoustic monitoring surveys at 30-36 sample units within the survey period, which is approximately 2-3 sample units surveyed per week. Thus, six field technicians are needed for the Pacific Northwest. The specific sample schedule for sample units in or adjacent to NPS parks will be set each year, coordinated by the NW Bat Hub in consultation with NPS staff..

Sample Units in NPS Parks

Maps of each park unit with associated target sample units can be found in Appendix C. Note that additional sample units may be added over time and reported in future versions of this plan. NPS staff will communicate to the NW Bat Hub coordinator any changes in capacity to complete surveys each year and the level of field support from Bat Hub crews that are required. A summary of sample units in parks follows. Note that sample unit IDs refer to the 10km CONUS sample unit ID.

Idaho Park Units

City of Rocks National Preserve

2 cells: 91766 and 91303.

Craters of the Moon National Monument and Preserve

4 cells: 97323, 97787, 98252, and 95476.

Hagerman Fossil Beds National Monument

1 cell: 95925.

Minidoka National Historic Site

1 cell: 95004.

Nez Perce National Historical Park

1 cell: 115828.

Oregon Park Units

Crater Lake National Park

7 cells: 103740, 103275, 103278, 102812, 102814, 102349, 102350.

John Day Fossil Beds National Monument

1 cell: 108393.

Lewis and Clark National Historical Park

2 cells: 120867 and 120404.

Oregon Caves National Monument and Preserve

2 cells: 100486 and 100023.

Washington Park Units

Lake Roosevelt National Recreation Area

2 cells: 124152 and 124154.

Mount Rainier National Park

2 cells: 122273 and 122276.

North Cascades National Park and Ross Lake National Recreation Area

1 cell: 130617.

Olympic National Park

3 cells: 129206, 128278, and 127353.

Whitman Mission National Historic Site

1 cell: 115351.

Field Methods

Pre-Season Preparations

Prior to each field season, the NW Bat Hub will coordinate fieldwork schedules with park and Inventory & Monitoring Program (I&M) staff. The fieldwork strategy will be iterative and flexible in response to changing capacities. Much of the success of NABat implementation across the Pacific Northwest stems from a high level of collaboration and sharing of detector equipment and expertise.

Research Permits

Prior to conducting field surveys on NPS lands, research permits will be completed for each park. This helps both the NW Bat Hub and NPS track the progress of the project and makes the work discoverable to other researchers. The application process must be initiated in January through the Research Permit and Reporting System website (<https://irma.nps.gov/rprs/>). Additionally, Bat Hub staff will need to provide advance notice to agency staff and any adjacent landowners of activities and expected survey dates. The goal is to have no surprises when non NPS staff arrive at a park to survey. Note that permits must be completed even when NPS staff are deploying detectors on behalf of the NW Bat Hub. Season closeout reports will be kept short and include references to the more comprehensive NABat annual report. NPS collaborators such as Cooperative Ecosystem Studies Unit (CESU) agreement technical representatives and other key officials will assist with permit requests and related tasks.

Equipment Preparation

Inventories of existing equipment (especially detectors), needed repairs, and construction or purchases of additional equipment will be completed well in advance of the approaching field season. Microphone sensitivity can reduce overtime, thus lowering bat detection probabilities so microphones must be tested regularly. The NW Bat Hub is responsible for this and NPS staff in possession of Bat Hub equipment will communicate directly with the NW Bat Hub coordinator about equipment needs. A list of equipment needed to successfully, safely, and comfortably operate in the field can be found in the field manual and SOP 1 of the protocol.

Detectors break if they are not properly handled and well maintained throughout the field season and during the off-season. Repair of bat detectors can take a substantial amount of time (>3 months) given the limited number of companies able to conduct such repairs. Hence, a detector functionality check will be completed before and immediately after the field season or before transferring shared detectors to another agency.

Training, Calibration, and Consistency

All individuals participating in fieldwork, including NPS staff conducting field surveys, will receive training provided or approved by the NW Bat Hub to ensure successful data collection and to maintain consistency for the NABat effort. The NW Bat Hub will provide coordination and training in accordance with the regional NABat survey protocol (Rodriguez et al. 2019) and the National NABat program. Trained participants will be made knowledgeable with the protocol details, site selection procedures, strategies for troubleshooting challenging deployment locations, detector set up/deployment, detector operation and settings, data collection and data transfer procedures. Quality

assurance and general adherence to the protocol is assessed by NW Bat Hub data management staff through a vetting of survey metadata and inspection of recording log files. Feedback will be provided to deployment staff to correct any errors. An electronic version of the field manual will be distributed prior to the survey season, with updates as needed. As advances in acoustic technologies occur, subsequent guidance from NABat and best practices will be reflected in the field manual to ensure quality of, and consistency in data collection.

While there are no explicit specifications for detector type, direct recording full-spectrum detectors are preferred. The Pettersson D500X and Wildlife Acoustics SM3BAT and SM4BAT are commonly used in the Pacific Northwest. Standard acoustic detector settings as defined by NABat for stationary point surveys must be applied and are outlined in the field manual.

Safety

Safety protocols and procedures are essential for field personnel conducting NABat surveys. Requirements may differ by region and administrative unit; however, a generalized approach is described in the SOP 2: Safety (Rodriguez et al. 2019) that can be modified to fulfill local needs. Prior to, and throughout the season, a thorough understanding and review of Job Hazard Analyses (JHA), communication procedures, and how to respond in case of an emergency must be completed.

Travel to and between sites comprise the majority of survey effort. A proper field vehicle, defensive driving techniques, and good decision making are emphasized during preseason training. Vehicles must also be equipped with a first aid kit and other safety equipment. Field crews may also be required to hike across rugged terrain in variable climates, therefore personal protective equipment (PPE) is mandatory for each field crew member to mitigate exposure to potential hazards.

Locating Survey Sites

The majority of survey sites are well established and clearly marked on the Field Maps application. Some locations will need to be changed as site conditions, access, or landownership change. Sites known to be problematic will be labelled as such in Field Maps.

There are 38 Legacy SUs being surveyed (~20% of the entire sample). Legacy SUs refer to sample units surveyed during the original interagency Bat Grid monitoring program in Oregon and Washington from 2003 to 2010. These sample units were included in the 2016 pilot survey spearheaded by Oregon Department of Fish and Wildlife (ODFW) in order to ensure backward-compatibility between the Bat Grid and NABat. No legacy sample units are included in the NPS sample currently.

Establishing New Detector Deployment Locations

If new detection location are needed in a given SU, Bat Hub staff should be consulted. Survey locations and detection targets will be selected to maximize the number of species expected to occur in an area. Availability of different habitat features will be site-specific, the Bat Hub coordinator can assist with initial selection or use local knowledge of field staff. Locations will require field verification for suitability, ensure they are within the target SU, and one detector location is placed

within each 5 x 5-km quadrant for a total of four per SU. Logistical constraints (e.g., accessibility, land ownership, safety concerns, etc.) that preclude placement of one detector per quadrant, place detectors at least 1.5-km (~1-mi) apart within the target SU. If more than one detector location cannot be established, the SU should be skipped.

Once a station has been established, clutter must be considered when placing the microphone to ensure high quality calls are recorded for species identification. Additional guidance on assessing clutter is provided in the PNW NABat Field Manual and Rodriguez et al (2019). While the intent is to resurvey the same locations each year, changes in habitat features or other conditions may necessitate small adjustments to the detector locations. A detector location moved beyond 50-m from the original location is considered a new location and must be given a new 'Location ID' (i.e., Sample Unit ID + Quad+ Quad Number, 12345_NW1, 2, 3...). Using a geo-referenced map or web map in the field can assist with placement within the target SU.

Integrating Local Projects

Park units have a need to implement local scale monitoring projects, such as determining how bat activity changes in response to a change in habitat. Monitoring for the NABat program can easily be integrated into these local monitoring projects. This can be accomplished by selecting sites that may serve the purposes of both the local project and NABat. For example, monitoring may need to occur at a specific detector location for an entire summer, while for the Pacific Northwest NABat effort only a single night of recording is needed. Alternatively, additional detector locations can be selected in proximity to the detector locations for the local projects to meet the requirements of having four spatial replicates with possibly one detector location in each quadrant of the sample unit. One example of local project integration is the forest thinning project being conducted by the Klamath Inventory and Monitoring Network (KLMN) of the National Park Service in Crater Lake National Park and Lassen Volcanic National Park. KLMN is looking at the effects of forest thinning on bats by quantifying bat activity pre- and post-thinning. The sampling strategy takes advantage of using the same detector location for the thinning-related monitoring and for NABat, while other detector locations are selected to satisfy the NABat effort.

Deployment and Data Collection

Field crews must be familiar with SOP 5: Deploying Detectors prior to starting field activities. Crews will be expected to complete the seasonal, weekly, and daily tasks listed to ensure a successful field season.

Annual Workload and Field Schedule

Bat Hub field crews will begin onboarding and training in late May. A minimum of one week will be spent covering basic bat ecology, detector use, best field practices, safety, navigation, data management, and logistics. Crew leads will be required to attend the full training, but flexibility will be allowed for student technicians to start later to accommodate class schedules.

Data collection will begin on June 1st, or on the first Monday in June if the 1st falls on a weekend. Where field crews are deployed for the first hitch of the season will depend on how many technicians will be able to start on or before June 1st. Once all of the technicians have been on-boarded, each

crew will depart to their respective states. Field hitches will be eight days long, with workdays lasting approximately ten hours. Field housing will be provided for off days.

On the first day, each crew will ensure that their itinerary for the week has been uploaded to Box. The morning will be spent checking weather predictions for the area in which they will be working that week, finalizing planned routes and camping locations, and double checking all field gear. They will then drive to their first SU and deploy four detectors. After deploying the detectors, the crew will establish camp. If they are in a sample unit where the habitat is appropriate for audible bat surveys, they will camp as close to their audible survey locations as possible. Before sunset, each team member will navigate to their respective survey locations. Surveys will end one hour after the end of civil twilight.

For sample units where audible bat surveys are not appropriate, the crews will end their workday once they have set up camp.

On hitch days two through seven, crews will begin their day by breaking down camp and retrieving their detectors. They will then drive to their next sample unit, deploy their detectors, set up camp, copy the previous night's data onto an external hard drive, and again complete audible bat surveys if applicable. On hitch day 8, the crew will break down camp, gather their detectors, and return to their lodging. The remainder of the day will be spent on data management and planning the next hitch. An end of hitch report will be sent to the Bat Hub permanent staff.

NPS field crew NABat work schedules will be much more variable. Field staff must complete surveys for all of their sample units between June 1 and September 1. Regardless of when they complete their surveys, all acoustic data should be copied onto portable storage devices or uploaded to a cloud service immediately after detector retrieval to avoid accidental data loss.

Field Data Management

Field crews will download area maps in Field Maps for collecting data offline. NW Bat Hub field crews will have tablets with mobile data and will sync Field Maps whenever they have a strong enough signal to do so. A final sync will be performed before any area map is deleted to ensure that all points have uploaded correctly.

NW Bat Hub field crews will mail their data to the data manager at the end of each month to avoid potential data loss and stagger the influx of acoustic data.

End of Season

All raw acoustic data, copies of datasheets, and detector location photos will be organized and backed up to large-capacity network attached storage devices (refer to SOP 7 for long-term storage procedures). This includes ensuring all data has been received by agency partners. All data collected must be sent to the NW Bat Hub by September 30th.

Field equipment including detectors must be cleaned, inventoried, and redistributed according to its owner. Any damage should be reported to supervisors immediately and again at the end of the field season.

Data Management

Data Entry

The process begins with two distinct sub-processes or tasks: metadata entry and recordings files management. Metadata is entered into digital data entry platforms via ESRI software (i.e. Field Maps). Field Maps provides field crews with additional mapping and navigation capabilities while collecting data directly within the same application. In the event that some project partners cannot utilize digital data collection, paper data entry forms will be used, scanned and mailed to the NW Bat Hub office for manual entry into the database. To ensure no data are lost due to technological issues in the field, it is recommended that all crews carry copies of the most recent paper forms. The physical recordings files (typically .wav) will be stepwise moved from detectors via portable computer storage devices and internet (cloud) technology. Once assembled, the files and all metadata are packaged into a portable storage drive and shipped to the NW Bat Hub (<https://osucascades.edu/HERS/northwest-bat-hub>) for call processing (Figure 2).

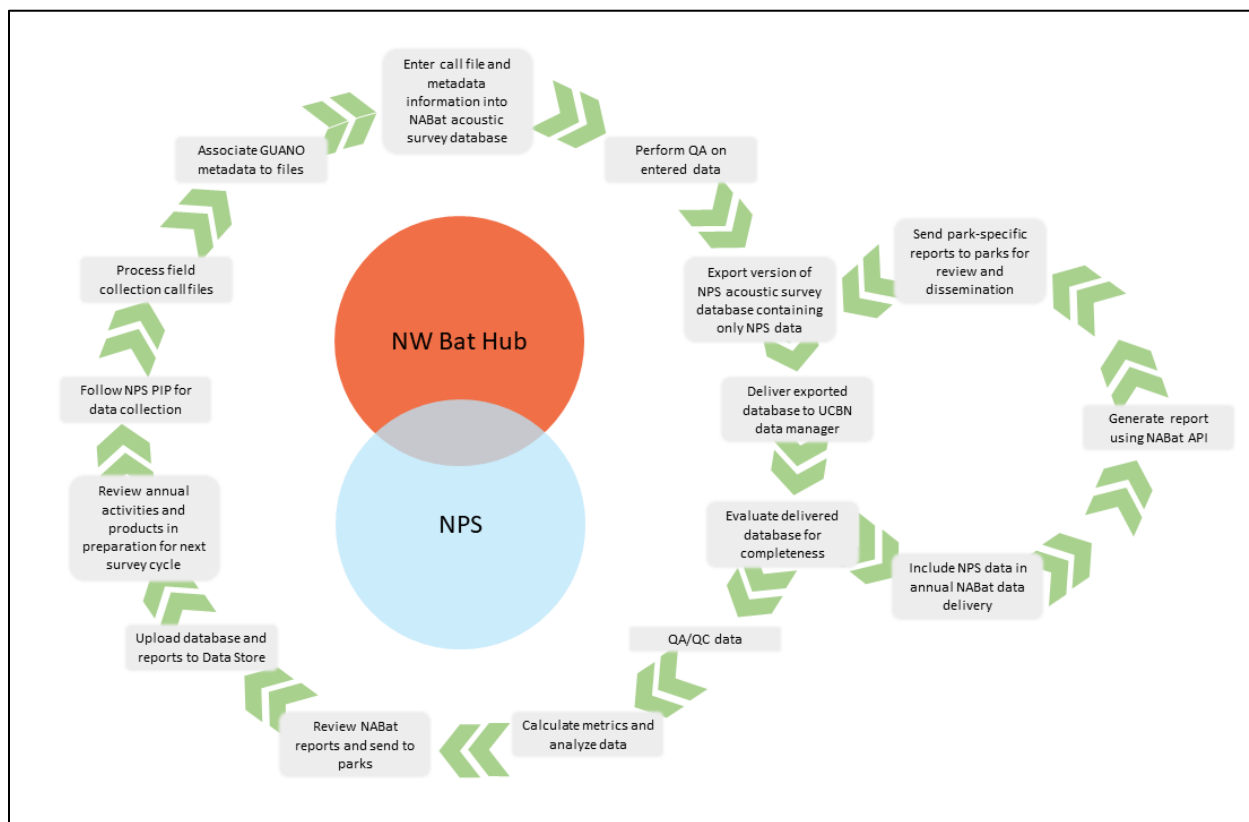


Figure 2. A workflow schematic that shows the annual cycle of activities that NW Bat Hub and NPS will undertake, collaboratively, with support from the national NABat program in Ft. Collins, CO.

This involves scrubbing non-bat files from the directories and attributing metadata to file headers; using software (typically Sonobat) to tentatively assign call files to species; and then using expert manual verification of each species tentatively identified per night per location. Data will be verified before re-distribution to partners, following data sharing agreements. The steps for data verification

are outlined in the data management SOP. Data will also be archived by the UCBN office using the NPS DataStore ([Irma.nps.gov/DataStore](http://irma.nps.gov/DataStore)) to meet data retention and compliance requirements.

Quality Assurance/Quality Control

Prior to processing acoustic data, the Bat Hub institutes a Quality Control protocol that includes spatial, temporal, and qualitative checks to ensure that call files are correctly associated with the corresponding metadata of Station deployment.

Data Processing

The process of analyzing bat echolocation calls involves four main procedures; filtering, attributing, auto-classifying, and manual review. The Bat Hub staff (e.g., Data Manager) are responsible for processing and analyzing call data.

Call Auto-Classification and Manual Vetting

All acoustic data collected is processed via an agreement with the OSU Cascades NW Bat Hub. The processing of all acoustic data is conducted with a suite of application under the Sonobat Bat Call Analysis Software (Arcata, CA, www.sonobat.com) and secondarily, files may be run through Kaleidoscope Pro software to further assist species classification. The general approach is to 1) separate bat call files from non-bat files via scrubbing; 2) attribute bat call files with GUANO metadata that ensure .wav files will always be linked to survey events; 3) auto-classify bat call files to species or species groups; 4) manually verify high-quality species assignments to eliminate false-positive errors using highly experienced observers; 5) organize all recording files into project directories for subsequent management, analysis, sharing and archiving.

A conservative approach is taken in determining the detection of a species at a site. At least one file is classified to species is confirmed via manual vetting per night of a deployment. If a species is manually verified at a site but has not been confirmed within the park or nearby areas, it will not be recorded as confirmed in the published dataset unless multiple experts have reviewed the file in context and all feel confident in the identification. The protocol lead, NW Bat Hub data manager, or similarly experienced person with local knowledge of bat distributions will review all processed data for inconsistencies or outliers. Once data has been reviewed, the NW Bat Hub will upload all data to the NABat data portal and will be considered final. NW Bat Hub will export a subset of these finalized data to the UCBN version of the NPS Bat Acoustic Database that only contain records for within park observations.

Databases

Local Raw Data

Physical storage of .wav recording files is done with large-capacity network attached storage devices (a NAS), with synchronized backups to a secure cloud-based server hosted by Oregon State University. Storage space is modular and can be expanded as needed. The NW Bat Hub also maintains a project Geographic Information System (GIS) to store and manage site and sample unit selection information.

NPS Bats Acoustic Survey Database

The UCBN Bat Monitoring Plan uses a modified version of the NPS Bats Acoustic Survey Database version 1.7 (available at: <https://irma.nps.gov/DataStore/Reference/Profile/2230347>), a Microsoft Access Database (.mdb) that was designed primarily to support NABat-type acoustic surveys and also has been used as a template for the USGS-FORT NABat national support office data management system. This database is used locally at UCBN to store and manage acoustic survey event metadata and processed call file records. All data collected by UCBN staff and contributors from partner organizations and individuals will be consolidated into this database.

NABat

NW Bat Hub staff will upload data collected from this regional program will be contributed to the national NABat central database (USGS-FORT, <https://nabatmonitoring.org>), the BatAMP Portal (<https://batamp.databasin.org/>) and elsewhere (e.g., regional National Forest Service enterprise data system). A detailed user guide (NPS 2016) describes the content and logic of the database.

Data Distribution

The NW Bat Hub and UCBN office provide data management on behalf of the park partners and will not distribute or share location (point coordinates) data publicly except through re-distribution of data via partners. For example, the NW Bat Hub will share verified data to the NABat national support office, which via its data sharing agreements, will release public-facing data as appropriate. Other pathways of non-public distribution will, for example, route subsets of data to regional partner agency points of contact. Analytical products such as distribution maps and public data aggregated to sample units will be published.

Data Analysis and Reporting

Data Analysis and Modeling

Analyses of data for reporting and subsequent conservation assessments and informed decision-making will include basic summaries and maps of species encounters and more involved occupancy modeling. Occupancy modeling is developed for this protocol as the core analytical strategy to support inferences about bat population status and trend as outlined in the monitoring and sampling objectives. However, there will be numerous other kinds of analytical opportunities that emerge from this program over time. The general overview of the analysis and reporting workflow is outlined in the subsequent workflow narrative and in the SOPs.

Data Reporting and Decision Making

Figure 3 outlines the basic workflow for re-distributing data to partners, and providing reports and decision-making support to partners. Iterative exploratory data analysis (EDA) is a valuable tool to identify erroneous data. To ensure the highest quality data are delivered, an established EDA process will use visualization, graphing and scripted queries to identify outlier and illogical data that have made their way through the quality control measures. These data will be vetted, corrected, or removed, and any changes will be thoroughly documented in the verification documents. Translation of the scientific information will be a cooperative process with regional partners facilitated by the NW Bat Hub. Subsets of the accumulated database will be distributed to partners per Bat Hub – partner agency data sharing agreements.

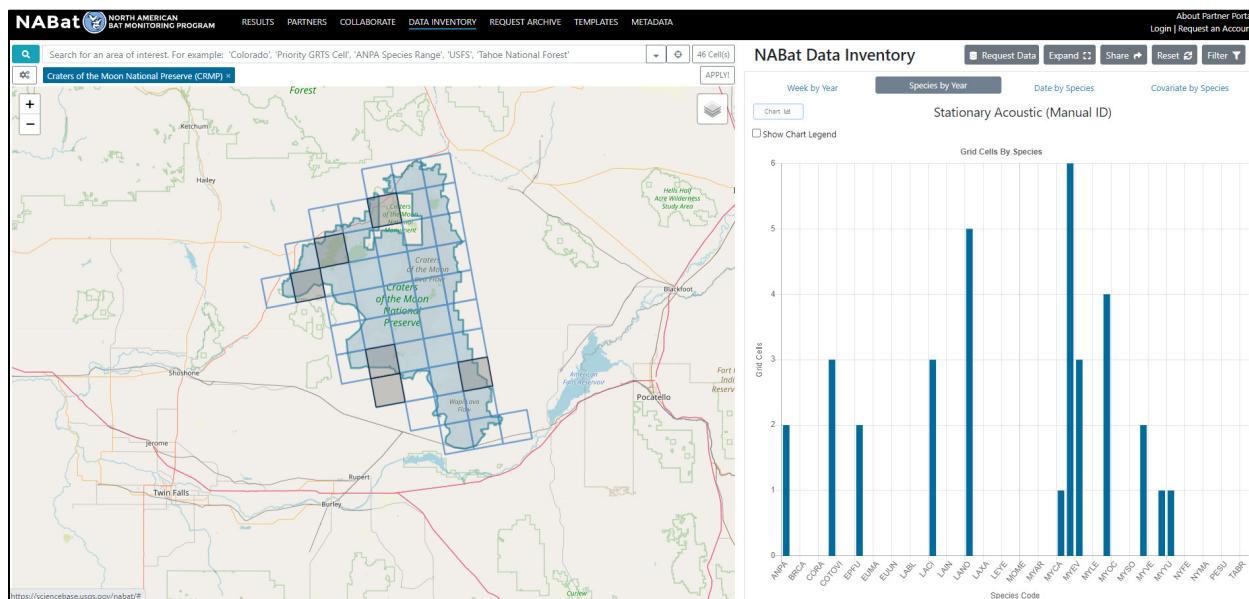


Figure 3. An example of annual report content provided by NABat that will be included in a brief annual review of accomplishments and findings provided by the NW Bat Hub to NPS each year.

Decision-making recommendations and similar translation will occur formally through peer-reviewed manuscripts, reports, and during partner steering committee and *ad hoc* working group

sessions as needed (e.g., to examine analyses of snag density for forest bats with US Forest Service planning teams).

Protocol Revision

The monitoring protocol is an actively evaluated and updated document that reflects the latest procedures of the monitoring program. Revisions are expected, and can involve only minor changes with little overall impact or occasional major revisions and course corrections. Evaluation and revision of the protocol is directed by the Bat Hub coordinator, with support and consultation from the HERS Lab and UCBN I&M team. The narrative as well as each SOP has a change history log whereby changes can be recorded. Older versions of the narrative and SOPs will be archived to ensure proper legacy of past work is maintained. Each revision will require the updating of the version number. Minor changes are recorded as decimal numbers (e.g. 1.0, 1.1, 1.2). Major changes are recorded as a change in the primary number of the protocol version (e.g. 1.0, 2.0, 3.0). In some cases, major revisions to the protocol may prompt the need for additional peer-review. See SOP 11 for detailed information.

Roles and Responsibilities

NW Bat Hub

The NW Bat Hub was established on the OSU Cascades campus within the HERS Lab in 2018 to provide a center of gravity for NABat in the region, as well as to support other kinds of collaborative bat research and monitoring in pursuit of scientifically-robust information about bat population extinction risks and persistence probabilities. The NW Bat Hub website can be found here:

<https://osucascades.edu/HERS/northwestern-bat-hub>.

The NW Bat Hub is more than a brick and mortar entity. Conceptually it is also a collective partnership that enables pooling and leveraging of resources contributed by multiple partners for mutual benefit. However, the NW Bat Hub does employ a small coordination team and field crew, providing the “glue” for the collective partnership. Bat Hub staff leads the direction, development, and implementation of the NABat program in the region, outlined in this protocol (and future protocols, e.g., if colony count surveys are systematically implemented as outlined by Loeb et al. [2015]). Bat Hub field crews ensure that a “backbone” of GRTS-ordered sample units is surveyed each year, augmenting partner field efforts. Importantly, the Bat Hub ensures a high degree of training, consistency, and calibration so that data are of highest quality and compatible for integration into synthesis and reporting.

The NW Bat Hub organizational structure is described in Figure 4:

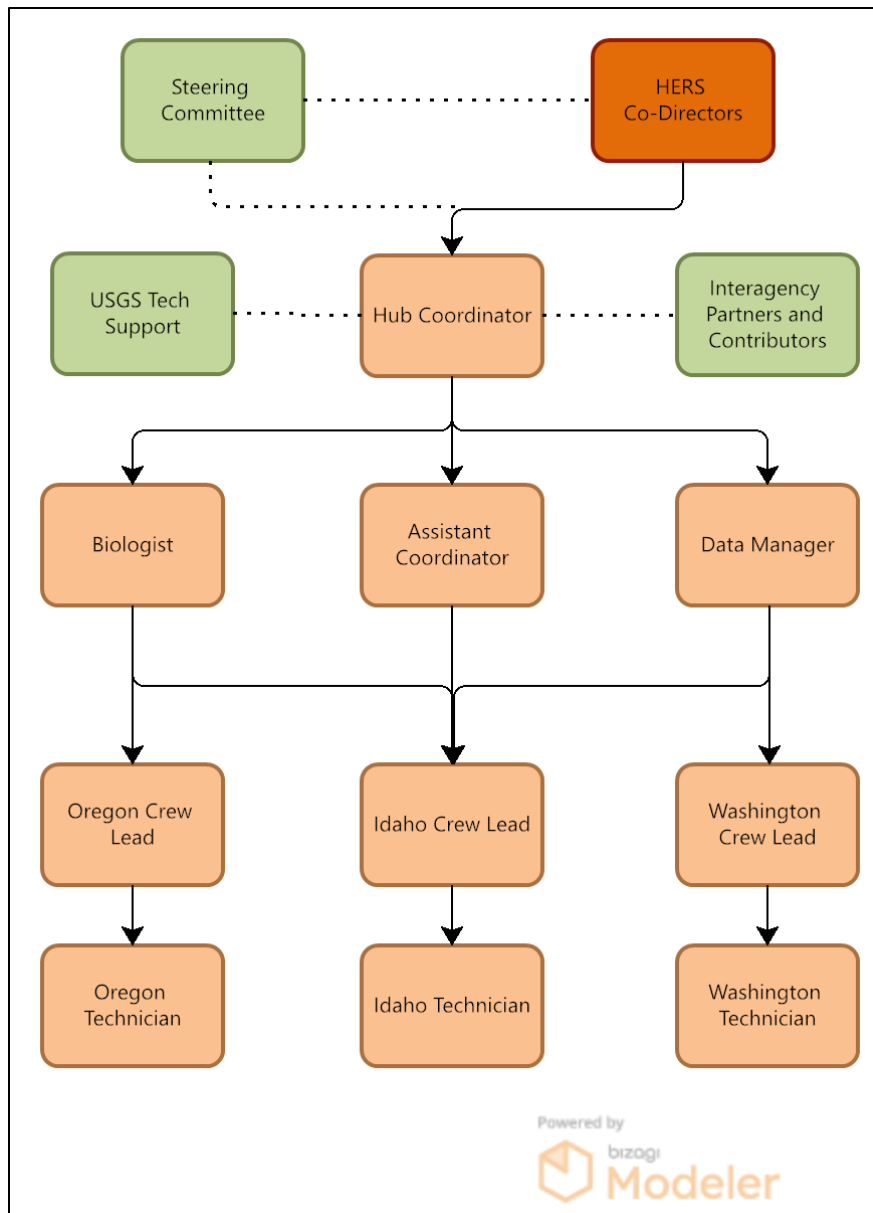


Figure 4. The general organizational structure of NW Bat Hub staff. Note that many essential partners from other organizations, including but not limited to the NABat Coordinating Office at the USGS Fort Collins Science Center, are not shown here. Supervision is illustrated through solid arrows, whereas non-supervisory relationships are shown with dashed lines.

NW Bat Hub Steering Committee

An ad hoc steering committee is comprised of individuals from NW Bat Hub partner organizations including HERS Lab co-directors and the coordinator of the NABat Coordinating Office at USGS-FORT as well as partner agency points of contact from FWS, NPS, US Forest Service, US Bureau of Land Management, and Oregon, Idaho, Washington, and California fish and wildlife agencies. Appropriate individuals from these organizations include those who are actively engaged in the development and implementation of the protocol and who are tasked with regional bat conservation

responsibilities. The committee meets each autumn to review accomplishments and outline and prioritize subsequent efforts. The NW Bat Hub Coordinator maintains regular communication with steering committee members via reports and direct communication.

NW Bat Hub Co-Directors

The HERS Lab and NPS are co-located at OSU Cascades and work together through cooperative agreement to oversee NW Bat Hub operations. The HERS Lab director serves as principal investigator on some agreements and grants. The NPS co-director of the HERS Lab serves as co-principal investigator on some agreements and grants. Other NPS staff, including vital signs monitoring data manager(s) will also provide guidance and support on Bat Hub operations (e.g., data management workflows). Supervision of and administrative support for the NW Bat Hub coordinator and support staff are provided by the HERS Lab director.

NW Bat Hub Coordinator and Assistant Coordinator

The NW Bat Hub coordinator and assistant coordinator develop and implement this protocol, with substantial support from others identified in Figure 4. Coordinator duties, with respect to this protocol, are classified into four broad categories. Project development includes project planning and working with the co-directors and the steering committee on the acquisition and administration of funds. The coordinator may serve as a co-principal investigator on some agreements. Partner interaction involves serving as a liaison to private landowners and tribal, state, and federal agency partners by communicating directly with them on land access, funding, data sharing, and coordination of project logistics. Partner interaction also includes working with the national NABat Coordinating Office on data sharing and quality control (e.g., ensuring methodological compatibility). Project implementation involves managing the day-to-day tasks of the NW Bat Hub. Duties include working with the GIS analyst and data manager on pre-season preparations (e.g., site selection, equipment management) and the full data management process. The coordinator hires, trains, and manages the field crews. The coordinator also interacts constantly with participating partner biologists on the sampling strategy both prior to and during the field season to ensure the target sample size is accomplished. Project dissemination involves communicating the activities and successes of the NW Bat Hub to partners and the general public. This includes producing reports and manuscripts for scientific publications and giving presentations at scientific meetings.

NW Bat Hub Data Manager

The data manager assists the coordinator by managing spatial data and producing maps that facilitate project planning and field implementation, including vetting accessibility of survey event locations via land use and ownership maps. The GIS analyst also supports data collection via mobile data collection applications integrated with the project GIS, that increase efficiencies in data collection and management.

The data manager is also responsible for quality control, both during and after the field season, data organization, and auto-classification of acoustic data. Other duties include developing efficient workflow routines, modifying databases (e.g., queries and reports), computing basic summaries and maps, and contributing to reports and publications. The data manager will assist in training of field crews and Bat Hub partner data contributors in data management tasks.

NW Bat Hub Bat Biologist

The bat biologist is responsible for the bulk of call vetting for all NABat data submitted to the NW Bat Hub. This requires the biologist to be recruited and retained that have demonstrated expertise in bat echolocation recording and call recognition. The bat biologist is also tasked with writing reports and publications, communicating with agency partners and working cooperatively with other Bat Hub staff to ensure successful implementation of field surveys.

NW Bat Hub Field Crew Leads

The field crew lead is responsible for working with the Bat Hub staff on successful implementation of field surveys, including the implementation of workflows outlined in this protocol and quality assurance and control steps. Field crew leads will begin prior to field season to assist with pre-season preparations. Field crew leads direct day-to-day operations of the two-person field crew in remote settings and shoulder considerable responsibilities for crew safety, property management, and data management and quality control.

NW Bat Hub Field Technicians

Field technicians support the crew lead with all duties associated with successful implementation of field surveys within their assigned state including crew safety, navigation to and from survey event locations, maintenance of equipment, landowner contacts, and data quality control.

NPS

Natural Resources Branch Chiefs/Chief of Resources/Permitters/I&M Program Manager

Within each park, appropriate staff will issue all necessary permits for stationary acoustic monitoring taking place within the park. This includes parks where Bat Hub staff will carry out the surveys as well as in instances where park field staff will conduct the surveys.

I&M Data Manager

The UCBN data manager will evaluate the database delivered by the NW Bat Hub for completeness, perform quality control checks, and calculate data metrics. They will also be responsible for reviewing the NABat reports completed by the NW Bat Hub, uploading them to the Data Store, and distributing them to each park. GIS support will be provided by the NPS data manager or delegate to NW Bat Hub staff as needed.

Biologists

Park and I&M biologists and other staff (e.g. I&M ecologist) will oversee the implementation of stationary acoustic monitoring within the sample unit(s) assigned to their park. This includes, but is not necessarily limited to, training field staff in proper detector setup and positioning, scheduling surveys during a period of favorable weather, and providing staff with all necessary materials including detectors and ancillary equipment, maps, and digital datasheets.

Bio Techs/Interns

The field crew is responsible for working under the supervision of park biologists to ensure successful implementation of field surveys, including the implementation of workflows outlined in this protocol and quality assurance and control steps. Park field crews will carry out all duties associated with successful implementation of field surveys within their park's sample unit(s)

including ensuring crew safety, navigation to and from survey event locations, maintenance of equipment, landowner contacts, and data quality control.

Interagency Partners and Contributors

Contributors to the implementation of this protocol include unaffiliated community members as well as biologists from state, federal, and tribal agency partner organizations. This broad base of partner support and involvement is a critical aspect of this coordinated monitoring program. The NW Bat Hub, as conceived, is more than a brick and mortar lab with small staff but also includes the broad regional partnership. This partnership ensures relevancy of the program, and broadly distributes the costs so that no one entity must bear too much load. Contribution from partners comes in the form of financial support to the NW Bat Hub staff via cooperative agreements and contracts as well as in the form of field survey data contribution. Some partners also contribute skills and services for data management, analysis, and reporting.

USGS Statisticians

Statisticians in the USGS Northern Rocky Mountain Science Center, supported by NW Bat Hub partner funds, provide statistical support for routine reporting and analyses as well as for outstanding research and methods development needs. This relationship was established for the Pacific Northwest during the era of the interagency Bat Grid (circa 2010). The NABat Coordinating Office at USGS Fort Collins Science Center provides data management support and ultimately is responsible for top-down continent-wide coordination and communication between NW Bat Hub and other regional hubs and teams that are providing intermediate-level infrastructure. Importantly, the NW Bat Hub and other hubs and regional teams will provide the data conduit between ground-level activities and national/international data delivery and information delivery.

Operational Requirements

Facility and Equipment Needs

A list of necessary and recommended field sampling equipment is given in SOP 1 of Rodriguez et al. A vehicle is required for transportation of field crews from field offices to detector locations. The recommended vehicle size is a 1/2 or 1/4 ton 4-wheel drive truck for each two-person team, personal gear, and detector equipment. For Bat Hub field crews, vehicles must be reserved well in advance (~early fall of the previous year) through Oregon State University's (OSU) Motor Pool. Each field crew member will need to complete and submit OSU's driver authorization form prior to operating any OSU-owned vehicle. A temporary field office will be established for each state's field crew to serve as a home base where administrative and personal activities can be conducted during off-duty periods. Multiple strategically-placed, field offices can increase efficiencies in the fieldwork and provide cost-savings to the overall project. When field crews are deployed away from field offices, they will be camping at facilities as close to the work area as possible. The Bat Hub Coordinator and Assistant Coordinator will coordinate equipment and housing logistics well in advance of the beginning of the field season.

Equipment and Software Procurement

The NW Bat Hub provides guidance on all stationary acoustic monitoring equipment purchases for NPS staff. NPS will collaborate with the Bat Hub Coordinator to discuss equipment and software needs.

Budget

The economy of scale created through the collaborative model of the NW Bat Hub, and NABat more broadly, distributes the burden of costs among partners such that no one entity has to carry too much. Over time, efficiencies have allowed the average cost per sample unit to decrease by ~30%. An ~\$1800 cost per sample unit budget, totaling \$54,000/year distributed as \$18,000 per NPS Network (UCBN, NCCN, KLMN), is the target minimum amount required for the NPS to contribute equitably to the NW Bat Hub. These funds will be acquired through NPS appropriations annually to Network I&M Division and park operations. Additional funds may be acquired through other programs as needed to augment and pursue special projects as partners and Hub staff identify needs.

Special Considerations

Sensitive Locations

Some detector locations may include sensitive or protected features such as caves, threatened or endangered species, and cultural resources. These detector locations are buffered (i.e. coordinates removed, rounded to contain fewer significant digits, or substituted with the centroid of the sample unit) when shared in a publicly accessible format to keep locational information confidential.

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Appendix A: Glossary of Terms

Backbone sample: The term “backbone” is used to describe the core target sample size that is prioritized within the region for annual surveys, following as closely as possible the spatially-balanced randomization order of the NABat master sample. The backbone sample, if achieved routinely, will ensure a representative sample and scope of inference, allowing an additional percentage (<30% of the backbone) of non-probability data contributions (found or legacy) from partners. In general, the backbone will be the responsibility of NW Bat Hub field crews, although partners distributed throughout the region will also be assigned sample units (cells) from the backbone list as well.

Bat call: A sequence of pulsed vocalizations produced by an echolocating bat typically lasting several milliseconds to seconds. Calls are typically recorded and stored as distinct audio (e.g., .wav) files and used to identify bat species presence and activity patterns. Calls can be comprised of different kinds of individual vocalization, including those used for social purposes or when foraging (e.g., feeding “buzzes”) and navigating (e.g., search-phase calls).

Clutter: Physical objects (e.g., tree branches, leaves, water surfaces, and cliff faces) that cause bats to alter their calling behavior and that create echoes of bat calls which alter the characteristics (i.e., time, frequency, and amplitude) of recorded calls and degrade the quality and identifiability of bat call recordings. Bats alter echolocation call properties and call sequence patterns in response to clutter in order to orient around and avoid collisions with these objects. These altered clutter-type echolocation calls differ from search-phase calls produced in un-cluttered environments that are more distinctive among species. The degree of clutter in an area signifies how readily species may be identified from their echolocation calls. Depending on the degree of clutter present, factors such as appropriate detector placement play an important role in recording bat calls that can be classified to species. Clutter can also be used as a detection-level covariate in occupancy models.

Detectability: The probability that animals are observed or recorded during the survey when present. A fundamental assumption in surveys that do not account for imperfect detection is that detectability is 100% or, if <100%, always the same over time and space. Given the implausibility of this assumption, standard practice is to estimate and account for imperfect detection during analyses, as is outlined in this protocol.

Detector locations: The point locations where bat detectors are placed within grid-cell sample units, as defined and mapped by UTM or latitude/longitude coordinates. Single-night recording at detector locations provides the spatial within-season replication needed to estimate detectability. Note we do not refer to these as “sites” to avoid confusion with usage in the occupancy modeling literature, although in common parlance detector locations will sometimes be referred to as sites (e.g., in the NABat online database and data entry tools www.nabatmonitoring.org).

Design weight: In statistical sampling, the sample design weight is the inverse of the sample inclusion probability. The design weight formally describes the amount of inferential information of each sample unit. For example, when sample sizes are small relative to a large sample frame (area of

inference), weights become larger because each sample unit represents a larger proportion of the sampling frame (i.e., it “carries more weight”).

Data contributed outside of the probability sample (e.g., because of proximity to duty station, for convenience) will typically be assigned a design weight of 1 because probability of inclusion is 100%. Data collected probabilistically following the ordered-list of the randomized master sample will have much large weights because of their inferential scope. These weights can be re-scaled for computational convenience during analyses.

Found data: Data provided by contributors collected concurrent to NABat but outside of the formal NABat sampling design. Legacy data differs from found data in that it predates the implementation of NABat. In reference to the Pacific Northwest NABat effort, found data refers to data acquired at sample units selected according to the legacy Bat Grid and local projects that do not follow the NABat randomization (GRTS master sample) but that utilize methods outlined in this protocol and are therefore compatible (in response design) to roll up in NABat analyses. Design weights can be used to account for the variable inclusion probabilities from the suite of legacy, found, and probability data contributions.

Generalized Random Tessellation Stratified (GRTS) design: A probabilistic randomization utilized by the NABat program sampling design that provides a spatially-balanced ordered list of sample units (10-km by 10-km), each with the unique property that any ordered subset of the list will also be spatially-balanced.

The GRTS ordering has been applied exhaustively to the entire list of all sample units in the sampling frame, creating a master sample from which subpopulations (subsets) can be identified and surveyed with varying sampling intensities (sample sizes can vary by subset) as logistics and available resources permit. The GRTS rank order number is stored under the field heading `GRTS_ID`.

Grid(s): There are six grid-based sampling frames, or grids, in use with NABat. The continental US grid, referred to as CONUS, encompasses the Pacific Northwest. (Talbert and Reichert 2018, available for download <https://www.sciencebase.gov/catalog/item/get/5b7aec2ce4b0f5d578845c90>).

Inclusion probability: In statistical sampling, the inclusion probability defines the likelihood of selecting a specific sample unit (e.g., a 10-km by 10-km area) from a random sampling draw.

Inclusion probabilities are very small (~ 0) when the total sample size is very small relative to the size of the sampling frame. Inclusion probabilities are 1 (100 % certainty of being included) when a nonprobability sampling scheme (e.g., purposive sampling) is used because only those units chosen for survey are included for consideration. Inclusion probabilities or their inverse, design weights, are used in analyses to properly scale the relative importance or contributions of data from each sample unit.

Master sample: The comprehensive list of all sample units within the sampling frame that is randomized and spatially-balanced following a GRTS draw. A single master sample was produced for each sampling frame portion of NABat (Continental United States, Canada, Alaska, Hawaii,

Mexico, and Puerto Rico), allowing all contributing partners (e.g., nations, states, and provinces) to sample from their portion of the master sample list. The Pacific Northwest encompasses a distinct subpopulation (subset) of the Continental US (CONUS) portion of the NABat sampling frame that is addressed by this protocol.

North American Bat Monitoring Program (NABat): A continental-wide program to monitor bats at local to range-wide scales that will provide reliable data to inform effective conservation and long term viability of bat populations across the continent.

Northwest Bat Hub (NW Bat Hub): The Northwestern Hub for Bat Population Research and Monitoring was established by interagency partners on the Oregon State University-Cascades campus to develop, coordinate, and implement this protocol, as well as other related research and monitoring activities prioritized by the partners. The NW Bat Hub represents a collective economy of scale whereby partners pool funds and leverage resources and expertise for broad, regional mutual benefit.

Non-probability: A statistical method of sampling from a definable domain that does not use randomization and does not allow for sample units to be assigned inclusion probabilities. Nonprobability samples are at much greater risk than probability samples of providing data that are not representative of the target population. Found and legacy data are typically non-probabilistic, although in the case of interagency Bat Grid legacy units, randomization was employed.

Occupancy model: The occupancy model is a statistical model that hierarchically fits logistic regression equations to encounter survey data to estimate the probability of detecting survey targets (e.g., bats) when present, and, conditional on detection probability, then estimates the probability of site or survey unit occurrence by the target organism. Occupancy probabilities and occupancy turnover probabilities (e.g., survey units transitioning occupied to unoccupied and vice versa from one year to the next) are useful parameters for conservation decision-making that directly reflects changes in population distributions and indirectly reflects changes in population abundances.

Probability sample: A statistical method of sampling from a defined domain, typically described by a sampling frame that uses a randomization process to select sample units for survey with each unit having a known selection probability. Simple random sampling is a common equal-probability sampling strategy. The GRTS algorithm provides for a more complex, but flexible, way to draw equal- or unequal probability samples from a sampling frame of sample units.

Sample unit: The individual members of a statistically defined population that is being sampled and that defines the units of analyses and the resolution (grain size) of inference. For NABat, sample units are the 10 km x 10 km areas from the grid-based sampling frame. The sample unit unique identifier system is a 6 or 7-digit numeric code for each sample unit that was established when the frames were established. The field heading for this identifier is CONUS_10KM. Note that in the

occupancy modeling literature, the sample unit is also referred to as the “site”. Therefore, we use the term “site” as synonymous with grid-cell sample unit and refer to the point locations where detectors are placed within sample units as “detector locations” and/or “stations”.

Sampling frame: A sampling frame is a statistical tool for defining the target population from which a survey sample is drawn. Sampling frames are typically finite (e.g., a list of lakes for water quality study), but can also be infinite (e.g., the infinite number of points within a polygon of interest on a map). The grid-based sampling frame of NABat is finite, allowing for the entire set of all 10- by 10-km grid sample units to be organized into a spatially balanced list and assigned inclusion probabilities. For the Pacific Northwest, the sampling frame includes the regional subset of the NABat CONUS grid which is comprised of 7,743 10 km x 10 km sample units (see Figure 1).

Site: See detector locations.

Stationary deployments: Acoustic surveys conducted at a particular location on the landscape for a single night during the period of 1 June to 1 September and revisited every year. Note this differs from the proposal by Loeb et al. (2015), but see the narrative text for a description of supporting statistical tests and justification (i.e., Wright et al., 2016 and Banner et al., 2019). NABat participants outside of the Pacific Northwestern US should consult with the NABat Coordinating Office before implementing any modifications to the Loeb et al. (2015) plan, which suggested that deployments last for four consecutive nights per location.

Stations: See detector locations.

Target population(s): The statistical population about which formal inference is desired, in this case the summer biological populations of bat species that have geographic ranges that overlap the Pacific Northwest. Currently, there are 15 species in common across the entire region, plus several species that range into the southern portion of the region.

Appendix B. List of Monitored Bat Species

Table B1. List of monitored bat species. An “X” indicates that bat species is monitored in that state.

Species Name	Common Name	State		
		OR	WA	ID
<i>Antrozous pallidus</i>	pallid bat	X	X	X
<i>Corynorhinus townsendii</i>	Townsend's big-eared bat	X	X	X
<i>Eptesicus fuscus</i>	big brown bat	X	X	X
<i>Euderma maculatum</i>	spotted bat	X	X	X
<i>Eumops perotis</i>	western mastiff bat	—	—	—
<i>Lasionycteris noctivagans</i>	silver-haired bat	X	X	X
<i>Lasiurus blossevillei</i>	western red bat	—	—	—
<i>Lasiurus cinereus</i>	hoary bat	X	X	X
<i>Myotis californicus</i>	California myotis	X	X	X
<i>Myotis ciliolabrum</i>	western small-footed myotis	X	X	X
<i>Myotis evotis</i>	western long-eared myotis	X	X	X
<i>Myotis keenii</i> *	Keen's myotis	—	X	—
<i>Myotis lucifugus</i>	little brown bat	X	X	X
<i>Myotis thysanodes</i>	fringed myotis	X	X	X
<i>Myotis volans</i>	long-legged myotis	X	X	X
<i>Myotis yumanensis</i>	Yuma myotis	X	X	X
<i>Parastrellus hesperus</i>	canyon bat	X	X	X
<i>Tadarida brasiliensis</i>	Mexican free-tailed bat	X	—	X

* According to Lausen et al. (2018), *Myotis keenii* should not be considered a species distinct from *Myotis evotis*.

Appendix C Park Unit Maps with GRTS Sample Units

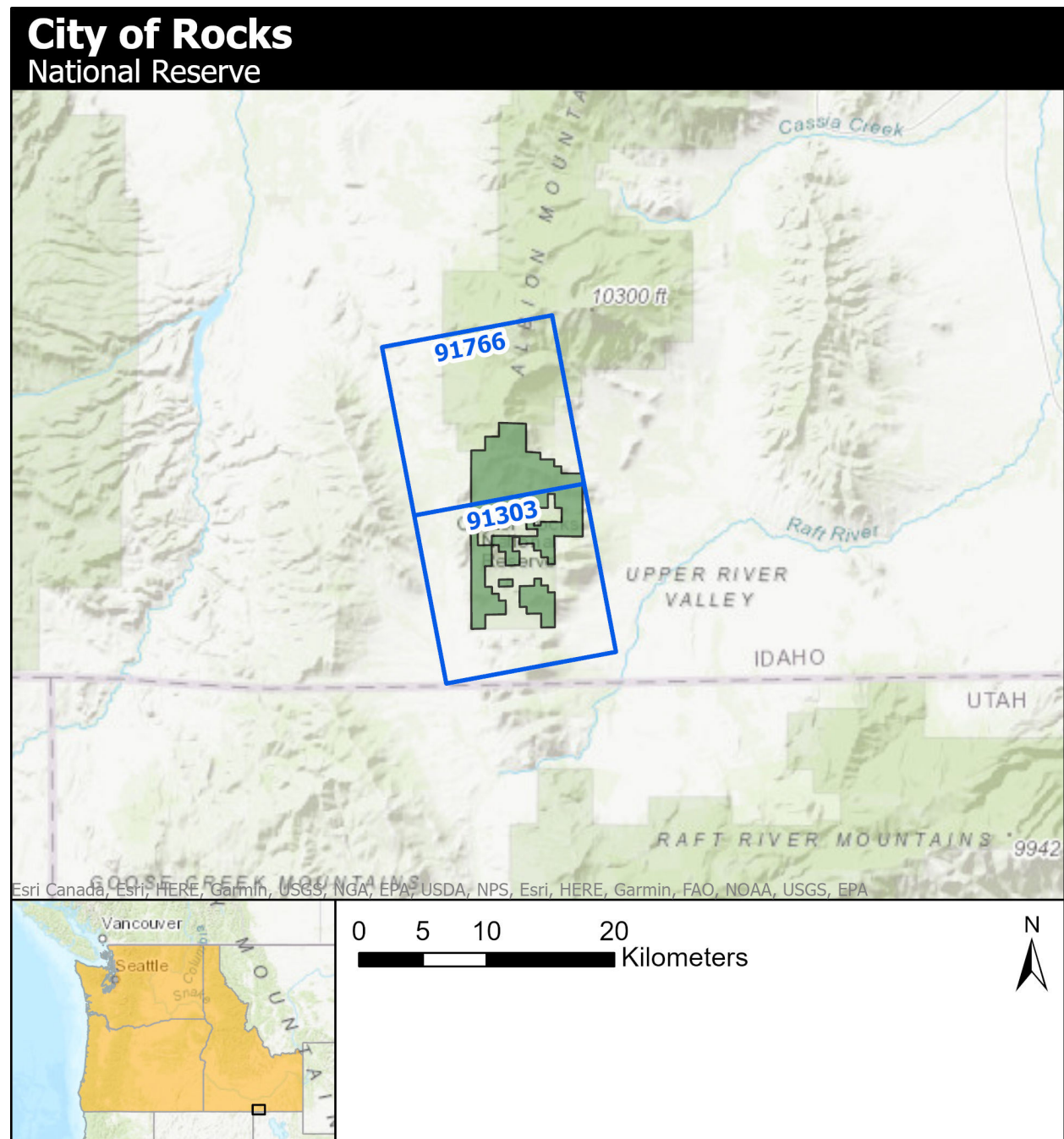


Figure C1. Map of GRTS sample units at City of Rocks National Reserve.

Crater Lake National Park

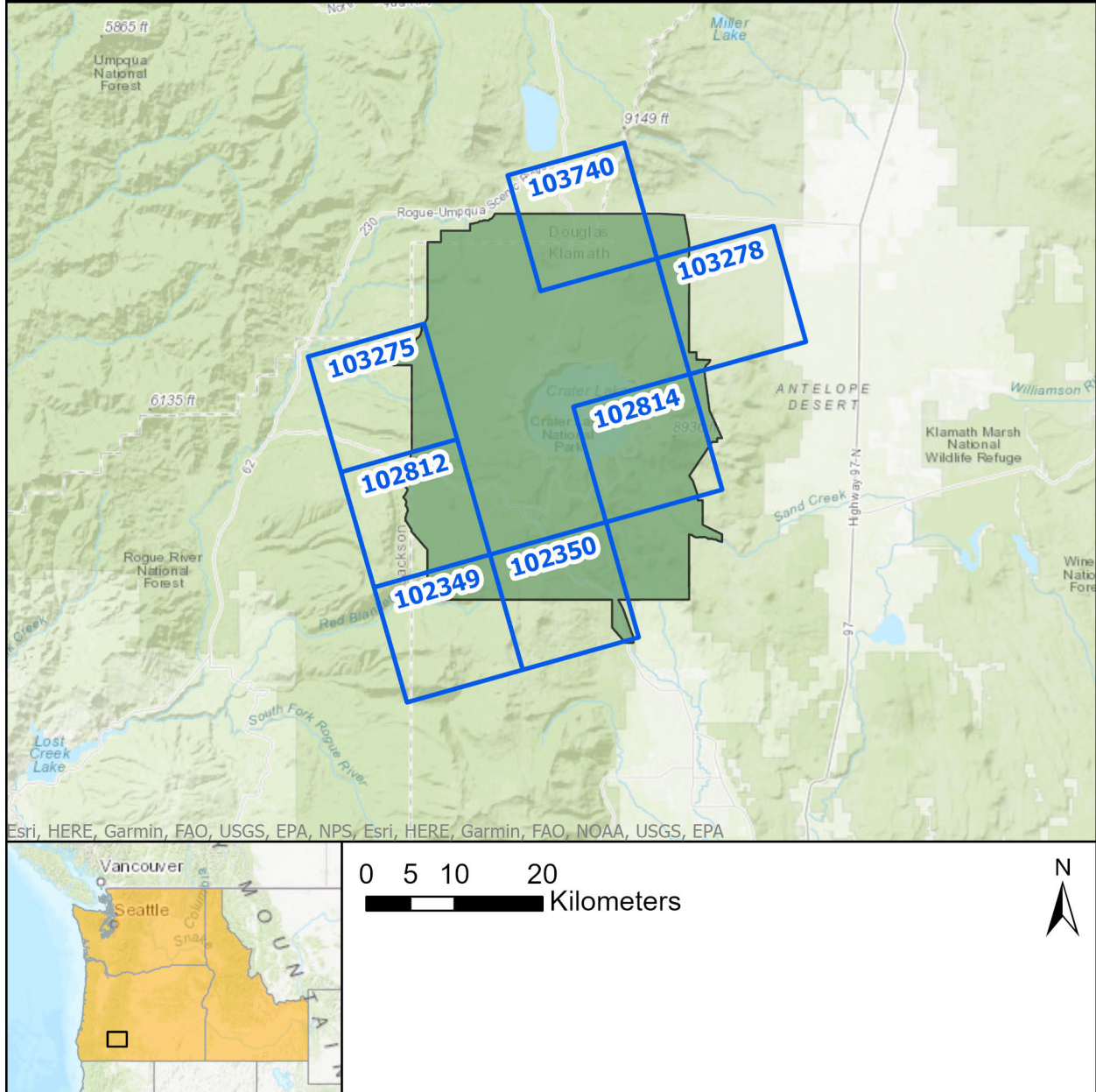


Figure C2. Map of GRTS sample units at Crater Lake National Park.

Craters of the Moon National Monument and Preserve

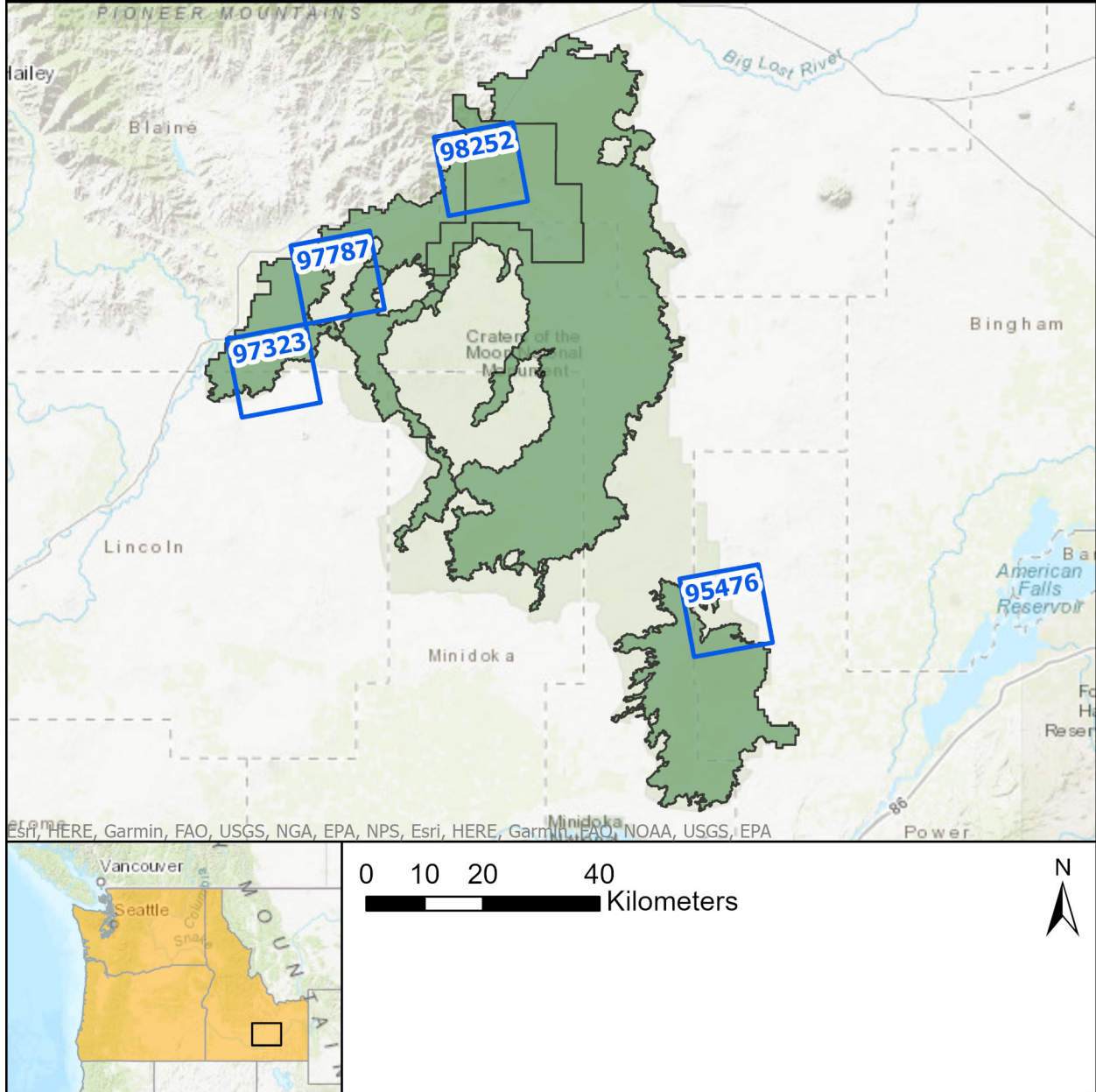


Figure C3. Map of GRTS sample units at Craters of the Moon National Monument and Preserve.

Hagerman Fossil Beds National Monument

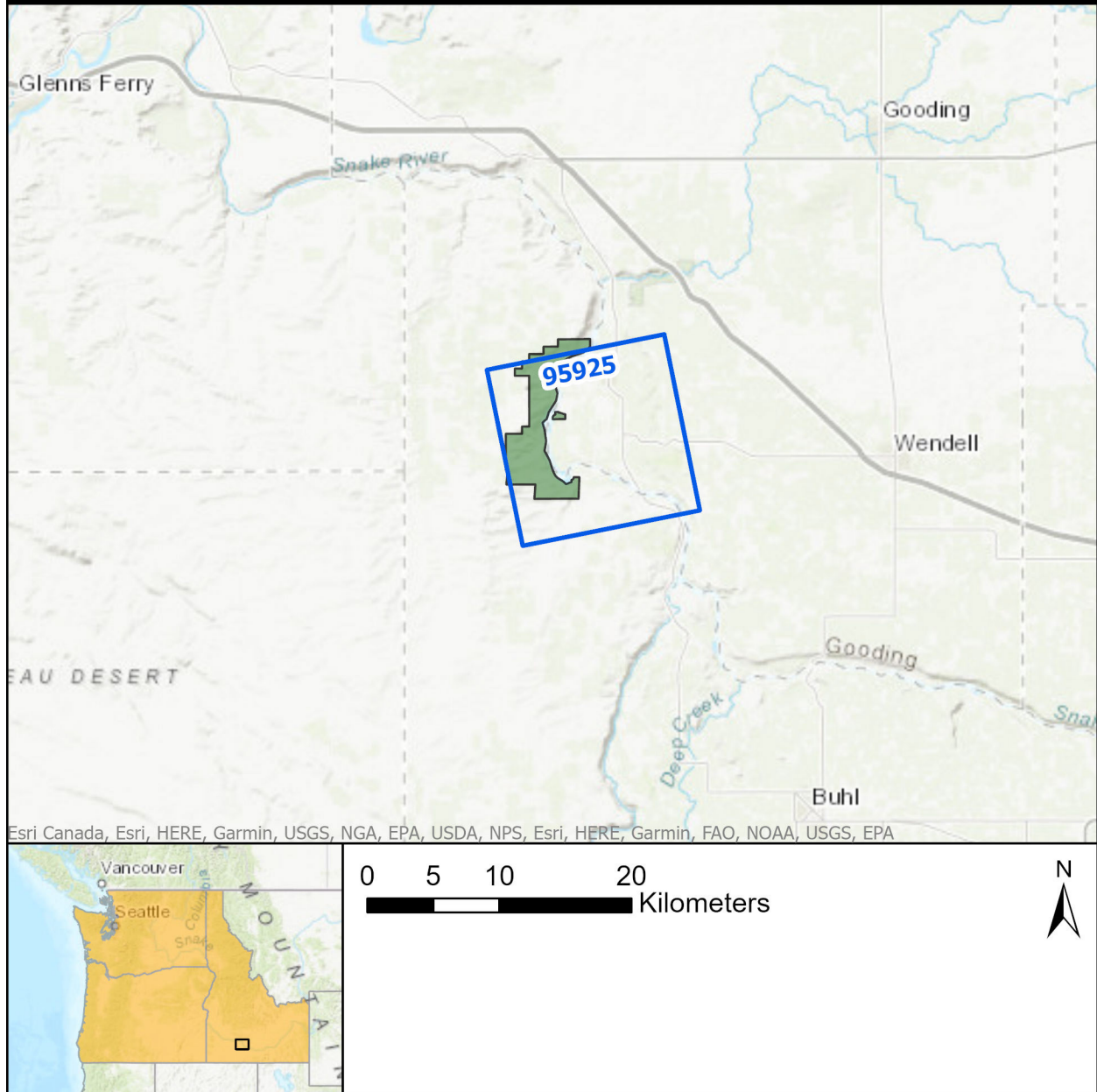


Figure C4. Map of GRTS sample units at Hagerman Fossil Beds National Monument.

John Day Fossil Beds National Monument

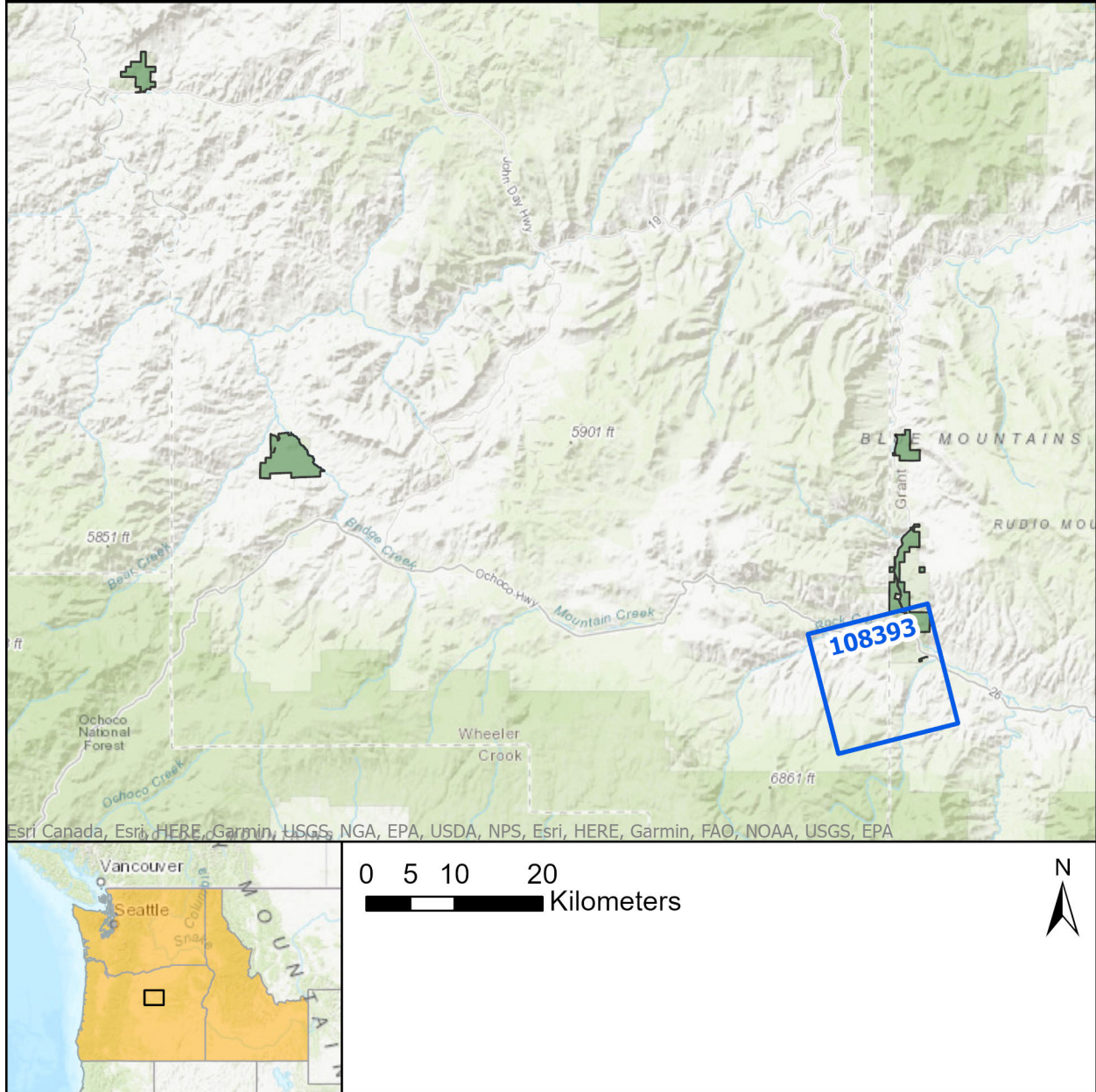


Figure C5. Map of GRTS sample units at John Day Fossil Beds National Monument.

Lake Roosevelt National Recreation Area

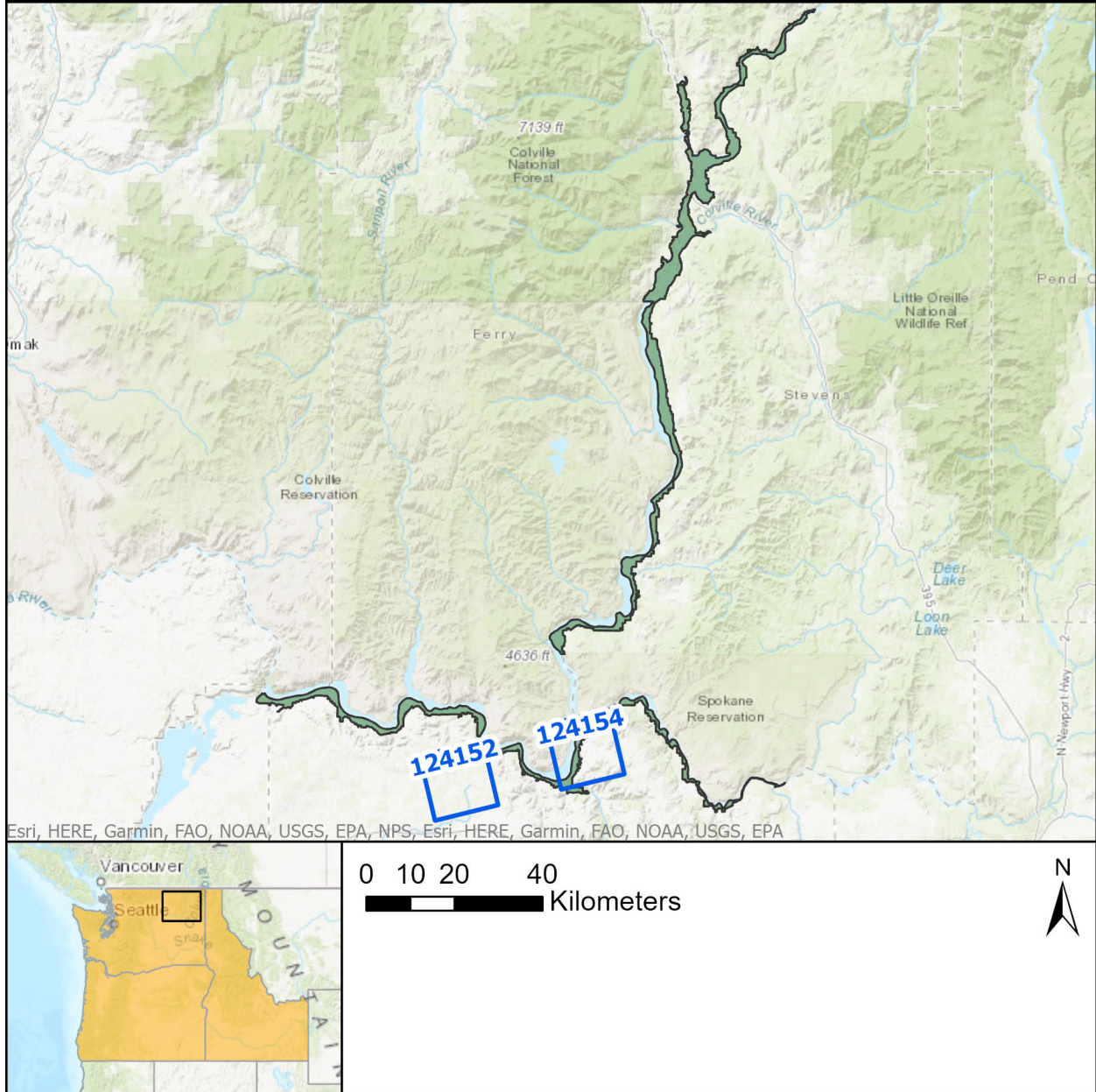


Figure C6. Map of GRTS sample units at Lake Roosevelt National Recreation Area.

Lewis and Clark National Historical Park

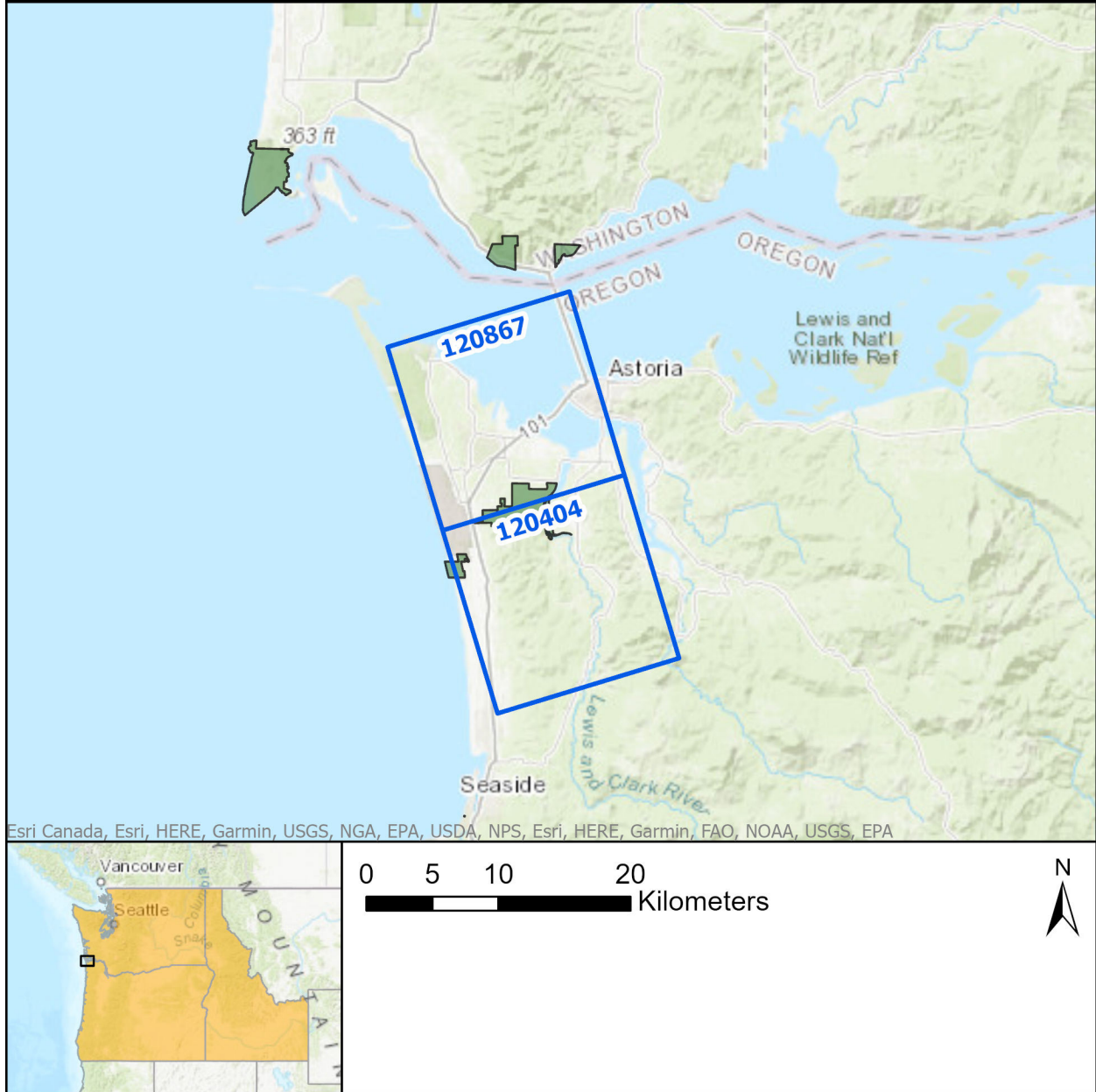


Figure C7. Map of GRTS sample units at Lewis and Clark National Historical Park.

Minidoka

National Historic Park

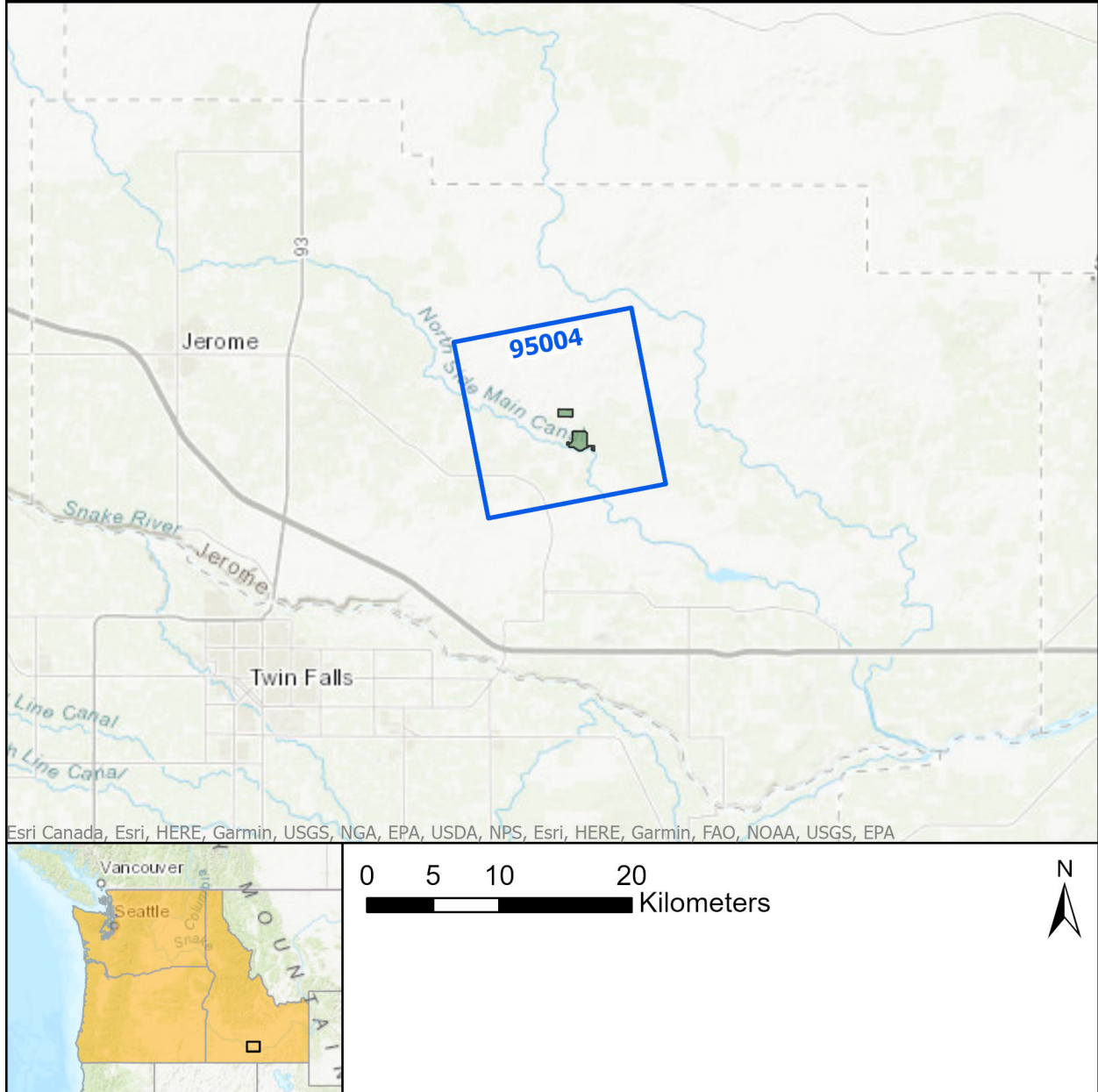


Figure C8. Map of GRTS sample units at Minidoka National Historic Site.

Mount Rainier National Park

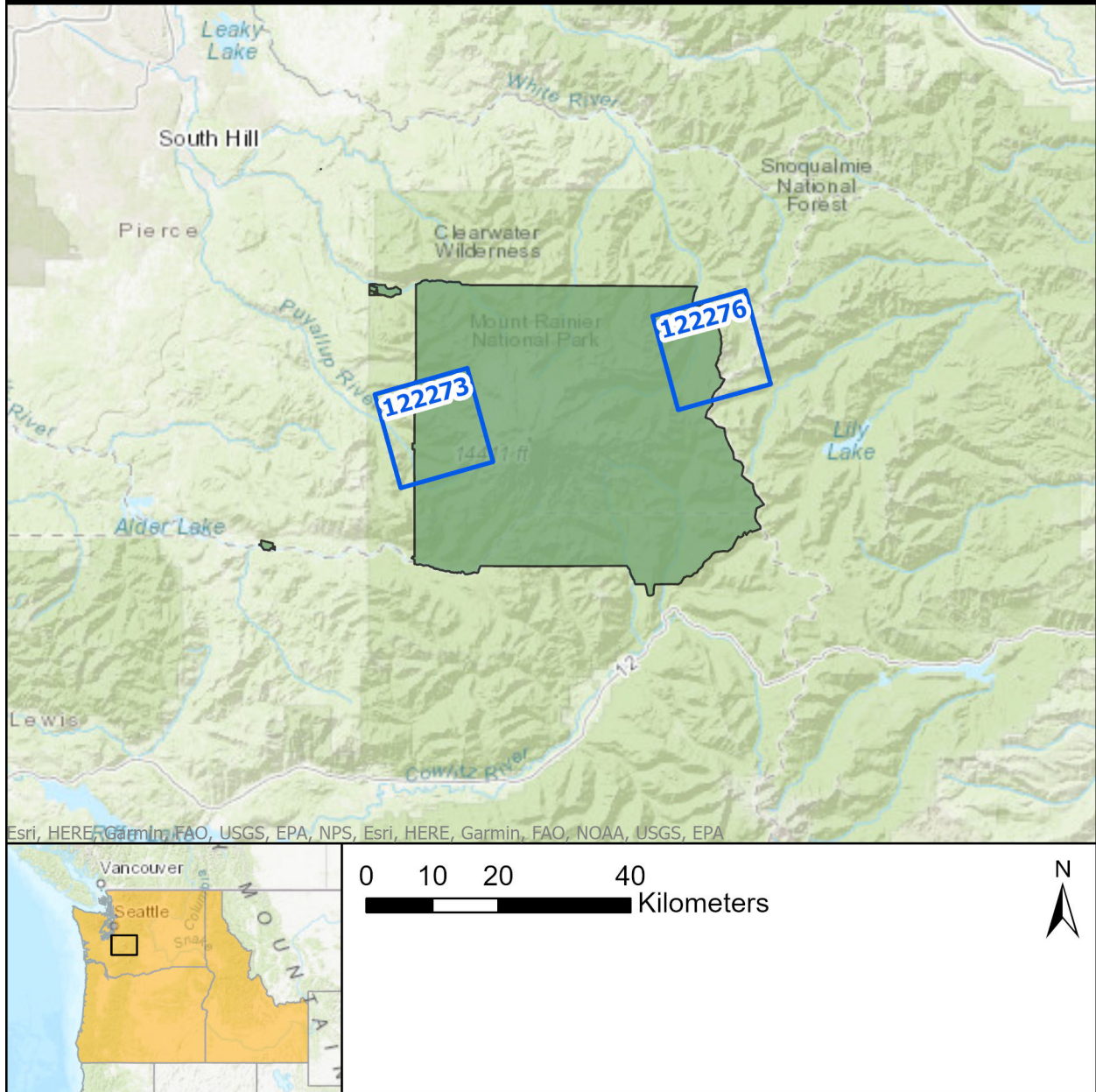


Figure C9. Map of GRTS sample units at Mount Rainier National Park.

Nez Perce National Historical Park

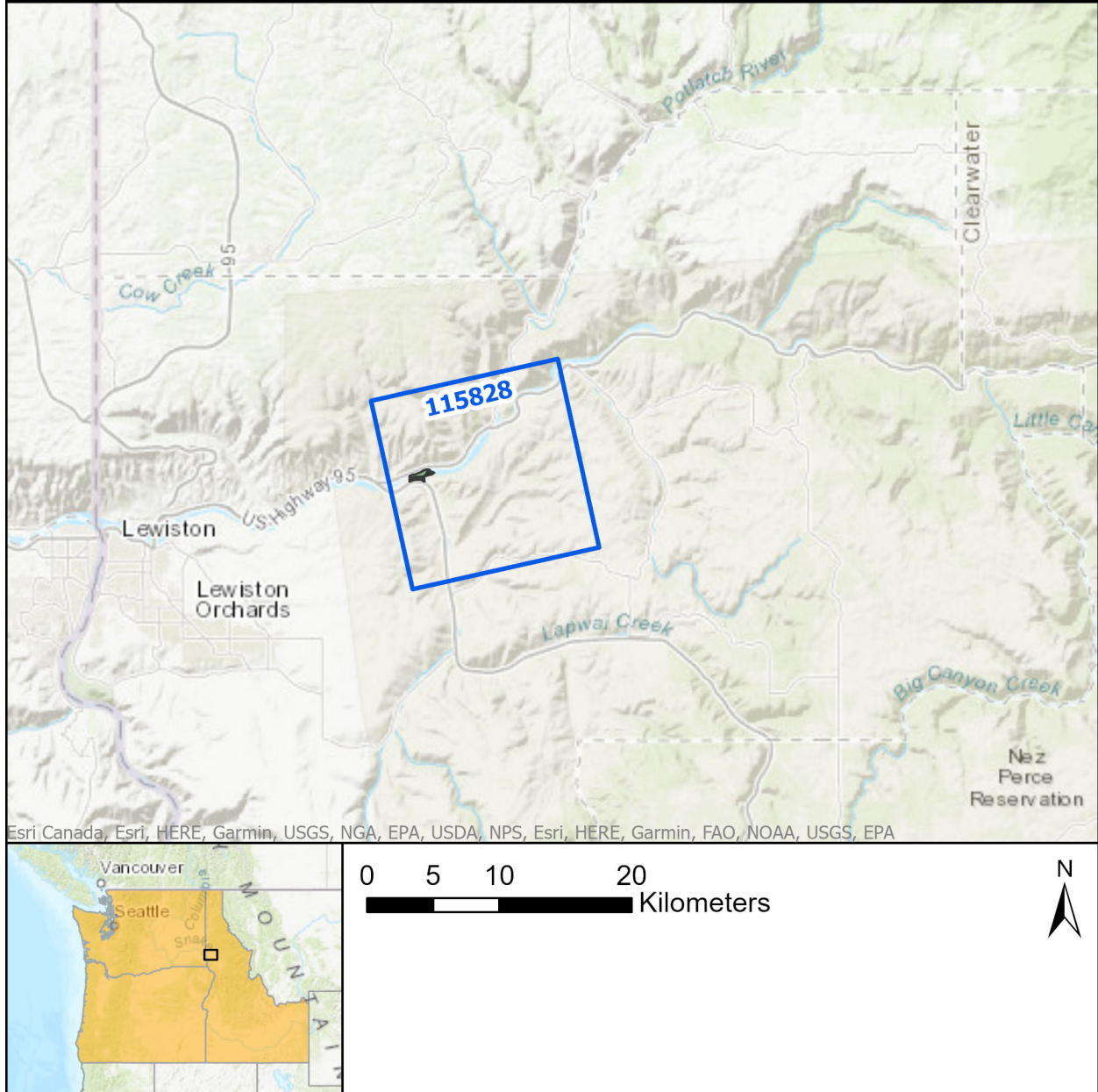


Figure C10. Map of GRTS sample units at Nez Perce National Historic Park.

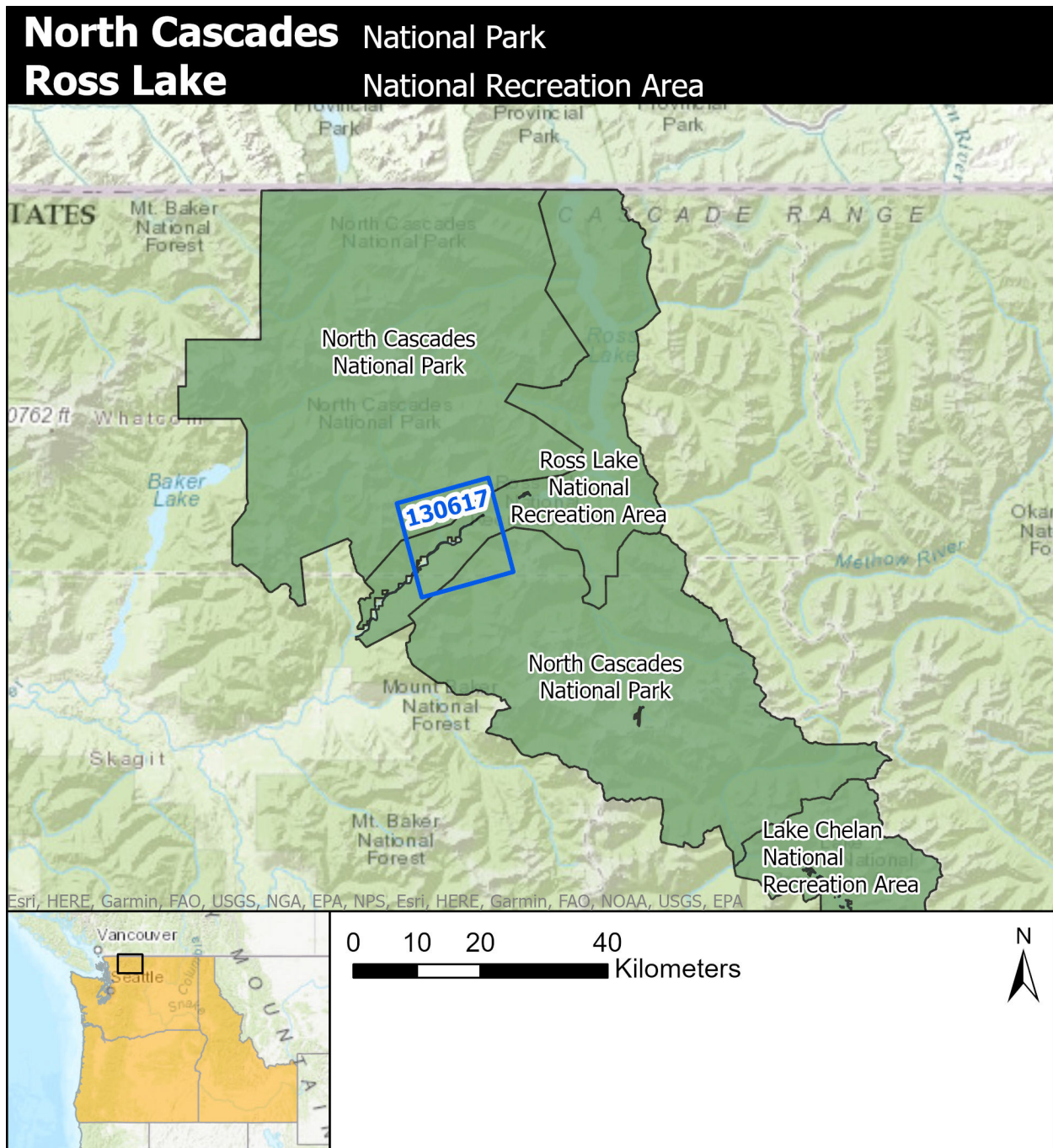


Figure C11. Map of GRTS sample units at Northern Cascades National Park and Ross Lake National Recreation Area.

Olympic National Park

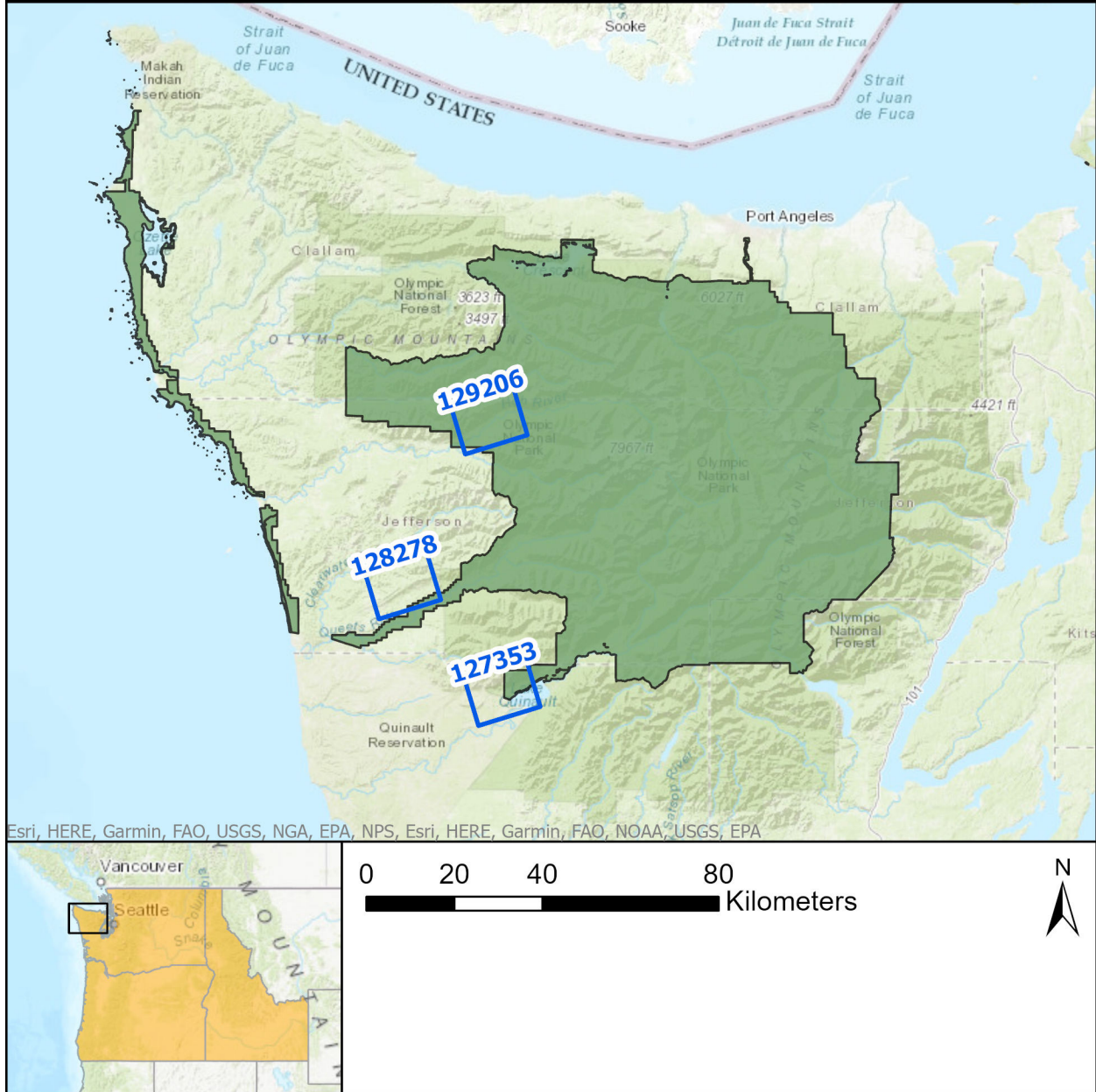


Figure C12. Map of GRTS sample units at Olympic National Park.

Oregon Caves

National Monument and Preserve

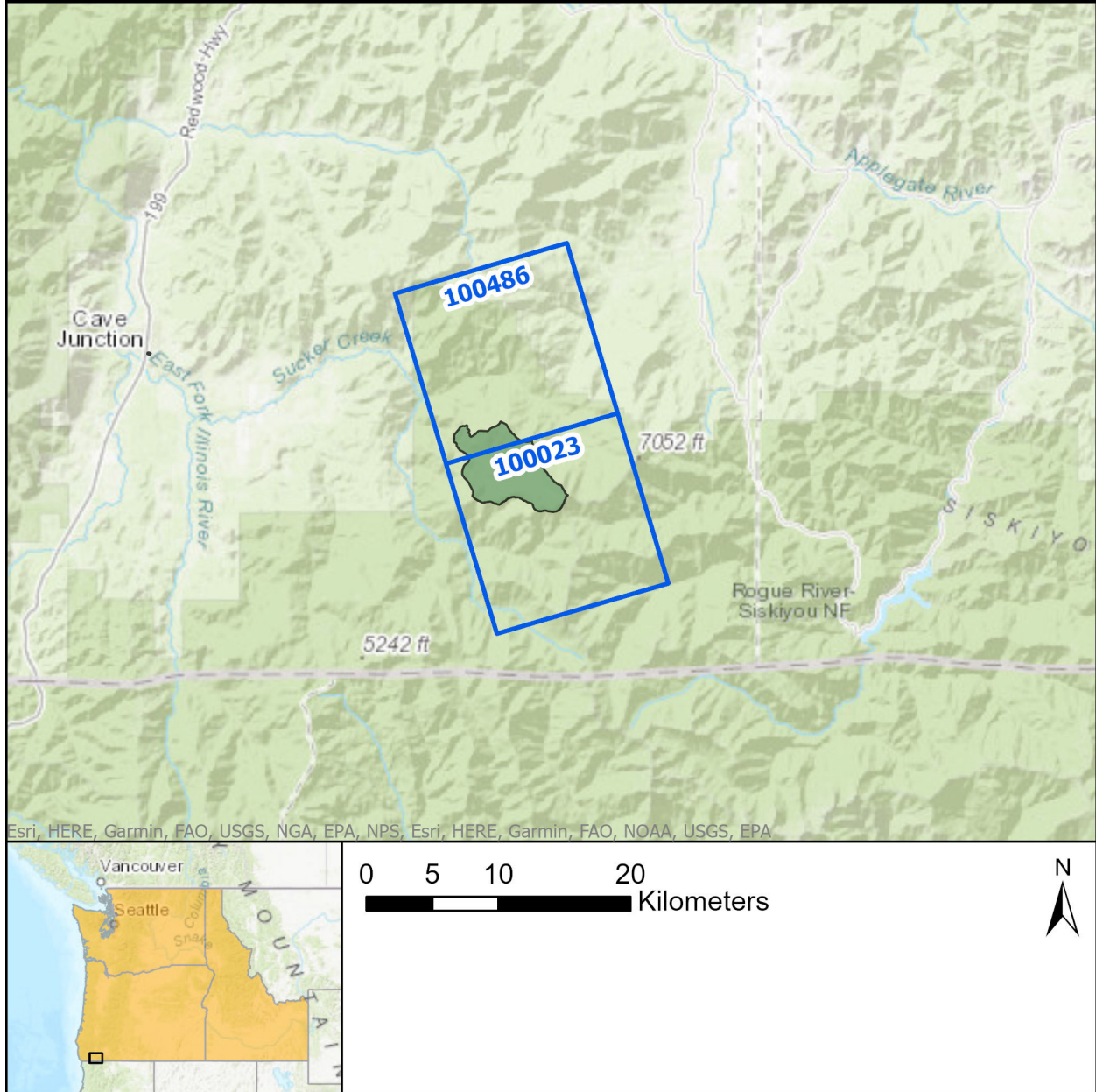


Figure C13. Map of GRTS sample units at Oregon Cave National Monument and Preserve.

Whitman Mission National Historic Site

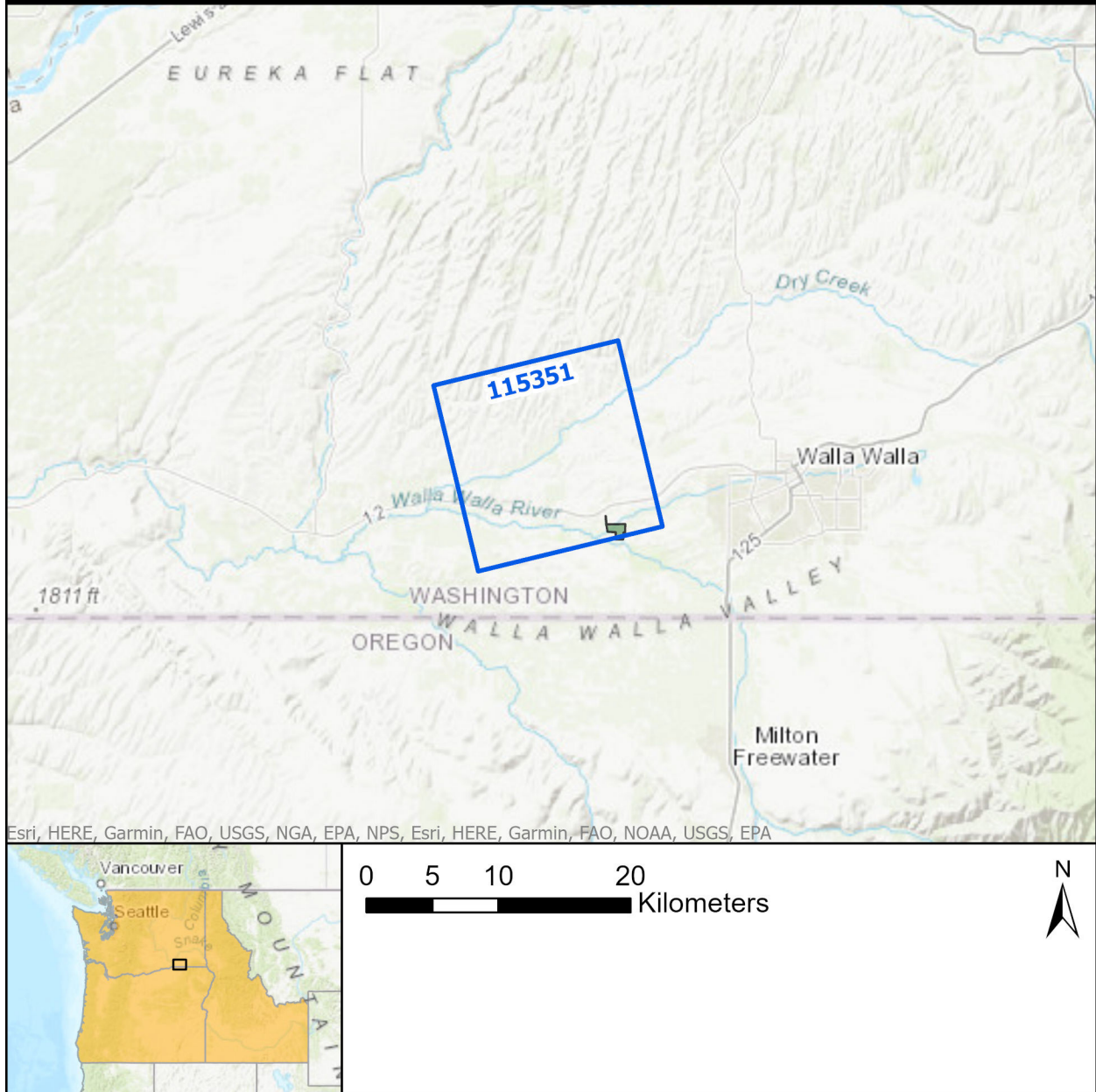


Figure C14. Map of GRTS sample units at Whitman Mission National Historic Site.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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