



Quality Assurance Plan for the Mid-Atlantic, Northeast Coastal Barrier, and Northeast Temperate Networks' Long-Term Breeding Landbird Monitoring Protocol

Quality Assurance Plan Version 1.0



A Common Yellowthroat singing. [BY-NC-ND 2.0](#): Andrew Reding.
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Quality assurance plan for the Mid-Atlantic, Northeast Coastal Barrier, and Northeast Temperate Networks' long-term breeding landbird monitoring protocol: Quality assurance plan version 1.0

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Associated Protocol Package Documents

This is one of a series of documents that collectively describe the objectives, procedures, and data quality of the Mid-Atlantic, Northeast Coastal and Barrier, and Northeast Temperate network's landbird monitoring protocols. Please visit the Landbird Monitoring Program reference on the US NPS's DataStore ([IRMA Reference Code #2190227](#)) for links to all supporting protocol documents and products associated with this program, including but not limited to:

- Network Protocol Narratives
- Standard Operating Procedures (SOPs)
- Network Safety Plans
- Summary of Major Protocol Changes

Revision History

The Region 1 Landbird Monitoring Protocol consists of two narratives, the Mid-Atlantic Network (Johnson and Wakamiya 2018) and the Northeast Temperate Network (Faccio et al. 2015), Standard Operating Procedures (SOPs) that outline specific aspects of the monitoring protocol, and a Quality Assurance Plan (QAP) that establishes and documents standards for data quality (this document).

The latest version of each and additional supporting information can be accessed online the National Park Service's DataStore (<https://irma.nps.gov/DataStore/Reference/Profile/2190227>).

The narrative, each SOP, and the quality assurance plan have respective revision history logs to document changes. The following revision history log is for the quality assurance plan.

Version numbers will be incremented by a whole number (e.g., Version 1.0 to 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.3 to Version 1.4) when there are minor modifications. Rows are added to the log as needed for each change or set of changes tied to an updated version number.

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #
–	–	–	–	–	–
–	–	–	–	–	–
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–	–	–	–	–	–
–	–	–	–	–	–

Acronyms/ List of Terms

ACAD: Acadia National Park

APCO: Appomattox Court House National Historical Park

BOWA: Booker T. Washington National Monument

COLO: Colonial National Historical Park

EISE: Eisenhower National Historic Site

FRSP: Fredericksburg and Spotsylvania National Military Park

GETT: Gettysburg National Military Park

GRTS: Generalized Random Tessellation Stratified

HOFU: Hopewell Furnace National Historic Site

IMD: Inventory and Monitoring Division

MABI: Marsh-Billings-Rockefeller National Historical Park

MIMA: Minute Man National Historical Park

MIDN: Mid-Atlantic Network

MORR: Morristown National Historical Park

NCBN: Northeast Coastal and Barrier Network

NETN: Northeast Temperate Network

NPS: National Park Service

PETE: Petersburg National Battlefield

QA: Quality assurance procedures

QAP: Quality Assurance Plan

QA/QC Visit: Quality Assurance/Quality Control Visit

QC: Quality control procedures

RICH: Richmond National Battlefield Park

ROVA: Roosevelt-Vanderbilt National Historic Sites

SAGA: Saint-Gaudens National Historical Park

SARA: Saratoga National Historical Park

SOP: Standard Operating Procedure

VAFO: Valley Forge National Historical Park

WEFA: Weir Farm National Historical Park

Abstract

In accordance with guidelines set forth by the National Park Service Inventory & Monitoring Division, a Quality Assurance Plan (QAP) has been created for use by three Inventory & Monitoring networks located within Region 1 (Northeast): the Mid-Atlantic, Northeast Coastal and Barrier, and Northeast Temperate networks. This QAP documents the standards, policies, and procedures used by all participating networks for activities related to the collection, processing, storage, analysis, publication, and sharing of breeding landbird monitoring data.

Introduction

The National Park Service (NPS) Inventory & Monitoring Program was established by an act of Congress in 1999 to provide more than 270 national park system units with a core suite of baseline scientific information (inventories) and to identify and implement long-term monitoring of high-priority measurements of resource condition in those units (Fancy et al. 2009). The overarching purpose of natural resource monitoring in parks is to develop scientifically sound information on the status and long-term trends in the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems.

Policies and procedures were designed to ensure that all scientific work conducted by or for the NPS Inventory and Monitoring Division (IMD) including data collection, reporting, and associated decision-support tools is appropriate for its intended use and of documented quality. To meet this requirement, all IMD protocols document protocol specific activities and associated data quality standards in quality assurance plans (QAPs). The intent of the QAP is to provide all potential end-users of protocol data a single source with adequate information to understand what data are being collected and how, as well as to what standards those data are being held to, so that users can independently determine whether or how those data may be interpreted and used.

This document summarizes the standards, policies, and procedures used by all participating networks for activities related to the collection, processing, storage, analysis, publication, and sharing of breeding landbird monitoring data. This document was adapted from the QAPs created for the Eastern Rivers and Mountains Network's Streamside Bird Monitoring Protocol (Marshall and Callahan 2018) and Mid-Atlantic Network's Breeding Bird Monitoring Protocol (Johnson and Wakamiya 2018). The QAP outlines the quality assurance and quality control procedures implemented during all levels of data collection and processing. Data that have undergone all quality assurance and quality control procedures and either meet stated data quality standards or are appropriately identified as not meeting the standards, are considered "certified" by the NPS. Data certification following the documented activities in this QAP is the primary means by which data quality is communicated to end users.

Protocol Overview, Objectives, and Sampling Design

Preserving the condition of park resources unimpaired in perpetuity is the fundamental management objective of the NPS. Indeed, this "anti-degradation" or "no decline in condition" management objective captures the essence of the NPS mission and forms the underpinnings of the NPS ecological monitoring program. The purpose of the breeding landbird monitoring program is to report information that will help park management maintain or improve the ecological condition of the breeding landbird community. The primary monitoring objectives of the breeding landbird monitoring programs in MIDN, NCBN, and NETN are to:

1. Estimate status and long-term trends in species composition, occupancy, and other indices of abundance of breeding landbird populations within forested or early, successional fields and grasslands in network parks.

2. Estimate status and trends in measures of biotic integrity (Bird Community Index - BCI) for breeding landbird communities in network parks.

The parks and associated habitats sampled for breeding landbirds covered by this QAP are listed in Table 1. Point counts are the most widely used method for monitoring bird communities (Ralph et al. 1995; Rosenstock et al. 2002) and were adopted by the Mid-Atlantic Network (MIDN), Northeast Coastal and Barrier Network (NCBN), and Northeast Temperate Network (NETN) to monitor the status and trends of landbirds in their respective parks. The protocol records (“counts”) all birds seen or heard during 10 minutes at specific locations (“points”). The site locations and sampling intensity in each park were determined by the size of the focal habitat, proximity of sites to other landscape features (e.g., roads, trails), and accessibility. In general, most sites were randomly selected from a 250-m grid of points overlaid on park focal habitats but in certain parks with more extensive habitat to monitor (e.g., ACAD), the location of forest plots and other landscape attributes were considered in the final site location. Points count stations are permanently marked and are sampled at least once or twice every year depending on the park or the number of observers available. The resulting counts are used to estimate bird distribution, diversity, abundance, and used to calculate biotic integrity indices like the Bird Community Index (O'Connell et al. 2003).

Table 1. Parks sampled for breeding landbirds per network and park. # Sites is the number of permanent point count stations as of 2024. The Year column represents the year sites were first sampled in each park.

Network	Park	Code	# Sites		Year
			Forest	Field/ Grassland	
Mid-Atlantic Network (MIDN)	Appomattox Court House National Historical Park	APCO	59	21	2010 ^A
	Booker T. Washington National Monument	BOWA	7	3	2009
	Eisenhower National Historic Site	EISE	0	0	NA ^A
	Fredericksburg & Spotsylvania National Military Park	FRSP	28	8	2009
	Gettysburg National Military Park	GETT	0	12	2021
	Hopewell Furnace National Historic Site	HOFU	21	7	2023
	Petersburg National Battlefield	PETE	32	4	2011
	Richmond National Battlefield Park	RICH	24	10	2010
	Valley Forge National Historical Park	VAFO	38	42	2009
Northeast Coastal & Barrier (NCBN)	Colonial National Historical Park	COLO	30	20	2015

^A Park is not currently participating in monitoring

^B ROVA includes ELRO, HOFR, VAMA

Table 1 (continued). Parks sampled for breeding landbirds per network and park. # Sites is the number of permanent point count stations as of 2024. The Year column represents the year sites were first sampled in each park.

Network	Park	Code	# Sites		Year
			Forest	Field/ Grassland	
Northeast Temperate Network (NETN)	Acadia National Park	ACAD	51	0	2007
	Marsh-Billings-Rockefeller National Historical Park	MABI	25	0	2006
	Minute Man National Historical Park	MIMA	23	6	2006
	Morristown National Historical Park	MORR	29	0	2006
	Roosevelt-Vanderbilt National Historic Sites	ROVA ^B	30	0	2006
	Saint-Gaudens National Historical Park	SAGA	8	0	2007
	Saugus Iron Works National Historic Site	SAIR	3	0	2008
	Saratoga National Historical Park	SARA	34	25	2006
	Weir Farm National Historical Park	WEFA	5	0	2006

^A Park is not currently participating in monitoring

^B ROVA includes ELRO, HOFR, VAMA

Protocol Activities

Data are collected or derived as a part of the breeding landbird monitoring protocol in two categories and three activities (Table 2). After sites have been established the bulk of activities for this protocol consist of field observations that relate to site conditions and bird observations at each event.

Table 2. Protocol activity matrix for the breeding landbird monitoring protocols.

Category	Activity Number	Activity	Description
Site Establishment	1	Site Establishment, Maintenance	To establish points, personnel navigate to pre-selected potential site locations and evaluate their suitability, and if acceptable, mark the location. Site maintenance is done on a yearly basis and requires network, park staff or volunteers navigate to sampling locations and replace sight markings as needed. (SOP 1- Site Selection and Point Count Site Establishment).
Field Observations	2	Site Conditions Data	At the start of each 10-minute point count the following information is recorded 1) the start time; 2) sky code; 3) wind code; 4) noise code; 5) site visit number; 6) ambient temperature; 7) any notes that help interpret the data. (SOP 4 - Conducting Variable Circular Plot Point Counts.)

Table 2 (continued). Protocol activity matrix for the breeding landbird monitoring protocols.

Category	Activity Number	Activity	Description
Field Observations (continued)	3	Avian Point Counts	During each 10 minute point count the following information for each observed individual animal (or group) is recorded: 1) species identity; 2) type of detection (e.g., Audio, Visual); 3) the distance band of first detection (<50 m, or >50 m from the point count station); 5) the minute from the start of the point count to first detection of each individual or group. (SOP 4 – Conducting Variable Circular Plot Point Counts.)

Data Quality Objectives

The data quality objective of the landbird monitoring protocol is to consistently produce data of sufficient quality to meet protocol objectives outlined above and to produce data of known and documented quality for all potential end-users of data and information generated by this protocol.

Data Quality Indicators

Several qualitative descriptors are used to help interpret and document the degree of acceptability or utility of the data to the user. These are referred to as “data quality indicators” (USEPA 1997) and include the representativeness, completeness, comparability, and timeliness of the overall protocol dataset. Two other indicators or values (bias and precision) relate to individual measures and are included with the performance standards.

The concept of *representativeness* within the context of this monitoring protocol refers to the ability of the protocol to precisely estimate population and community metrics for the specified target habitats within parks. Target sampling areas and intensity as well as the methodology used to specify the sampling frame and site selection (and appropriate scope of statistical inference) are summarized above and discussed in detail in the protocol narrative sections dealing with this topic. Briefly, a park-level spatially balanced sample of permanent monitoring sites was generated to provide a representative sample of habitats (forests and grasslands) in each park. Additionally, repeat visits to each sampling site and time of first detection allows for a suite of analysis approaches that account for imperfect detection for species with sufficient data. It is important to point out that the breeding landbird protocol is volunteer based so there may be sites that are not sampled as frequently as others. Users of the data should be aware that some monitoring sites receive only 1 visit per year while others are surveyed twice or more per year and on occasion some sites are unable to be visited because of a lack of volunteers.

Sampling *completeness* is defined following Stanley and Verner (1985) as “a measure of the amount of data collected from a measurement process compared to the amount that was expected under the conditions of measurement.” A completeness goal of 100% has been established for the various measures included in this protocol (both the number of sampling events each year as well as the required measures during each event). However, because the breeding landbird protocol is volunteer based some sites may not be visited at all in some years because of a lack of volunteers or are only surveyed once annually when they typically are surveyed twice annually.

Data *comparability* refers to the confidence with which one data set can be compared to another. To achieve maximum utility, this protocol must yield data that are consistent and comparable from one year to the next within each site and park, and to the extent possible with other NPS, state and Federal programs. Comparability within a site, park and between years is achieved through strict adherence to the standard operating procedures documented in this protocol including thorough documentation of any changes or revisions to procedures. Protocol changes and/or deviations from the protocol that could affect data comparability among years are documented in the Summary of

Major Protocol Changes and Deviations document. Implementation of a generic and standardized “point count” procedure also allows comparison with other NPS, state, and Federal programs.

Timeliness refers to the length of time required to collect, process, and certify data relative to the intended uses of the data. Data collection and processing for the landbird monitoring protocol occurs on an annual basis with all field work (i.e., data collection) completed by the middle of July each year. Data processing takes roughly three months and, as a result, all data are certified and available for general use by the end of each calendar year. See the Data Certification and Dissemination section below.

Data Quality Standards

Four data quality standards are defined and documented below: 1) measurement quality objectives, 2) taxonomic standards, 3) policy and protected data standards, and 4) accreditation standards.

Measurement quality objectives are data quality requirements specifying the level of bias and precision (and in some cases resolution, sensitivity, etc.) of equipment, sensors, or observers to reliably measure characteristics of the target population. Bias is a systematic difference between a measured value and the true value and represents an estimate of systematic measurement error. Precision is the degree of mutual agreement among repeated measurements and represents an estimate of random measurement error. Collectively these data characteristics provide an estimate of the total uncertainty surrounding any measurement (typically referred to as accuracy). In many cases, however, assessing bias in point count data is not meaningful because true values are not measurable or known. Therefore, we primarily focus on measurements of precision to assess data quality for this protocol.

The measurement quality objectives for the breeding landbird monitoring protocol are presented and summarized in Table 3. Training is conducted prior to the field season to ensure that field personnel (volunteers) are capable of collecting data that meet the measurement quality objectives. Field personnel are assessed on their ability to collect data that meet the measurement quality objectives at the beginning of their first field season (see Quality Assurance Procedures below).

Table 3. Measurement quality objectives for measures collected in the breeding landbird monitoring protocols.

Category	Measure Number	Measure	Performance Standard	Reference(s)
Site Establishment, Maintenance	1	Site Location (UTM Coordinates)	± 5m horizontal accuracy	SOP 1: Site Selection and Point Count Site Establishment
Field Observations	2	Site Conditions Data	Standards are undefined. Volunteers are given categories for characterizing site condition measures, but precision of measures is unknown. Accuracy of temperature data is defined by the method of temperature collection.	SOP 4: Conducting Variable Circular Plot Point Counts
	3a	Point Count: Taxonomic Resolution	Species level	SOP 4: Conducting Variable Circular Plot Point Counts
	3b	Point Count: Identification Completeness	99.9% of identifications are made to species level	SOP 4: Conducting Variable Circular Plot Point Counts
	3c	Point Count: Identification Accuracy	>90% accuracy; using audio and visual cues	SOP 4: Conducting Variable Circular Plot Point Counts
	3d	Point Count: Distance Accuracy	± 10m	SOP 4: Conducting Variable Circular Plot Point Counts

Taxonomic Standards

All bird data collection and associated reporting from the breeding landbird monitoring protocol uses the taxonomy of the American Ornithological Society available at <http://checklist.aou.org/> and referred to as the Birds of North and Middle America Checklist. All squirrel and chipmunk data collection and associated reporting by NETN uses the taxonomy of American Society of Mammalogists available at <https://www.mammalsociety.org/publications/mammalian-species> (also see Koprowski 1994; Steele 1998).

The Birds of North and Middle America Checklist is widely accepted as the official source on the taxonomy of birds found in North and Middle America, including adjacent islands. This list is produced by the North American Classification Committee (NACC), an official committee of the American Ornithological Society (formed by the merger of the American Ornithologists' Union and Cooper Ornithological Society). Accepted changes to taxonomy are summarized in annual supplements to the checklist which are published in a scientific journal (Ornithology) in July of each year. After taxonomic changes are published, networks will make annual updates to the protocol taxonomy (SOP 2 – Field Season Preparation and Annual Roles and Responsibilities).

Field identifications of birds (visual and auditory) are based on the Sibley guide to birds (audio available online and through the App) (Sibley 2014) which, in turn, is based on the NACC taxonomy. The recording of field observations of bird species common names (and four-letter species codes) is based on the taxonomy described above. Four-letter species codes for bird names are maintained by the Institute for Bird Populations (<https://www.birdpop.org/pages/birdSpeciesCodes.php>), follow the taxonomy of the NACC, and are updated annually (SOP 2 – Field Season Preparation and Annual Roles and Responsibilities).

Field identifications of squirrels and chipmunks (visual and auditory) are based on the Mammals of North America field guide (Kays and Wilson 2009) and species level accounts for Eastern Gray (Koprowski 1994) and North American red (pine) squirrels (Steele 1998).

Policy & Protected Data Standards

According to federal policy, data collected by NPS are to be made public. However, there are limited cases in which data may be withheld from release to protect park resources. Dissemination of certain information could put particular resources at risk, and some cultural and natural resource information is protected from public disclosure by resource confidentiality laws. These laws prohibit agencies from releasing protected information except in limited, specified circumstances.

The process of identifying protected data—including which data are protected, the degree of protection warranted, and if data will be disseminated—was completed by all networks and signed by park superintendents by 2019. As a rule, NPS will provide as much monitoring data as possible to the public to facilitate communication and collaboration. NPS therefore does not generally protect location data, such as coordinates of monitoring sites.

Currently, no species occurrence data associated with the breeding landbird monitoring protocol are considered sensitive and/or protected. Personally identifiable information (PII) associated with non-NPS personnel (e.g., field crew members) is legally protected and all PII will be redacted from public dissemination.

Accreditation Standards

No professional or lab accreditations are required for the breeding landbird monitoring protocol.

Quality Assurance and Quality Control Procedures

This section outlines the quality assurance and quality control procedures implemented during all levels of data collection and processing. Quality assurance (QA) procedures are targeted at minimizing errors in data collection while ensuring that data are collected to established and documented standards (to the greatest extent possible). Quality control (QC) is an evaluation of data, once collected, to ensure they meet documented standards, and to correct any data that do not meet standards. Data that cannot be corrected are flagged as excluded and a reason for exclusion is recorded. Excluded data are removed from any subsequent data analysis.

Quality Assurance

This section describes quality assurance procedures implemented for data collection and processing activities beginning with an overview of the design of the protocol database.

Database Design

The breeding landbird monitoring protocol database is made of two components, a web-based front-end user interface and a back-end database which resides on a SQL server located within an NPS data center. The user-interface is accessed through the National Park Service's Integrated Resource Management Application (IRMA), which can be accessed using various web browsers. The user interface consists of various forms to help the user enter and validate data. The database provides standardized values for data fields to minimize data entry errors and each field has validation rules in place to check values as they are entered to prevent typographic and logic errors. Reporting tools allow for queries of the data for various QA/QC and final reports. More information on the protocol database can be found in SOP 5: Landbird Monitoring Database User Guide.

Before the Field Season

Achieving the data quality objective for this protocol is a continuous process that follows an annual cycle. The cycle begins before each field season by reviewing, updating, and thoroughly documenting changes to all SOPs, ensuring proper equipment is available and in working order, reviewing and updating the expected species list in the database, among numerous other tasks as outlined in SOP 2: Field Season Preparation and Annual Roles and Responsibilities. These tasks are completed by the landbird monitoring coordinator and data manager.

Recruitment and Training

The breeding landbird monitoring program relies on recruiting volunteers local to each park, as they are most familiar with the local composition of bird species. Volunteers are recruited from local birding clubs, Audubon Chapters, birding listservs, or simply by word of mouth. To capture meaningful data, it is imperative that data are collected in a consistent manner by highly trained volunteers. All volunteers are required to demonstrate their aptitude at identifying birds by completing a short quiz. SOP 3: Volunteer Recruitment and Training, outlines the specific procedures for recruitment and training of volunteers for this protocol.

The topics presented here, along with the related SOPs, are among the most important parts of the quality assurance of this protocol because they summarize the essential qualifications and skills field crew members must possess, provide guidance on recruiting qualified volunteers, and outline the required training. The quality of the observer, combined with appropriate training, oversight and communication determines the quality of the data. Moreover, most of the performance standards outlined in Table 3 are assessed and achieved during preparation for the field season and field observer training.

Site Establishment, Maintenance, and Revisitation

All point count stations were permanently established within $\pm 10\text{m}$ of the Geographic Information System (GIS) waypoint generated during the site selection and evaluation process as described in SOP 1: Site Selection and Point Count Site Establishment. Once established, the station location was recorded with a GPS unit with $\pm 5\text{m}$ horizontal accuracy (includes bias and precision). These locations were validated in the protocol GIS and are used by all subsequent observers to relocate the sampling sites or to re-establish the site if markers disappear.

While the performance standard for this activity (Table 3) was $\pm 5\text{m}$ horizontal accuracy at the time of site establishment, this standard is now largely evaluated through completeness measures. In other words, can observers successfully navigate to and complete surveys at all required point count stations? Should an observer not be able to locate a point count station, NPS staff will re-establish the station using the same coordinates and ensuring GPS accuracy within $\pm 5\text{m}$ as outlined in SOP 1: Site Selection and Point Count Site Establishment.

Site Observations

Site Conditions

Prior to visiting sites observers are required to review weather conditions to ensure that environmental conditions during the planned survey are acceptable. Acceptable conditions to complete a point count (time of day and weather) are outlined in SOP 4: Conducting Variable Circular Plot Point Counts.

When conducting a point count survey, adherence to any standard is difficult for measures of environmental variables that are not directly measured by calibrated sensors but assigned to standardized categories by a single observer working independently. Since the datasheet provides standardized values for recording sky, wind, and background noise conditions, these measures are assumed to be consistent when measured by the same observer among sites and surveys. While the datasheets provide standardized values with associated descriptions of each measured condition, it is possible that different individual observers could vary in the category assigned to a similar environmental conditions.

Most observers are using weather applications on smartphones to record the temperature at the beginning of each survey. It is possible that observers may also bring analog thermometers to sites without cellular reception. Since adherence to a standard is difficult for temperature measurements, it is recommended that users wishing to incorporate this variable either review site temperature data

against a local weather station record or use standardized gridded products (e.g., PRISM: <https://prism.oregonstate.edu/>) to assign temperature data to site observations.

Taxonomic Resolution and Identification Completeness

Birds (and squirrels/chipmunks in NETN) detected during point counts are identified to the species level (see also Taxonomic Standards). Observers are trained to use an “unknown bird” identifier for birds they cannot identify to species and only when they are sure that the bird is a unique individual not previously identified at any point during the 10-minute count. This standard was established based on a review of over 41,000 bird observations between 2009 and 2023 where < 0.1% of identifications were coded as “unknown bird”. The use of “unknown bird” by observers will be assessed annually and a significant increase in its use would necessitate re-training of the observers.

Identification Accuracy

Adherence to this standard is admittedly difficult to assess in this protocol where all point counts are conducted by a single observer working independently and the “true” species composition is unknown. The >90% standard is based on the results of a series of experiments designed to evaluate the auditory detection process of avian point counts (Alldredge et al. 2007a; Alldredge et al. 2007b; Simons et al. 2007) where the trained, experienced observers misidentified an average of 4% (range 0–10%) of individual birds. Because the data in this protocol are also collected by trained, experienced observers we assume identification accuracy is similar and that this standard is being met.

To further support this assumption, the NPS Networks within the northeast region (Region 1) initiated a cooperative agreement with the University of Delaware to evaluate their existing avian monitoring protocol in 2015. We coordinated with the National Capital Region Network to use their crew of paid observers to collect data in two MIDN parks. This allowed us to test for differences in volunteer versus paid observers and determine if there could be any potential observer-type bias that could arise in larger-scale regional analyses. The resulting analysis found no significant relationship between observer type and detection probability within forest or grassland monitoring points (Shriver and Ladin 2016). These results support our conclusion that using volunteers for landbird monitoring yields quality data that is comparable to other monitoring programs in North America (e.g., USGS Breeding Bird Survey), and meets the standards we have outlined above.

Distance Accuracy

Similar to identification accuracy, adherence to the specified distance accuracy standard is difficult to assess since all point counts are conducted by a single observer working independently and the “true” distance to a detected bird is unknown. As above, the ± 10 m standard is based on the results of a series of experiments designed to evaluate the auditory detection process of avian point counts (Alldredge et al. 2007a, Alldredge et al. 2007b, Simons et al. 2007) where the average distance measurement error across all distances, species, and observers was 9.0 m (SD = 25.8 m) for the untrained observer experiment and 7.6 m (SD = 21.4 m) for the trained observer experiment (Alldredge et al. 2007b). Because the data in this protocol are also collected by trained, experienced observers we assume distance measurement accuracy is similar and that this standard is being met. In

support of this assumption, distance measurement is specifically covered during training, and observers are encouraged to complete practice exercises (See SOP 3: Volunteer Recruitment and Training). Ultimately, we acknowledge that observers are likely assigning the wrong distance band to an unknown number of birds and cannot explicitly quantify the extent to which it occurs.

Oversight and Communication

Maintaining oversight of the volunteers during the field season and fostering open communication between observers, park natural resource staff, and the landbird monitoring coordinator is another key factor in obtaining quality field data and balancing sampling effort equally across sampling points. Volunteers must work with park staff to sample correctly and be willing to ask questions whenever they are unclear of the proper procedures.

Data Collection

Quality assurance processes associated with each of the data collection activities of the landbird monitoring protocol (Table 1) include training, oversight and communication, and strict adherence to guidance in SOP 3: Volunteer Recruitment and Training and SOP 4: Conducting Variable Circular Plot Point Counts. This SOP thoroughly details proper procedures for every step of the data collection process including properly recording observations and measures on field data sheets.

Data Entry and Verification

All point count data are collected on paper datasheets called Field Mapping Cards and then transcribed onto tabular type of data sheet called a bird data coding sheet that is more amenable to data entry into the landbird monitoring database. If an observer enters their own data into the online database, they do not need to transcribe the data to the bird data coding sheet (See SOP 6: Data Quality Control and Publication). To ensure quality data transcription, it is critically important that proper verification occurs at each stage of transcription from the original source. To minimize the possibility of carrying data entry errors forward into analysis, the data includes a 100% and 10% check verification processes outlined in SOP 6. The landbird monitoring coordinator works with the biotechnician or volunteer entering bird data to resolve any questionable data found during verification. Observers are contacted to clarify any issues found during data entry and review, and any remediation is annotated on the datasheets and archived.

Quality Control

Data Validation

Upon completion of data entry and verification, the verified data (described above) are given to the landbird monitoring coordinator to check for completeness and logical consistency, both visually and through queries (see SOP 6: Data Quality Control and Publication). The landbird monitoring coordinator compiles any questions or concerns regarding the data in an Excel spreadsheet and works with the biotechnician and volunteers to correct or annotate the data as needed.

SOP 6: Data Quality Control and Publication outlines a series of procedures designed to further evaluate and clean the data. These steps include complete validation of volunteer datasheets that are found to have significant transcription errors, a review of all data against a list of known common

errors using queries, and reviewing the species list of each park for unusual species. This last step is accomplished by reviewing the species list of each park for any species identifications that are questionable. The landbird monitoring coordinator reviews any field notes provided by the observer (e.g., “bird was located and observed to verify species after the point count was completed”), checks external data sources such as eBird (<https://ebird.org>), and uses their professional judgment to determine if any action is warranted. If a species-level observation is questionable and cannot be sufficiently supported by the observer, it is flagged for exclusion in the database with accompanying notes regarding the reason for exclusion.

Not all errors and inconsistencies can be fixed, in which case a description of the resulting errors and why edits were not made is then documented and, when necessary, notes placed into the database. Data that is not usable for data analysis (‘excluded records’) will be flagged as such in the database and removed from any data products produced by the protocol. At this stage, the data are considered provisional.

The landbird monitoring coordinator conducts a second round of Quality Control procedures at the end of the field season as part of the certification process (see SOP 6: Data Quality Control and Publication). These Quality Control checks are run on the yearly data using SQL or R code and, again, checked for completeness and logical consistency. The landbird monitoring coordinator may also compare aggregate data across years to look for outliers. Once this last round is complete the certification procedures outlined in SOP 6 are completed, the data are considered certified and are made available in the NPS DataStore.

Documentation

Data Certification

Data certification is the process confirming that:

- Data have been through all QA/QC procedures outlined herein.
- Data either meet specified quality standards and/or that data that do not meet those standards are appropriately identified.
- Data are suitable for general use.

The levels of data processing are:

- **Raw:** Data in their state of original collection, either in the form of paper or electronic field forms, electronic sensor files, or digital media (photo, video, or audio). These data generally have been collected following some QA procedures but have not undergone any QC procedures.
- **Provisional:** Data that have undergone incomplete QA/QC procedures as defined in the QAP and are not suitable for general use. Provisional data may be used in some cases, however, depending on the amount of QA/QC completed, and the intended use.
- **Accepted:** Data that have undergone all QA and QC procedures as defined in a published protocol and associated SOPs. Used in cases where a Quality Assurance Plan has not been developed and approved.
- **Certified Data.** Data that a) have been through all QA/QC procedures as outlined in the Quality Assurance Plan, b) meet expected quality standards, or are appropriately identified and annotated at the record level in cases where they do not meet those standards, c) have documented procedures for data collection, processing, and transformation in appropriate metadata formats, and d) are suitable for use.

Data certification is documented in the protocol database at the Event level. All subsequent changes to certified data are documented in the audit log of the database and a description of the change is provided along with the date of change and the individual who made the change. Data certification is applied to the data by the database administrator once the Landbird Monitoring Coordinator has approved the data for certification. Certification may be applied at the network, or park level as needed.

Metadata

Metadata are created for certified data in the EML format (<https://eml.ecoinformatics.org/>) using the R package EMLassemblyline (<https://edior.github.io/EMLassemblyline/index.html>). All networks using the landbird monitoring protocol follow all guidance and best practices for metadata provided by the Inventory and Monitoring Division.

Information Dissemination

All reports including protocol data disseminated for general (public) use should be based on certified data unless specified otherwise. In general, data should be certified prior to internal use for supporting park-, regional-, or national-level resource management decisions. However, in some cases the use of provisional data (data that have not undergone complete QA/QC as defined in this QAP), may be warranted to base decisions on best-available science.

Communicating Data Quality

Data certification and the processes documented in this QAP are the primary means by which data quality is communicated to end users. A descriptive paragraph or document for each report or data set will include a URL to the breeding bird landbird monitoring protocols in the NPS DataStore to ensure that data can be traced to the latest version of the protocol, all associated standard operating procedures, and this QAP.

Archive of Records

The following files are archived annually on network servers after data certification:

- A data package containing a “flattened” data file export from database; (*.csv file type) containing the most recently certified and all previously certified data, and EML compliant metadata file. This data package is also published annually to the NPS DataStore.
- Version of the landbird monitoring protocol, SOPs, and QAP used for data collection and certification.
- Electronic copies of all field data sheets scanned to the .pdf data type after data verification (i.e., the raw data).
- Project Data Certification Form, Seasonal Closeout Checklist, and minutes from the annual operational review.

For all reports generated from landbird monitoring protocol data, the following files are archived on the network’s server:

- Final manuscript.
- Draft of report submitted for peer review, along with peer review comments and author response to those comments.
- Data Package: a Zip file containing the version of the Analysis Datasets used.
- Analytical code (e.g., R script) and flat data files (e.g., CSV files) used for data analysis presented in the report.

Protocol Quality Assessment

This section outlines a series of periodic reviews and evaluations to be conducted as part of the implementation of the breeding landbird monitoring protocol (Table 4).

Table 4. Data quality evaluations to be conducted as a part of implementing the landbird monitoring protocol.

Evaluation	Purpose & Description	Frequency
Field Season Review	Landbird monitoring coordinator meets with Natural Resource Management staff at each participating park to identify lessons learned in terms of operational efficiencies, logistical or technical challenges, unexpected field conditions, safety issues, etc. Based on these discussions, the SOPs are clarified or updated as needed to provide better guidance to future field crews.	Annually at completion of field season.
Data Quality Evaluation: Data Completeness	Evaluate the number of sites sampled and requisite measurements recorded compared to the anticipated totals.	Annually as data are certified.
Data Quality Evaluation: Data Timeliness	Measure of time required to certify data.	Annually as data are certified.
Data Quality Evaluation: Data Quality Assessment	Measure of the number of data points that do not meet measurement objectives.	Annually as data are certified.
Annual Operational Review	Protocol team obtains feedback from staff and supervisor on protocol implementation. Ensures that the protocol remains in sync with annual monitoring activities. Documents changes in procedures and equipment. Captures lessons learned and any changes to be made going forward. Provides NPS staff with an opportunity to discuss the state of the science of the protocol. Based on these discussions, protocol documents are clarified or updated as needed.	Annually during season close out.
Scientific Review	Evaluates whether the protocol meets its stated objectives and produces the best available science. A targeted scientific review addresses one or two specific facets of the protocol (e.g., sampling frequency, field procedures). A full scientific review takes a holistic, in-depth look at the protocol, due to multiple potential areas of concern about the protocol's ability to meet its objectives (Mitchell et al. 2018).	Periodically.

These quality checks promote a cyclic process of continuous feedback and improvement of both the data and the quality planning process. The program implementing the protocol is responsible for organizing and conducting the reviews and assessments and for ensuring that summary information, deviations from SOPs, data nonconformities, new ideas and methods, etc., are properly documented

through revisions to the protocol narrative, SOPs, Summary of Major Protocol Changes document, QAP and/or Safety Plan where relevant.

Five evaluations occur annually at the completion of the field season and at the time of data certification and archiving (Table 4).

A separate protocol review (which includes a full scientific review and overall assessment of whether the collected data are sufficient to meet protocol objectives) occurs periodically. These will occur when substantial changes are made to protocol objectives or processes, concurrent with a significant data analysis/trend detection report, or as requested by a supervisor. Based on these criteria, protocol reviews occur on an as needed basis.

Roles and Responsibilities

Table 5 identifies organizations and individuals involved in the implementation of the landbird monitoring protocol.

Table 5. Roles, responsibilities and contact information for persons or organizations affiliated with implementation of landbird monitoring protocol.

Affiliation / Position	Role
Regional Program Manager	QAP approval, protocol approval, ensuring that data meet quality objectives
Network Program Manager	Program coordination; oversight of development and implementation of monitoring protocols; ensure protocol implementation meets NPS scientific integrity standards and all data meet DQOs; conduct appropriate peer review of all published products.
Protocol Lead	Serve as scientific lead; organize and conduct protocol quality assessment reviews; lead data analysis and reporting.
Landbird Monitoring Coordinator	Protocol implementation; lead volunteer recruitment and training; update Volunteer manual; oversee data collection, entry, and verification; lead QA/QC and data certification; ensure all data meet DQOs;
Protocol Data Manager	Manage Development and Production Database instances and associated Azure DevOps project; develop and maintain dataset metadata; post annual data packages to NPS Data Store.
Biotechnician and Volunteer observers	Protocol implementation, data collection, ensuring that data meet quality objectives

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