



Landbird Monitoring Protocol for the Arctic Network

Natural Resource Report NPS/ARCN/NRR—2018/1623



ON THE COVER

Bluethroat (*Luscinia svecica*) near Primus Creek in Noatak National Preserve, 2016.

Photograph by: Jaren Hughey, National Park Service

Landbird Monitoring Protocol for the Arctic Network

Natural Resource Report NPS/ARC/NRR—2018/1623

Jeremy D. Mizel

National Park Service
4175 Geist Rd.
Fairbanks, AK 99702

April 2018

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

This report received formal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data, and whose background and expertise put them on par technically and scientifically with the authors of the information.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from the [Arctic Network Inventory and Monitoring Program](#) website and the [Natural Resource Publications Management](#) website. If you have difficulty accessing information in this publication, particularly if using assistive technology, please email irma@nps.gov.

Please cite this publication as:

Mizel, J. D. 2018. Landbird monitoring protocol for the Arctic Network. Natural Resource Report NPS/ARC/NRR—2018/1623. National Park Service, Fort Collins, Colorado.

Narrative Change History

Original Version #	Date of Revision	Revised By	Changes	Justification	Page #'s Affected	New Version #

Contents

	Page
Figures.....	vii
Executive Summary	ix
1 Background and Objectives.....	1
2 Sampling design and methods	3
2.1 Inference methods.....	3
2.2 Previous monitoring efforts	4
2.3 Site selection and annual rotation	4
2.4 Route establishment.....	7
2.5 Defining plots.....	11
2.6 Bird surveys	12
2.7 Survey timing.....	12
3 Data management	15
3.1 Data Management Life Cycle	15
3.1.1 Data Quality.....	15
3.1.2 Freedom of Information Act.....	16
3.1.3 Records Management	16
3.1.4 Core Functional Model.....	17
3.1.5 Data Sensitivity Statement.....	17
3.1.6 Roles and Responsibilities.....	17
3.2 Quality assurance and control.....	18
3.2.1 Quality assurance.....	18
3.2.2 Quality Control	18
3.2.3 Deliverables Schedule	18
3.3 Product archival and documentation.....	18
3.3.1 IRMA Data Store.....	19
3.3.2 Reports.....	20
3.3.3 Data.....	20
3.3.4 Resource Brief	20

Contents (continued)

	Page
3.3.5 Products Publication	20
3.3.6 Metadata	20
3.3.7 Line of Sight	21
3.3.8 NPSpecies	21
3.3.9 Data and Information Security.....	21
3.4 Closeout	21
3.5 Certification	22
3.6 Database	22
3.7 Data Flow.....	22
3.8 File structure	23
4 Personnel requirements and training	25
5 Operational requirements	27
5.1 Site access	27
6 Literature Cited.....	29
7 Appendix A: Data deliverables schedule	33

Figures

	Page
Figure 1. The NPS Arctic Inventory and Monitoring Network (ARCN).....	2
Figure 2. ARCN landbird study sites.	5
Figure 3. Elevational gradient within the Primus Creek study site.	6
Figure 4. Route establishment.....	8
Figure 5. Kelly Bench study area.....	9
Figure 6. The Anaktuvuk Pass study area.....	10
Figure 7. Primus Creek study area	11
Figure 8. Long term monitoring project data management life cycle.....	15
Figure 9. The ARCN Core Functional Model overview.....	17
Figure 10. Standard Vital Sign Project reference architecture in the IRMA Data Store.	19
Figure 11. Data Management Chain of Custody.....	21
Figure 12. Dataflow overview showing integration of observational and spatial data.	23
Figure 13. File structure for ARCN	24

Executive Summary

One of the most visible changes related to a warming climate in Alaska is the rapid expansion of woody vegetation (e.g., erect shrubs) across open landscapes and into higher elevations. Landbird species select breeding and foraging sites in particular habitat types and structures, and by virtue of their high mobility, have the capacity for rapidly adapting to changes in vegetation by modifying their breeding distributions. Thus, monitoring of landbirds may be useful in indicating ecological responses to climate change in the Arctic.

Landbirds were selected as a “vital sign” for long-term monitoring in the Arctic Inventory and Monitoring Network (ARCN) of the National Park Service. Specific objectives of the ARCN landbird monitoring program include: 1) documenting temporal trends in abundance and occupancy of landbirds; and 2) documenting changes in spatial distribution through time.

This protocol details a route-based survey method applied at three reference sites in the Arctic Network. Routes are resurveyed multiple times in a season and the spatial locations of birds are recorded during surveys. Repeat survey designs account for variation in the probability of availability and provide inference to the superpopulation or all individuals with a non-negligible probability of being present within the sample unit during the sampling period. By making minimal assumptions about the availability process, we expect that monitoring of the superpopulation will provide greater sensitivity to the underlying population dynamics. Recording the spatial locations of individuals allows modeling of abundance as an inhomogenous point process. The advantages of this approach are two-fold: 1) accounting for within-sampling unit variation in abundance; and 2) potentially increased sensitivity to detecting changes in distribution through time.

1 Background and Objectives

Landbird species are highly mobile, short-lived, select particular habitat types and structures for breeding and foraging, and consequently, exhibit considerable sensitivity to environmental change (Martin 1995). Further, they lend themselves to study as indicators of environmental change because they are ubiquitous and form assemblages that integrate a diverse set of life history and ecological characteristics (Martin 1995). Thus, monitoring of landbird populations may provide insight into local and regional environmental change and, consequently, was selected as a component (or vital sign) of the Inventory and Monitoring Program in the Arctic Network of National Parks (ARCN, Figure 1).

One of the most visible changes related to a warming climate in Alaska is the rapid expansion of woody vegetation (e.g., erect shrubs) across open landscapes (Sturm et al. 2001, 2005, Tape et al. 2006) and into higher elevations (Stueve et al. 2011). Recent work in Denali NP showed rapid alteration of the passerine community (Mizel et al. 2016) consistent with observed patterns of climate-induced expansion of woody vegetation across open landscapes in the subarctic and Arctic (Sturm et al. 2001, Tape et al. 2006, Stueve et al. 2011, Roland and Stehn 2014). Most shrub-tundra bird species exhibited upward shifts in their optimum elevation and several forest-associated species showed range expansion near treeline. Other species showed temporal trends in occupancy probability across their elevational ranges or in concert with range shifts indicating that populations are likely changing in abundance as well as spatial distribution (Schmidt et al. 2013, Mizel et al. 2016). Species associated with the shrubline ecotone exhibited the largest shifts (relative to their elevational breadth) and occupancy declines of the species that were considered.

In addition, under climate warming, population declines and/or reductions in fitness in high latitude birds have been associated with reduced availability of food resources (Pearce-Higgins et al. 2010), greater environmental stochasticity (Jarvinen 1994, Martin and Wiebe 2004, Wilson and Martin 2012), and the decoupling of their arrival phenology with seasonal food availability (Both and Visser, 2001, Visser et al., 2004). Thus, monitoring of landbirds may be useful in indicating ecological responses to climate change in the Arctic. Specific objectives of the Arctic Network's landbird monitoring program include: 1) documenting temporal trends in abundance and occupancy; and 2) documenting changes in spatial distribution through time (i.e., relative to vegetation distribution as indicated by remote sensing data). Our inference objectives do not include making predictions outside of our study areas – inference is to three reference study areas. We expect that alteration of landbird communities in the Arctic will occur through the convergence of strong distributional change across multiple geographic dimensions (e.g., latitude and topographic) (Mizel et al. 2016). This type of change may trigger complex and potentially transitory changes in species interactions and community structure, and thus presents challenges for accurate prediction of the community trajectory into the future (Suttle et al. 2007, Gilman et al. 2010, Mizel et al. 2016).

Although monitoring of a few shorebird species may be possible, the methods detailed here are tailored towards monitoring passerines. We anticipate having sufficient data for monitoring the following passerine species at one or more of the study areas: Bluethroat (*Luscinia svecica*),

Northern Wheatear (*Oenanthe oenanthe*), American Pipit (*Anthus rubescens*), Horned Lark (*Eremophila alpestris*), American Robin (*Turdus migratorius*), Gray-cheeked Thrush (*Catharus minimus*), Arctic Warbler (*Phylloscopus borealis*), Wilson's Warbler (*Wilsonia pusilla*), Orange-crowned Warbler (*Vermivora celata*), Yellow Warbler (*Setophaga petechia*), American Tree Sparrow (*Spizella arborea*), Savannah Sparrow (*Passerculus sandwichensis*), White-crowned Sparrow (*Zonotrichia leucophrys*), Golden-crowned Sparrow (*Zonotrichia atricapilla*), Fox Sparrow (*Passerella iliaca*), and Lapland Longspur (*Calcarius lapponicus*).

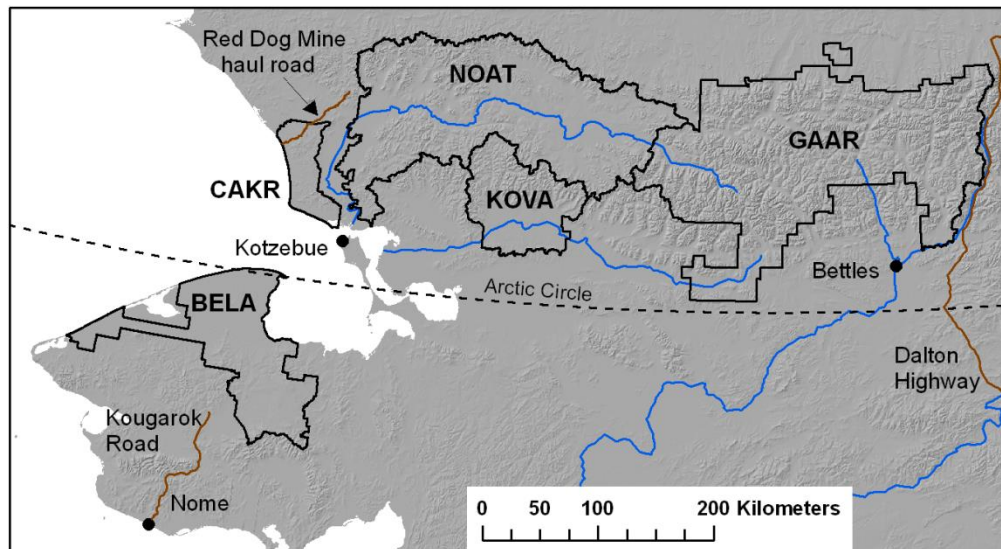


Figure 1. The NPS Arctic Inventory and Monitoring Network (ARCN). BELA – Bering Land Bridge National Preserve, CAKR – Cape Krusenstern National Monument, GAAR – Gates of the Arctic National Park and Preserve, KOVA – Kobuk Valley National Park, NOAT – Noatak National Preserve. CAKR, KOVA, and NOAT are combined administratively into the Western Arctic Parklands (WEAR). The three locations with commercial and charter air services (Bettles, Kotzebue, and Nome) are shown. The Red Dog Mine haul road is the only road in the network.

2 Sampling design and methods

2.1 Inference methods

Historically, unadjusted count data has formed the basis for inferences about the population dynamics and distribution of bird species (Nichols et al. 2009). Recent decades have seen a greater recognition that variation in detection probability, if ignored, may confound variation in abundance and occupancy (e.g., Farnsworth et al. 2002, 2005, Rosenstock et al. 2002, Alldredge et al. 2007, Nichols et al. 2009). Emphasis has been placed on the development of survey methodologies and hierarchical modeling approaches that conceive population sampling in terms of explicit, probability-based state and observation processes unified by their conditional relationship to one another (Royle and Dorazio 2008). A variety of survey methods are available for adjusting landbird counts including repeat surveys (Royle 2004), distance sampling (Buckland et al. 2001, 2004), time of detection methods (Farnsworth et al. 2002, Alldredge et al. 2007), double observer methods (Alldredge et al. 2008, Nichols et al. 2000), and various combinations of the aforementioned (Chandler et al. 2011, Sólymos et al. 2013, Amundson et al. 2014). However, these methods vary in terms of the components of detection probability that they estimate and consequently, provide inference to subsets of the ‘superpopulation’; i.e., the population comprised of all individuals with a non-negligible probability of being present in the sample unit over the survey period (Kendall et al. 1997, Nichols et al. 2009, Schmidt et al. 2013).

In a review of inference methods for landbirds, Nichols et al. (2009) decomposed the detection process into four primary components including the probability that: 1) the bird’s home range overlaps the sampling unit, p_s ; 2) the bird is present within the area exposed to sampling during the survey occasion, p_p ; 3) the bird is available for detection during the survey occasion, p_a ; and 4) the bird is detected given that it is present and available, p_d . The first of these components, p_s , is a function of the spatial distribution of territories relative to the locations of sampling units. The complement of p_p is the spatial temporary emigration probability while the complement of p_a is the random temporary emigration probability, which in passerines depends largely on survey timing relative to the phenology of individual species and diurnal variation in singing rate (Kéry et al. 2005, Schmidt et al. 2013, Kéry and Royle 2016).

Single-visit distance sampling typically only addresses p_s (through survey design) and p_d (through the detection function). When the components of temporary emigration, p_p and p_a , are not directly estimated, inference is limited to some unknown proportion of the superpopulation and abundance estimates are negatively biased (Nichols et al. 2009, Chandler et al. 2011, Schmidt et al. 2013). In a similar context, studies that do not explicitly account for distance-related heterogeneity in detection ultimately estimate abundance for an unknown plot size (Efford and Dawson 2009, 2012). Overall, estimates of superpopulation abundance (i.e., repeat survey designs) require fewer assumptions about temporary emigration processes and, consequently, should have greater sensitivity for assessing population and spatial dynamics.

Here we adopt a repeat survey approach while also recording the spatial locations of individuals (Mizel et al. 2018). This provides us with the flexibility of explicitly accounting for spatial and

random temporary emigration processes (p_p , p_a) in a point process model (Kéry and Royle 2016) or a distance sampling analysis (Chandler et al. 2011) or simply using site-occupancy (MacKenzie et al. 2002, Royle and Nichols 2003, MacKenzie et al. 2006) and N-mixture models (Royle 2004, Kéry et al. 2005, Schmidt et al. 2013) which estimate a single composite of detection probability.

2.2 Previous monitoring efforts

ARCN occupies over 20 million acres, about one-fourth of the entire area of NPS-administrated lands in the United States (Figure 1). There is only one developed road in the network, the Red Dog Mine haul road (or DeLong Mountain Transportation System, DTMS), 75 km (47 miles) long and itself accessible only by air or boat. All landing sites in the parks are undeveloped (i.e., a lake, river, river gravel bar, etc.) and are subject to takeoff and landing hazards.

Efforts to monitor avian assemblages in Arctic Network parks have sought to balance logistical feasibility, the need to account for incomplete detection, and the power to detect changes in population size and distribution. Early monitoring efforts in Arctic Network parks focused on riverine bird assemblages and, in lieu of reliance on intensive air support, used river floating as the primary means of gaining spatial inference (DeGroot and McMillan 2012). However, these surveys were largely restricted to riparian habitats limiting inference to broader scale ecological patterns including changes in distribution relative to vegetation. Expected changes in the spatial distributions of bird species in the Arctic make it important to sample across the elevational gradient (i.e., vegetation communities) rather than restrict surveys to riparian areas.

2.3 Site selection and annual rotation

Due to budgetary restrictions and logistical challenges, we could not sample across the range of ecoregions within the network. It was necessary to focus on one general ecoregion at a series of reference sites in order to monitor a similar suite of species. Specifically, we targeted an open shrub-tundra to alpine gradient along the north side of the Brooks Range. Three reference sites were chosen for sampling: Anaktuvuk Pass, Primus Creek, and Kelly Bench (Fig. 2). All three study areas cover elevational gradients that encompass vegetation communities from lowland to alpine habitats with open shrublands, *Dryas* and/or mixed dwarf shrub tundra, and barren slopes (Figure 3). Such characteristics provide an opportunity for inferences about passerine distributional shifts related to shrub expansion into open habitats.

The level of annual sampling effort (1 study area per year) was based in part on funding for a crew of 4 (1 wildlife biologist, 1 biological technician, and 2 volunteers/interns) with the potential addition of 2 volunteers for two weeks in early June. In addition, moving the crew to several sites (all by bush-plane) would increase costs significantly while also complicating logistics and reducing survey time. Waiting for bush plane transport involves packing everything up and not surveying, often for several days if the weather conditions are poor. While in some years the weather may be cooperative, 1-2 survey days are lost every time camp is moved. Further, our survey protocol involves conducting repeat surveys at different periods during the breeding season to estimate seasonal variation in detection probability. Both from a logistical and budgetary standpoint, we could not rely on constant air support to survey across a broad area while also conducting 3-4 repeat visits spaced several days apart. Ultimately, we concluded that surveying 2-3 smaller sites/year for marginally greater spatial

inference was not worth the reduced survey time, increased costs, and greater logistical complexity. The additional sites would still be inconsequential relative to the size of the Arctic Network and, based upon our experience trying to get to these sites, we emphasized logistical simplicity in the design in order to increase efficiency and fit within budgetary constraints. A feasible, efficient and affordable annual effort was to establish a basecamp at one site and conduct repeat surveys in an outward fashion.

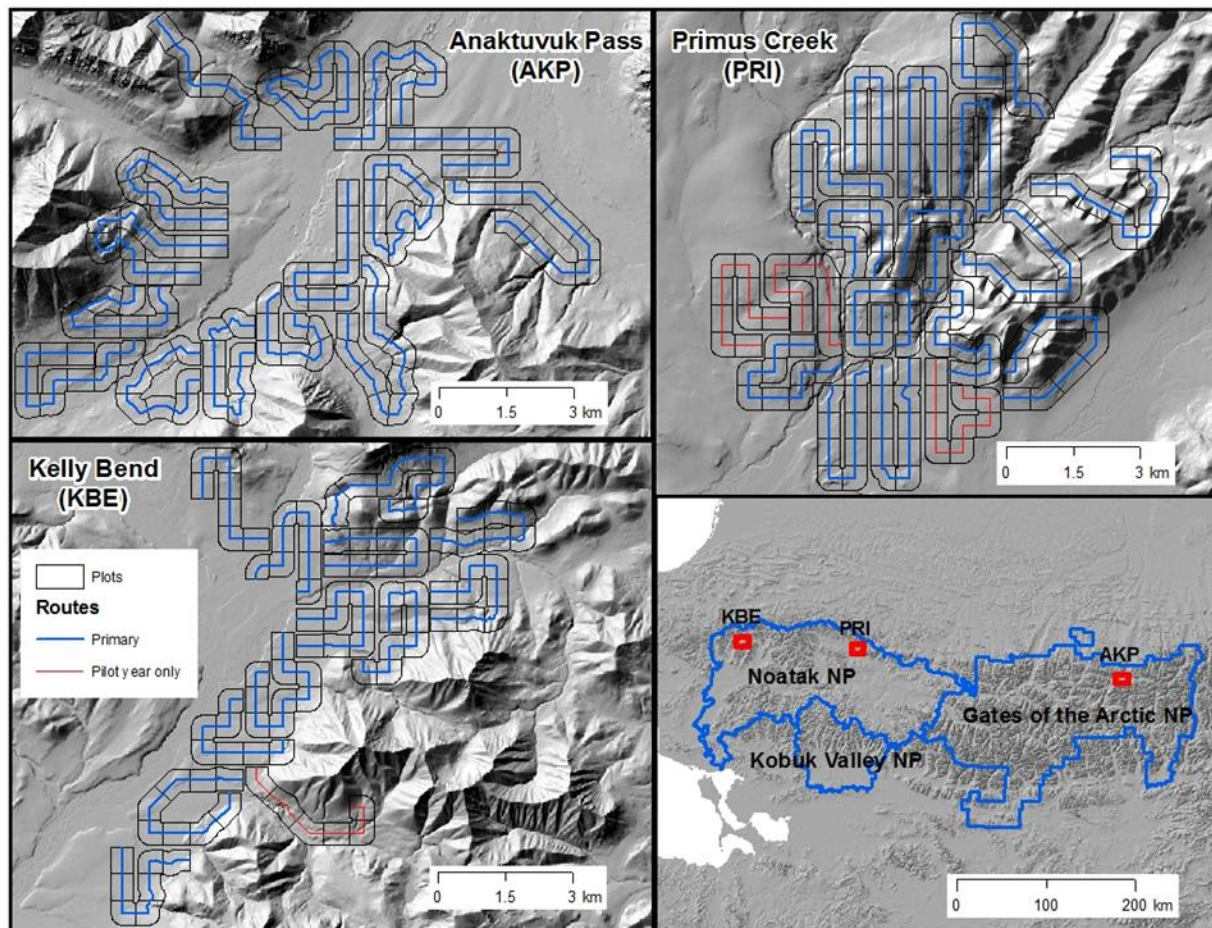


Figure 2. ARCN landbird study sites. The Anaktuvuk Pass (AKP) study area is located on Nunamiut Corporation and Arctic Slope Regional Corporation (ASRC) inholdings. We did not locate any surveys within 1.8 km of the village.

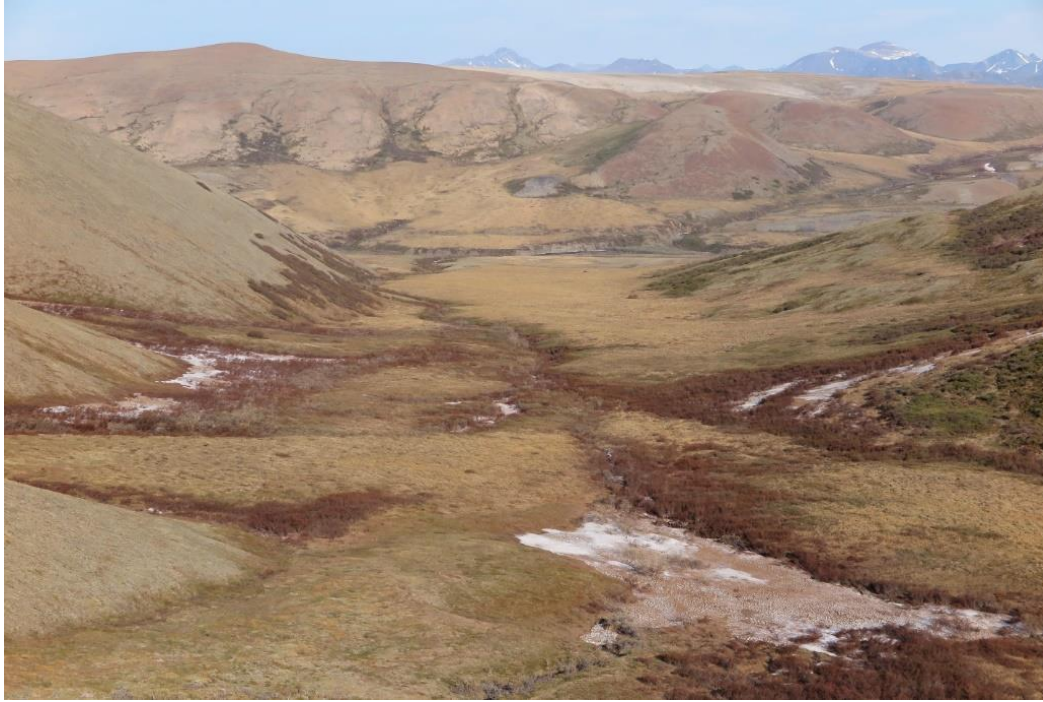


Figure 3. Elevational gradient within the Primus Creek study site (photo: Jared Hughey).

Study areas were located at montane sites on the north side of the Brooks Range that were accessible by commercial air service (Anaktuvuk Pass) or wheeled multi-passenger bush plane (Primus Creek and Kelly Bench). We excluded areas that were only accessible by helicopter due to cost, potential disturbance to wildlife, and designation of portions of the network as Wilderness. We did not consider sites that were only accessible by aircraft on floats because lakes in the Brooks Range generally become ice-free after June 15, precluding sampling during the period of peak passerine singing (and detectability) at these sites (Thompson et al. 2017). River bar landing strips were often marginal due to the potential for these to be covered in aufeis or washed out in some years. We learned of tundra-bench landing strips accessible by multi-passenger planes primarily through conversations with bush plane pilots. Selection was also based on the restriction that sites contain a relatively large area of moderate terrain; i.e., an area containing terrain with <25 degree slope in which we could locate ≥ 12 survey routes within 8 km of the airstrip. The two remote sites that we selected are regarded as good-condition landing strips that are accessible by multi-passenger bush planes. Further, data from MODIS satellite (Moderate Resolution Imaging Spectroradiometer) indicates that both landing strips are on average snow-free on or before May 24, permitting sampling during peak singing. In general, we rejected sites (e.g., Copter Peak landing strip) because they didn't provide access to a large enough area of moderate terrain to make sampling from a basecamp efficient.

We envision a three-year rotation of study sites. Anaktuvuk Pass, Primus Creek, and Kelly Bench (Figure 2) were first surveyed in 2015, 2016, and 2017, respectively. Variation in species composition and density is already apparent and stochastic temporal variation is also expected. While each site will be surveyed only ~ 3 times over a 10 year period, we expect that our inference methods

will have increased sensitivity to the underlying spatial and population dynamics compared to single-visit, distance sampling approaches. We are recording and framing inference around the individual encounter locations allowing us to exploit the spatial information inherent in the location of encounter for potentially stronger inference about spatial processes (Mizel et al. 2018). In contrast, standard model-based approaches aggregate encounters at the plot-level and rely on plot-level effects for explaining spatial variation in density. This approach induces over-dispersion when density varies within plots (due to non-uniform vegetation within plots) (Mizel et al. 2018). Using simulations from an inhomogeneous point process, Mizel et al. (2018) demonstrated increased precision and reduced bias from their spatial distance sampling model compared to standard model-based approaches. Specifically, the coefficient of variation (CV) for the population size estimate from the spatial distance sampling model was reduced by 25% compared to the standard model-based approach. In addition, we expect that accommodating temporary emigration through repeat surveys will reduce the amount of stochastic temporal variation in our estimates overall (Mizel et al. 2018).

Further, the Arctic Network data will be jointly analyzed with data from the Central Alaska Network, allowing borrowing of information about detection probability parameters. We will have three off-road study areas and three on-road study areas in the Central Alaska Network. Off-road sampling in the Central Alaska Network follows the Arctic Network protocol.

2.4 Route establishment

Studies of avian population ecology in remote areas face considerable logistical challenges making it critical to develop efficient survey designs for these landscapes. Previous studies in ARCN used point transect sampling designs, typically with 500-800 m spacing between points. In these studies, the time spent off-survey or in transit was ~5-6 times that spent on-survey. Here, we adopt a continuous on-effort survey along fixed survey routes (Mizel et al. 2018). Theoretically, as survey effort increases (e.g., time or route length), the population that is exposed to sampling during a survey occasion will approach the ‘true’ population size (Royle and Dorazio 2006). Thus, relative to point counts, the continuous on-effort, line transect method would be expected to result in an increase in the probability of exposure to sampling.

To establish routes, grids comprised of 600 m x 600 m cells were centered on access points including (see inset for Figure 4): the village of Anaktuvuk Pass in GAAR (9.0 x 13.2 km grid), an airstrip near Primus Creek in NOAT (10.8 x 10.8 km grid), and an airstrip near the confluence of Kuruk Creek and the Kelly River in NOAT (10.8 x 9.6 km grid) (Figure 2). The Anaktuvuk Pass (AKP) study area is located on Nunamiut Corporation and Arctic Slope Regional Corporation (ASRC) inholdings. We did not locate any surveys within 1.3 km of the village (Figure 2).

In the pilot year at each study area, we established fixed survey routes through the center of grid cells (Figure 4 and Figure 5 inset). Routes were designed to be completed in a single day and, thus, bisect 7-11 cells and average 5.4 km in length. Survey routes were allowed to bend primarily to return observers close to their original starting point and a series of camps from which multiple routes may be accessed. The overall strategy was to establish a series of routes that radiated out from the basecamp/village and then another layer of routes beyond the latter which could be accessed by a series of spike camps (Figs. 6-7). In general, routes were located such that they intersected the

centroid of each cell and then were deflected at an angle of 0 or 90 degrees (i.e., followed a parallel or perpendicular direction) (Figure 4). In some cases, we shifted routes off of the central axis of the cell due to the presence of terrain features (e.g., cliffs and creeks). These routes were either curvilinear or passed diagonally through cells (Figure 4).

Routes and survey grids were first created in ArcGIS, and then uploaded to GPS units. On the very first survey of each route, crews attempted to follow the initial version of the route, but were allowed to redirect routes in order to avoid steep topography, dense, tall shrub thickets, and high flow creek crossings. Crews then uploaded their track files to ArcGIS where they were edited and re-uploaded to the GPS units. These are to be considered the final version of the routes.

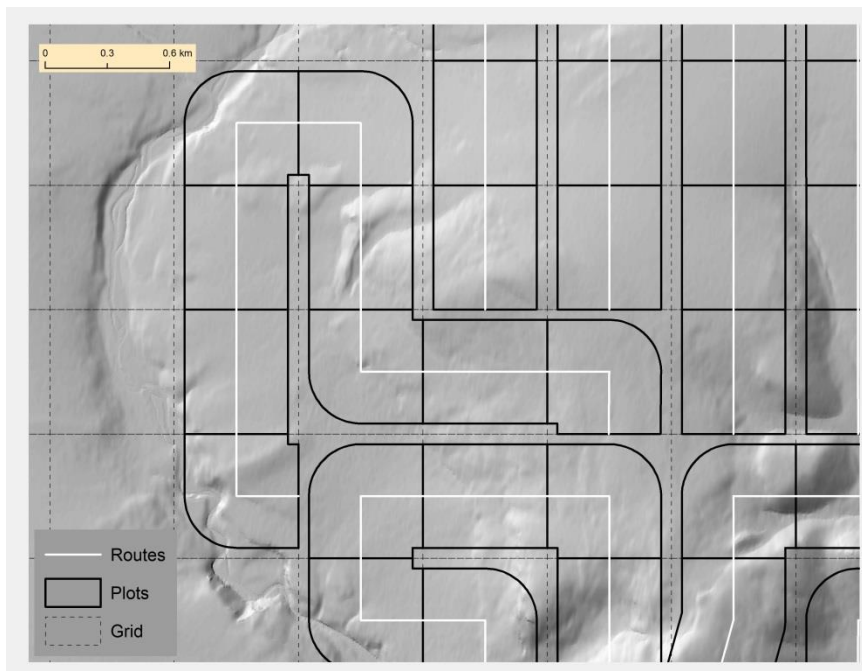


Figure 4. In general, routes were located such that they intersected the centroid of each cell and then were deflected at an angle of 0 or 90 degrees (i.e., followed a parallel or perpendicular direction).

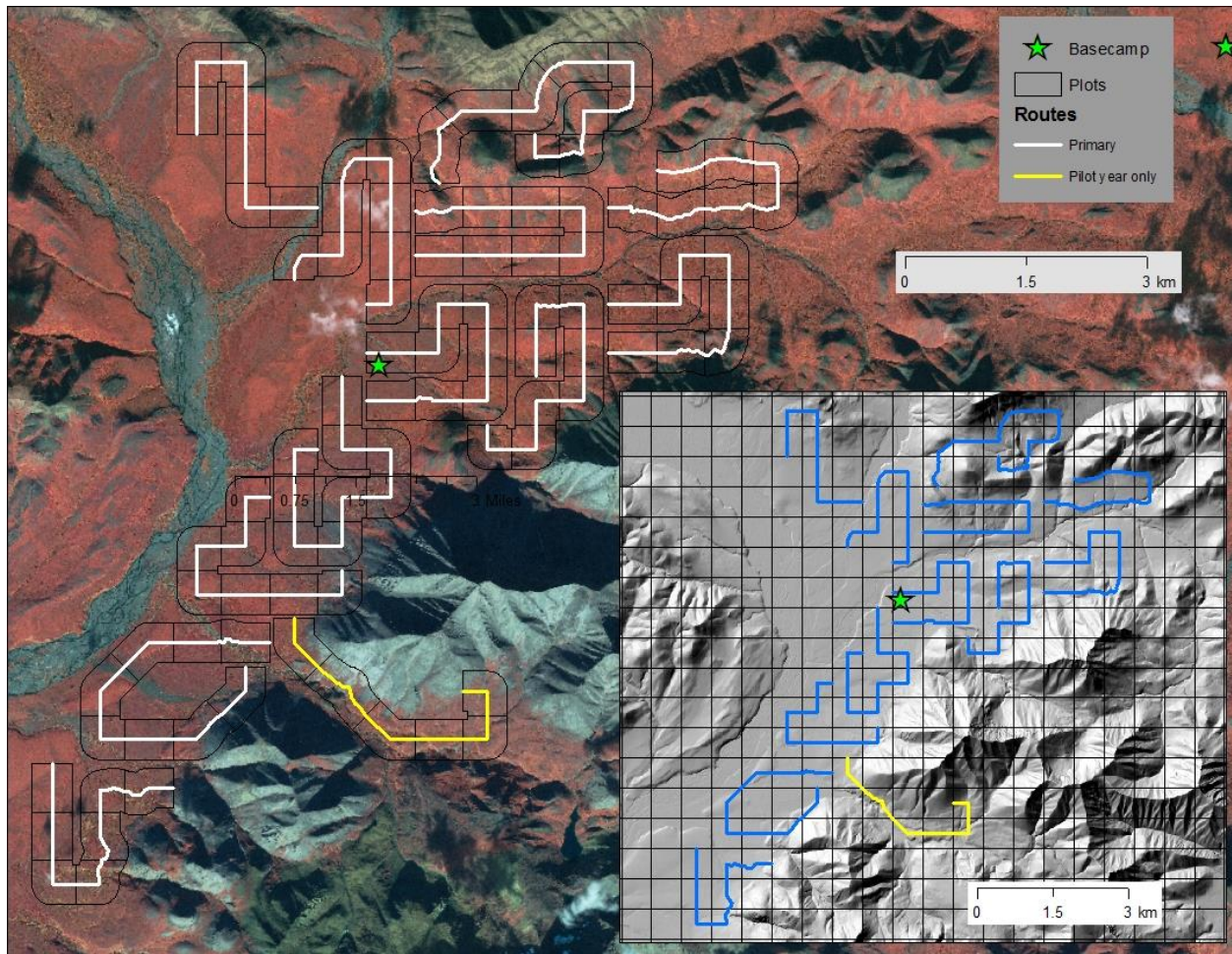


Figure 5. Kelly Bench routes and basecamp/airstrip (green star). The inset shows the 600 x 600-m grid used to locate the survey routes.

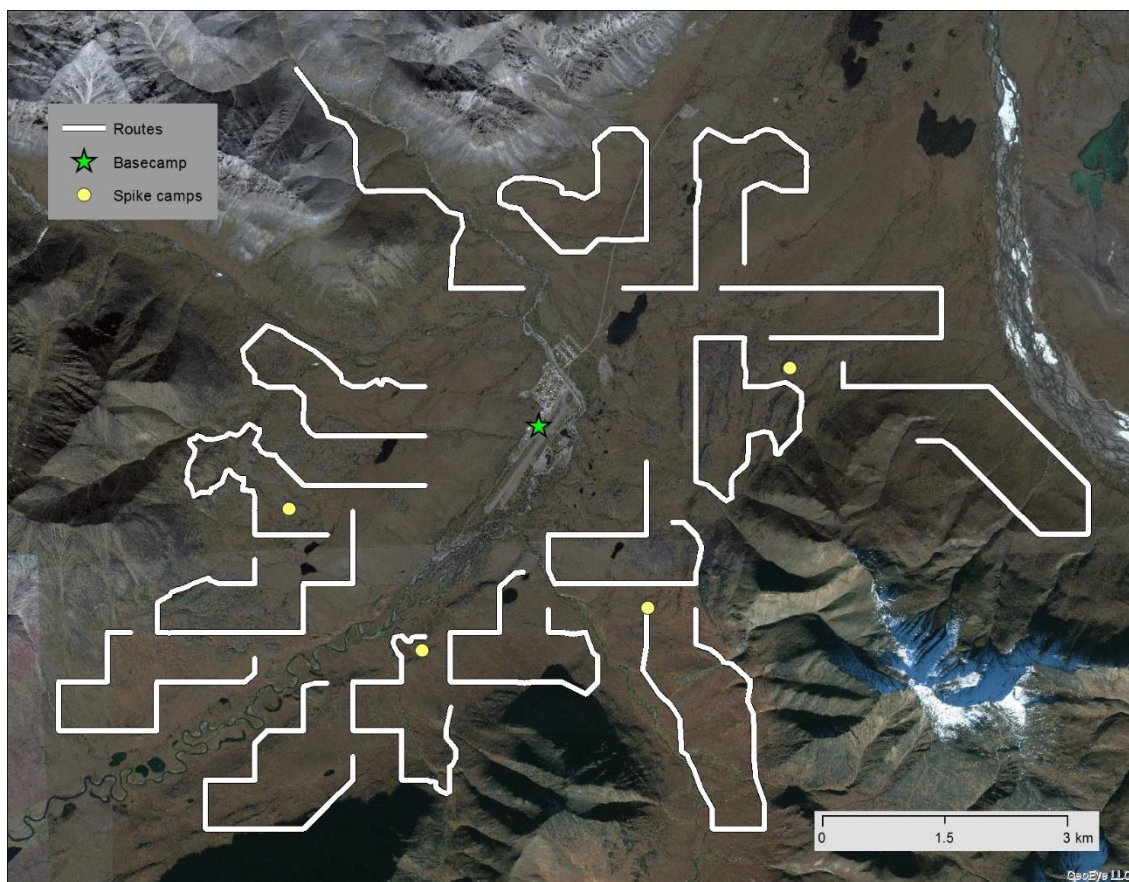


Figure 6. The Anaktuvuk Pass study area is located on Nunamiut Corporation and Arctic Slope Regional Corporation (ASRC) inholdings. We did not locate any surveys within 1.3 km of the village (green star).

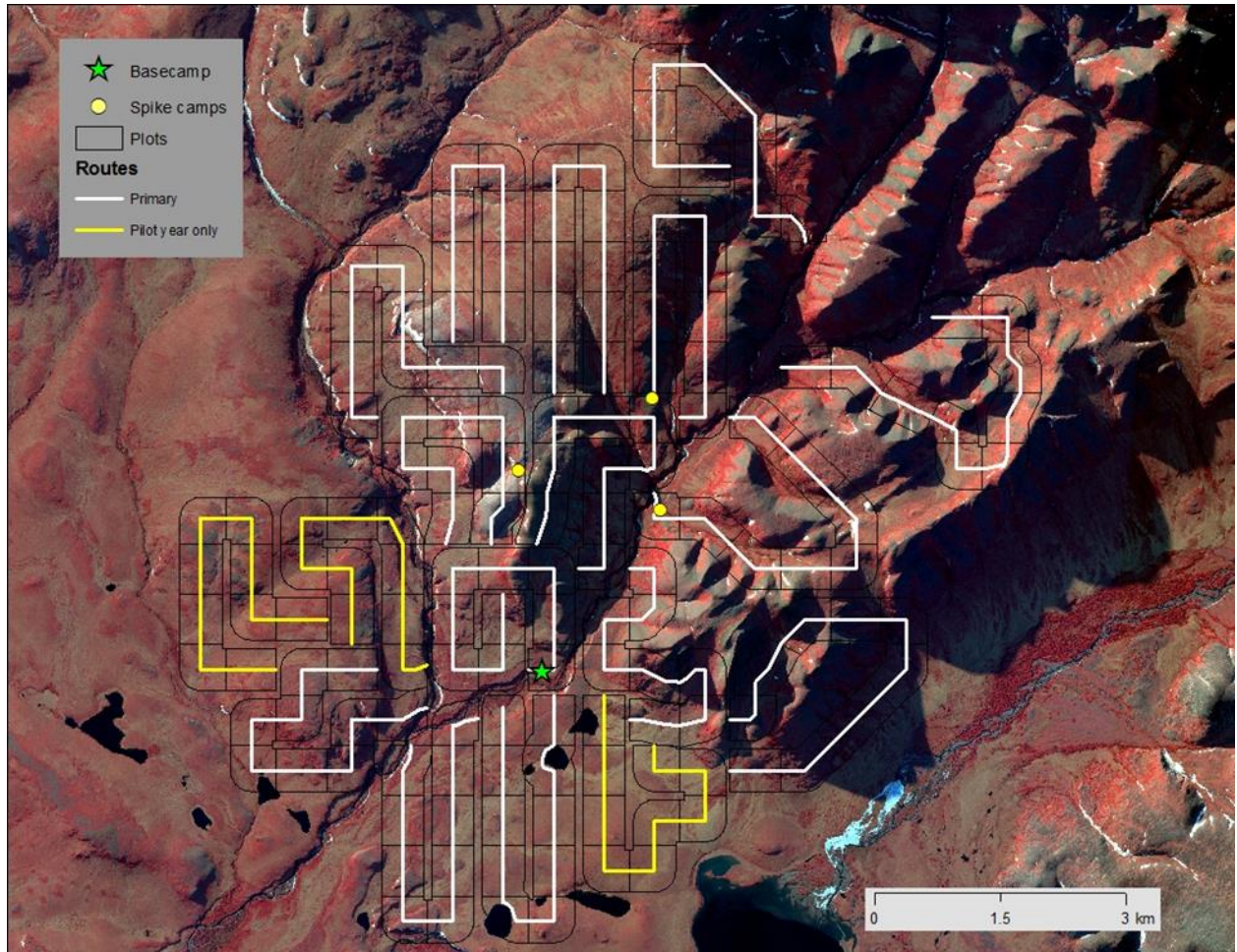


Figure 7. Primus Creek routes and spike camp locations (yellow markers). The basecamp (green star) is located at the airstrip.

2.5 Defining plots

Again, the analysis of these data is expected to evolve and we have flexibility in defining the sample units because we are collecting the encounter locations of individuals; i.e., the sample units are somewhat arbitrary at this point. For example, it is possible to analyze these data by imbedding each route within an individual state-space and make inference to the number of territory centers in the state-space (Mizel, unpublished data). However, for consistency, we detail below the sample unit delineation used for the spatial distance sampling case study in Mizel et al. (2018). In this analysis, the nested structure was as follows: 1) study area; 2) route; and 3) plot.

To define plots, routes were buffered by 250 m and divided into a series of plots, in general, by clipping the buffered area using the grid cell boundaries (Figures 5-7). Thus, the grid cells were only a mechanism to systematically locate the routes on the ground during the first year a study area was visited. The plots (or the truncated survey strips) serve as the sample units.

We used 250 m as the maximum truncation distance because observations >250 m comprise <5% of the data for all shrub-tundra passerine species and truncation of this outlying portion of the data generally improves estimation of the detection function (Buckland et al. 2001). Defining a maximum truncation distance for all species also helps streamline post-processing of the bird location data in ArcGIS (i.e., spatially associating birds with plots), but leaves flexibility to use species-specific truncation distances in spatial distance sampling analyses.

The number of spatial replicates at each study area was as follows: 15 routes and 132 plots at Anaktuvuk Pass; 15 routes and 134 plots at Primus Creek; and 12 routes and 94 plots at Kelly Bend. In total, there are 42 routes and 360 plots.

2.6 Bird surveys

Surveys are conducted by two-person teams comprised of one experienced bird surveyor and one data recorder. Observers navigate the survey routes as displayed on their GPS units and communicate observations (species, detection type, bearing, distance, etc.) to the recorder. Each route is surveyed as if it is one continuous line transect; i.e., only one observation per individual bird is recorded during a given route-visit. Upon detecting a bird, the observer takes a waypoint and estimates a distance and bearing to bird, allowing us to later derive the bird's location. Following the field season, observations are associated with plots by projecting them over the plot polygons in ArcGIS. Routes are revisited multiple times in a season (e.g., 3-4 visits/route). See SOP #2 for further details.

2.7 Survey timing

Site access varies annually according to spring snow cover. In general, surveys should be conducted between approximately May 21 – June 27; e.g., Anaktuvuk Pass (23 May – 29 June, 2015) and Primus Creek (21 May – 19 June, 2016). The condition of the airstrip (including snow cover persistence) can be checked by a flyover prior to the planned arrival date for the crew. Each year, the plan should initially be to arrive at the site on May 20 with the possibility of delays according to airstrip condition. In an early year, you may arrive on May 20 and a large proportion of the sparrow, Lapland Longspur, American Pipit, and Horned Lark) populations will already be present and at peak singing. In the average year, it may be a week or so later when the bulk of the sparrows and longspurs have arrived. Irving (1960) detailed the arrival of migrants near Anaktuvuk Pass including observations that most American Pipits had arrived by May 19 in one year, while Horned Larks were often present in April and early May.

The end date for the surveys will also be variable. Once fledglings begin to appear in numbers later in June, the character of the surveys changes; singing is replaced by chipping and, as soon as one pair starts chipping, it triggers chipping by adjacent pairs as you walk through their territories. We have noticed this behavior occurring among the sparrows usually in the last week of June. This also coincides with a precipitous decline in the singing rates of some of the later arriving species (e.g., Northern Wheatear, Bluethroat, and Golden-crowned Sparrow). While some of the riparian species are still singing at high rates later in June, the survey effort often becomes inefficient around June 23 – June 27.

A good strategy is to attempt to conduct 3 repeat surveys of lowland tundra and alpine sites before mid-June while also ensuring that at least 2 repeat surveys of upland, shrubby sites are conducted May 31–June 12. The former is important because detectability of Lapland Longspurs, an abundant species at lowland sites, and Northern Wheatear, an alpine species, declines precipitously in mid-June, making surveying later in June relatively inefficient. Adopting the latter strategy allows for monitoring occupancy of Bluethroats, which appear to arrive in late May and early June and display for approximately 10-14 days, after which they are virtually undetectable during surveys. Bluethroats appear to cease flight displays and singing following clutch completion (Merilä, and Sorjonen 1994). As for surveying late in the season, species associated with riparian and upland, shrubby habitat (other than Bluethroats) are still relatively detectable after June 15. It is important to schedule re-visits with this in mind.

3 Data management

3.1 Data Management Life Cycle

Data management for the Arctic Network landbird monitoring program will proceed through an ongoing life cycle as shown in Figure 8, (NPSa 2008). Major stages of the life cycle include protocol development, data collection, quality control and database integration, dataset certification, product documentation and archival, and data analysis and reporting (NPSb 2008).

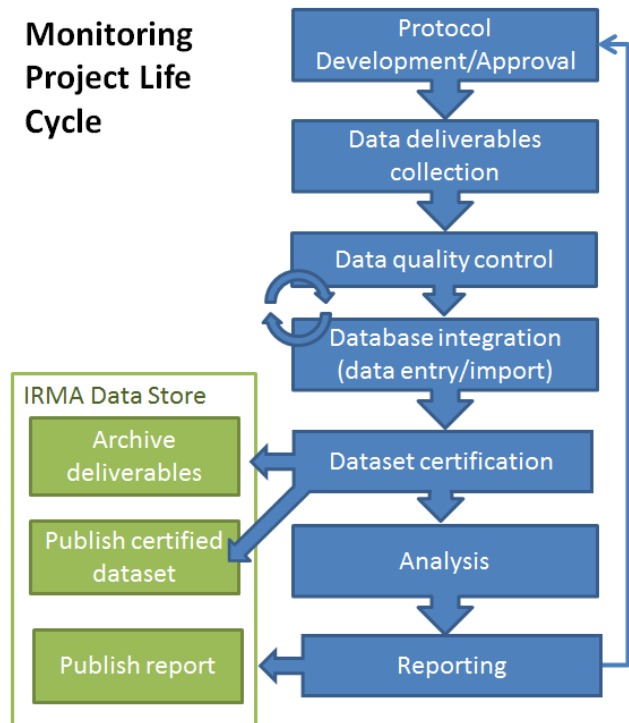


Figure 8. Long term monitoring project data management life cycle.

Major components of the data management life cycle are discussed below. Specific procedures given in the accompanying landbirds standard operating procedures document.

3.1.1 Data Quality

Director's Order #11B mandates a high level of information quality from the service's scientific programs:

“The National Park Service will ensure that information it releases will be developed from reliable data sources and will otherwise ensure information quality at each stage of information development. The NPS's methods for producing quality information will be made transparent, to the maximum extent practicable, through accurate documentation, use of appropriate internal and external review procedures, consultation with experts and users, and verification of the quality of the information disseminated to the public. The NPS will also keep users informed about corrections and revisions.

Information will be developed only from reliable data sources based on accepted practices and policies utilizing accepted methods for information collection and verification. It will be reproducible to the extent possible. Influential information will be produced with a high degree of transparency about data and methods. The information should include all pertinent information to allow the public to understand the park's legislative authorities, mission, activities, organization, strategic plan, performance plan, and performance accomplishments.”

Director’s Order #11A section 5.8: Data Integrity Standards outlines the NPS policy for accuracy, completeness and review:

“All information owners will maintain all official NPS records and data in a manner which meets the highest data integrity standards, including timeliness, accuracy and completeness (also see DO #19). Each information owner will take what ever steps necessary to ensure that NPS systems have sufficient data quality reviews and audits from both an internal system perspective, as well as externally thorough control reviews.”

Adherence to the data management procedures in this monitoring protocol will ensure compliance with DO#11.

3.1.2 Freedom of Information Act

The Network will comply with all FOIA restrictions regarding the release of data and information as instructed in NPS Director’s Order #66B.

3.1.3 Records Management

Direction for managing physical and digital materials is provided in NPS Director’s Order 11D.

“The NPS has a strong business need for excellent records management, in that the Service’s mission is to care for natural and cultural resources so that they are left “unimpaired” for future generations. This requirement for managing resources in perpetuity sets a high standard for record keeping. No resources can be managed well in the future without complete records of how they were managed in the past. Because the NPS manages some of America’s most significant cultural and natural resources, the public also has a significant interest in our records. Section 1.9.2 of NPS Management Policies 2006 (NPS 2006) states that the future of the Service depends on the availability, management, dissemination, and preservation of information, and directs the agency to implement professional quality programs to manage information resources.”

3.1.4 Core Functional Model

Data generated by the landbird monitoring program are managed according to the Core Functional Model described in Figure 9.

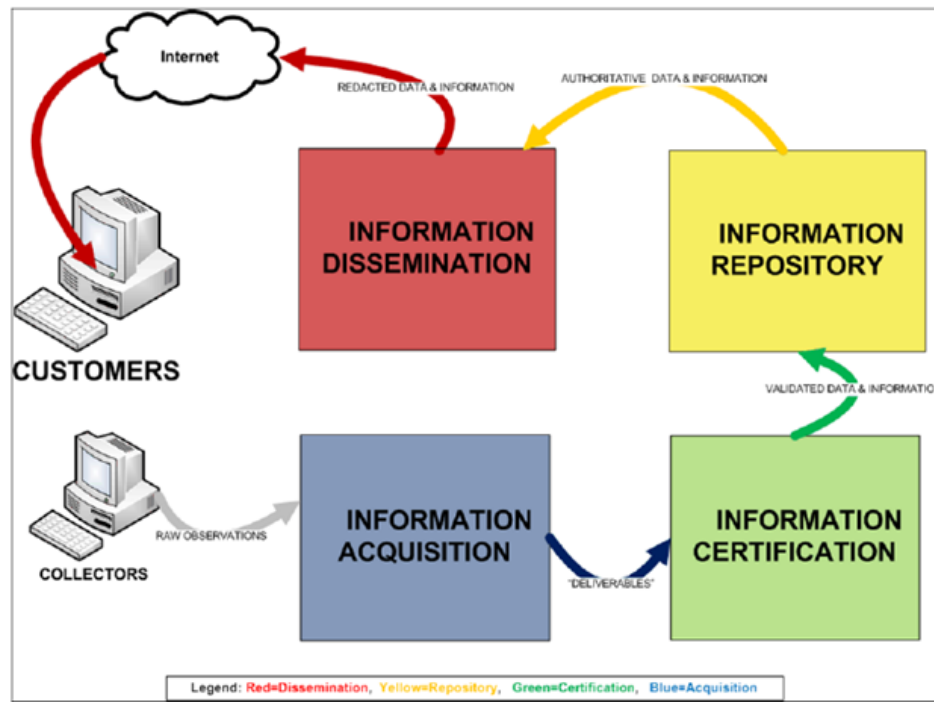


Figure 9. The ARC Core Functional Model overview.

Dissemination services (red, Figure 9) provide all deliverables to all customers using internet web sites and web services through the NPS Integrated Resource Management Applications (IRMA) Data Store (<https://irma.nps.gov/DataStore/>). Repositories (yellow) store the certified inventory and monitoring products called for in the protocols. Certification processes (green) assure repositories have the highest quality data and that sensitive items are restricted to authorized users. Data acquisition processes (blue) led by park staff and cooperators include a wide array of tasks, ranging from collecting raw data to composing reports on long-term trends.

3.1.5 Data Sensitivity Statement

The ARC/CAKN landbird monitoring protocol does not collect sensitive data and requires no special handling procedures.

3.1.6 Roles and Responsibilities

The project leader is responsible for the timely completion of all data management tasks outlined in this protocol. The Network data manager maintains the hardware and software platform in support of the Vital Sign's data stream, provides for data security, accessibility and longevity and gives technological support and guidance in all aspects of data management activities.

3.2 Quality assurance and control

Quality control (QC) is proactive consisting of planned activities for ensuring quality in the processes where data are developed. Quality assurance (QA) is a framework for preventing errors. QC is reactive and focuses on verifying data, identifying and correcting defects or errors in final products. QC is a framework for correcting errors where QA is the method for preventing them.

3.2.1 Quality assurance

The ARCN landbird Vital Sign plans for high data quality assurance by proactively deploying a system of administrative procedures and technological safeguards:

- Standard operating procedures designed to minimize the introduction of errors during data collection and processing.
- Field crew training.
- Standard database controls including a relational data model, constraints, and logical business rule enforcement (Frakes et al. 2015).
- Standard front end application controls (Frakes et al. 2015).
- Deliverables schedule with data product specifications.
- Dataset certification procedures.

3.2.2 Quality Control

Ensuring high data quality as a high priority for the landbird Vital Sign. Quality control procedures focus on verifying data as well as identifying and correcting errors in final data products. Quality control safeguards include:

- Data verification of the database against the original paper datasheets (SOP #4).
- Graphical and visual exploratory data analysis
- Periodic data quality checks while in the field by the crew leader or PI.
- Data quality checks including viewing of the data in ArcGIS.
- Visual data verification
- Database generated data quality reports

3.2.3 Deliverables Schedule

The landbird monitoring program creates and maintains specific data deliverables (Appendix A). Each deliverable is disseminated directly from the IRMA Data Store, the single authoritative source for Network products. In the event that a data product ever diverges from that in the IRMA Data Store the latter version should be considered authoritative.

3.3 Product archival and documentation

Director's Order 19 states that all records of natural and cultural resources and their management are considered mission-critical records (necessary for fulfillment of the NPS mission) and must be permanently archived. Mission critical deliverables are considered to be archived when they are uploaded to the IRMA Data Store. With few exceptions IRMA is the only authoritative repository for mission critical I&M products.

Data archiving is done in concert with seasonal close out and dataset certification. All data are archived in the following ways:

- IRMA Data Store. Formats may include:
 - Raw and processed data files described in this protocol's deliverables schedule (Appendix A).
 - Certified dataset: human and machine readable text file of the master landbird monitoring database.
- Network file server.

Landbird monitoring data are maintained on a network file share located in the Fairbanks Administrative Center (FAC) in Fairbanks, Alaska. The certified database content is backed up to off-site storage and also copied to a database server at the NPS Natural Resource Stewardship and Science Directorate (NRSS) in Denver, Colorado. The NRSS and FAC use enterprise-level business continuity processes to maintain their version of the landbird database. In the event of catastrophe at one site, the original data may be restored from the other.

3.3.1 IRMA Data Store

The IRMA Data Store is the primary organizational repository and publication platform for information related to the landbird monitoring program. The landbird Vital Sign has a single master IRMA project reference (<https://irma.nps.gov/DataStore/Reference/Profile/2219895>) to which all products are related (Figure 10).

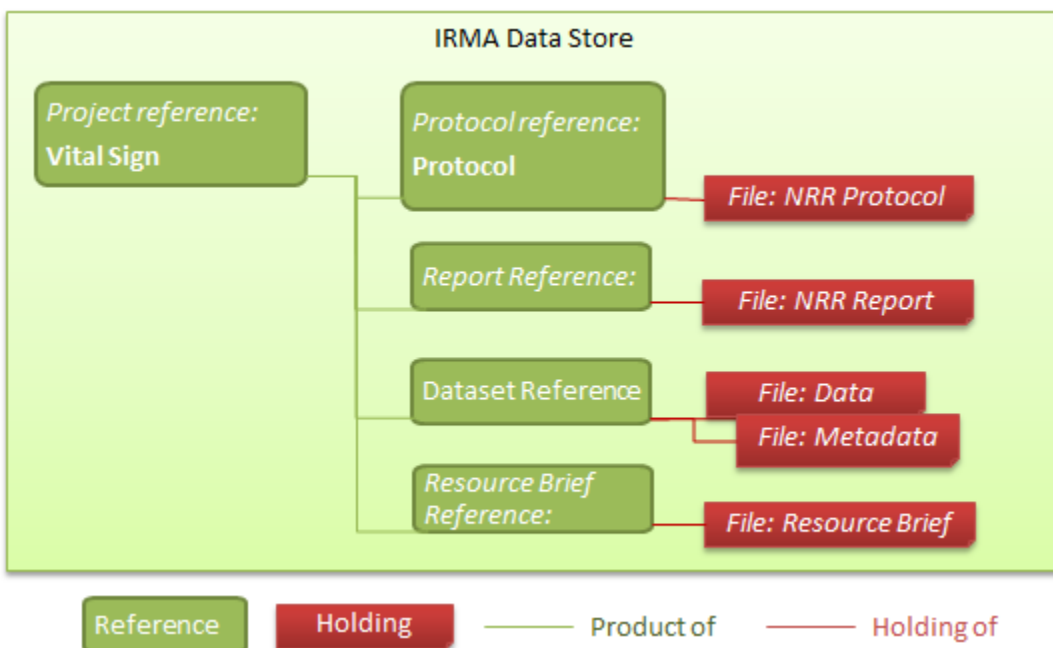


Figure 10. Standard Vital Sign Project reference architecture in the IRMA Data Store.

The public Vital Sign web page covering landbird monitoring will publish the releasable contents of this reference and its related references via web services. It is the joint responsibility of the PI and the data manager to keep the system of related IRMA Data Store references up to date.

3.3.2 Reports

Reports are published in the NPS Natural Resource Report publication series (<http://nature.nps.gov/publications/nrpm/index.cfm>) or professional journals. Reports and journal articles reporting analytical results will be published in tandem with the dataset that was used.

Natural Resource Reports are automatically tracked and announced to Network program managers and data managers but journal articles are not. The PI will create Data Store references for journal articles related to monitoring, link them to the Vital Sign's IRMA Project reference (Figure 10) and notify Network staff of their presence.

3.3.3 Data

All reports providing statistical results will also publish the data on which they were based. Metadata will be provided as well as a link to the certified original dataset (NPS 2005). Data are made available through the IRMA Data Store in machine readable formats according to Director's Order #11A and as mandated by the Federal Open Data Initiative (Executive Order No. 13642).

The landbird Vital Sign will have a single public dataset reference in the IRMA Data Store to which certified data will be published (Figure 10). This reference will be the only authoritative data source available to the public.

3.3.4 Resource Brief

The I&M resource brief is the primary outreach document for the landbird monitoring program. The principal investigator will revise any existing resource brief after new findings to reflect current understanding of the resource's trend and implications for park management. Resource briefs are made available on the Network web site through an IRMA Data Store Resource Brief product reference that is attached as a product of the main Vital Sign Project reference (Fig. 10).

3.3.5 Products Publication

Reports, datasets and other monitoring products are published through NPS websites using the Vital Sign's master Data Store Project reference via web services exposed by the IRMA Data Store. Authoritative products will only be distributed through the IRMA Data Store (Figure 10).

3.3.6 Metadata

All project datasets, including spatial and non-spatial data, are archived in the IRMA data store with metadata (NPS 2005). The mandate for adequate metadata comes from Director's Order #11A:

"All NPS data systems will develop data dictionaries and conform to available NPS organization-wide dictionaries. Geographic Information and Metadata must meet all Federal standards, DOI standards and NPS standards."

Preferred metadata formats include Federal Geographic Data Committee (FGDC) and Ecological Metadata Language (KNB 2017).

3.3.7 Line of Sight

Line of Sight is the informal name given to the I&M program's philosophy that every datum should be inextricably linked in a traversable way to the standard operating procedure and protocol version that guided its collection. This custodial chain is maintained through metadata columns in the main monitoring database coupled with metadata maintained in each protocol and standard operating procedure's IRMA reference. A data consumer will be reliably able to access a data record and discover the standard operating procedure version that defined its collection and processing (Figure 11).



Figure 11. Each informational component informs and is informed by other components. Discovery of one component leads to discovery of all other components in a formalized data management chain of custody.

3.3.8 NPSpecies

The landbird project leader will provide information on new species and supporting evidence to the national NPSpecies database (<https://irma.nps.gov/NPSpecies>).

3.3.9 Data and Information Security

Digital products produced by the landbird monitoring program will be stored in the IRMA Data Store, databases on I&M and/or local servers, and the Network file server in descending order of preference. Under no circumstances will any mission-critical information reside on individual I&M staff computers whether they are assigned to monitoring personnel by the NPS or not. Project materials will be secured and available on I&M servers at all times. The data manager, in conjunction with IT staff at FAC and with the I&M Division support office, is responsible for backups, security and longevity of monitoring data.

3.4 Closeout

Closeout is the part of the landbird monitoring data management life cycle through which seasonal data collection files and certified data are archived in the IRMA Data Store. Specific closeout procedures are found in ARCN/CAKN/DMSOP-1 (Miller 2017). Closeout happens after a remeasurement cycle when data files have been collected, processed and integrated into the main monitoring database. After field data are integrated with the master monitoring database they are archived as holdings of private IRMA Dataset References. Closeout is complete when the IRMA Dataset's holdings match the deliverables schedule (Appendix A). After closeout all permissions are removed from the season's IRMA Dataset reference except for the project leader and data manager. The dataset reference will then be linked to the main landbird monitoring IRMA Project reference so that it becomes discoverable within the NPS (Miller 2017).

The closeout method described above will ensure that all data objects collected during a remeasurement cycle are accounted for, documented and available for perpetuity should the need arise to re-use or revisit the data. Closeout procedures for all ARC/N monitoring programs are described more fully in ARC/N/CAKN/DMSOP-1 (Miller 2017).

3.5 Certification

Certification is the phase of the landbird monitoring data management life cycle where the principal investigator formally confirms that the Vital Sign's dataset is ready for analysis (NPS 2016). Certification also affirms the scientific, administrative and technical integrity of the program including:

- The protocol and standard operating procedures are current. All technical changes are up to date and documented.
- Raw and intermediate data deliverables have been processed.
- Quality control procedures have been run
- Data deliverables have been integrated with the vital sign's database or data management system.
- Data deliverables have been archived and documented appropriately.
- Each data record is traceable to the protocol version and SOP version that guided its collection.
- All closeout activities have been performed.
- The certified database or data files have been published to the Vital Sign's public Dataset reference in the IRMA Data Store.
- The Vital Sign's IRMA Data Store references and cross-links are complete.
- The dataset is of sufficient quality that analyses may be performed on it and the results published.

Dataset certification procedures for all ARC/N monitoring programs are described more fully in [ARC/N/CAKN/DMSOP-1](#) (Miller 2017).

3.6 Database

Database development will follow an iterative, 'minimum needs' model. Basic data files will be used at the outset until the work load demands development of a relational database. Front end database application development will proceed when user needs require it. Analytical views will be developed as analyses mature. We will plan for ongoing database and application development and dedicate ourselves to updating technical documentation in lockstep with technical improvements.

3.7 Data Flow

The basic dataflow is comprised of an observational dataset (i.e., the datasheet variables), a table of unique plot-visits and their covariates (i.e., the "visit table") (see SOP #4), a spatial dataset (i.e., shapefiles for the bird location waypoints) (see SOP #5), and the assignment of each observation to a pixel in a habitat raster (see SOP #7). The basic dataflow is shown in Figure 12.

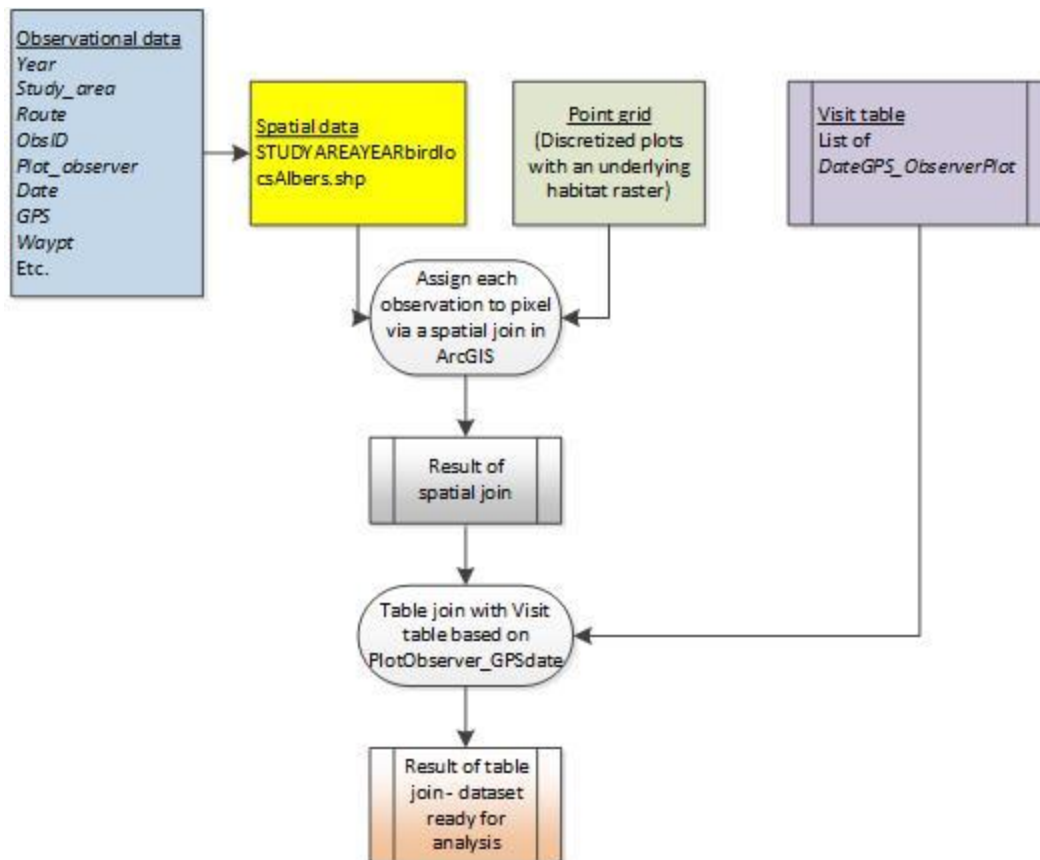


Figure 12. Dataflow overview showing integration of observational and spatial data.

3.8 File structure

The file structure shown in **Figure 13** is located under: O:\Monitoring\Vital Signs\Landbirds\. Under the project folder, separate folders are provided for the field maps and datasheets, spatial baselayers, publications, observational data, and spatial data.

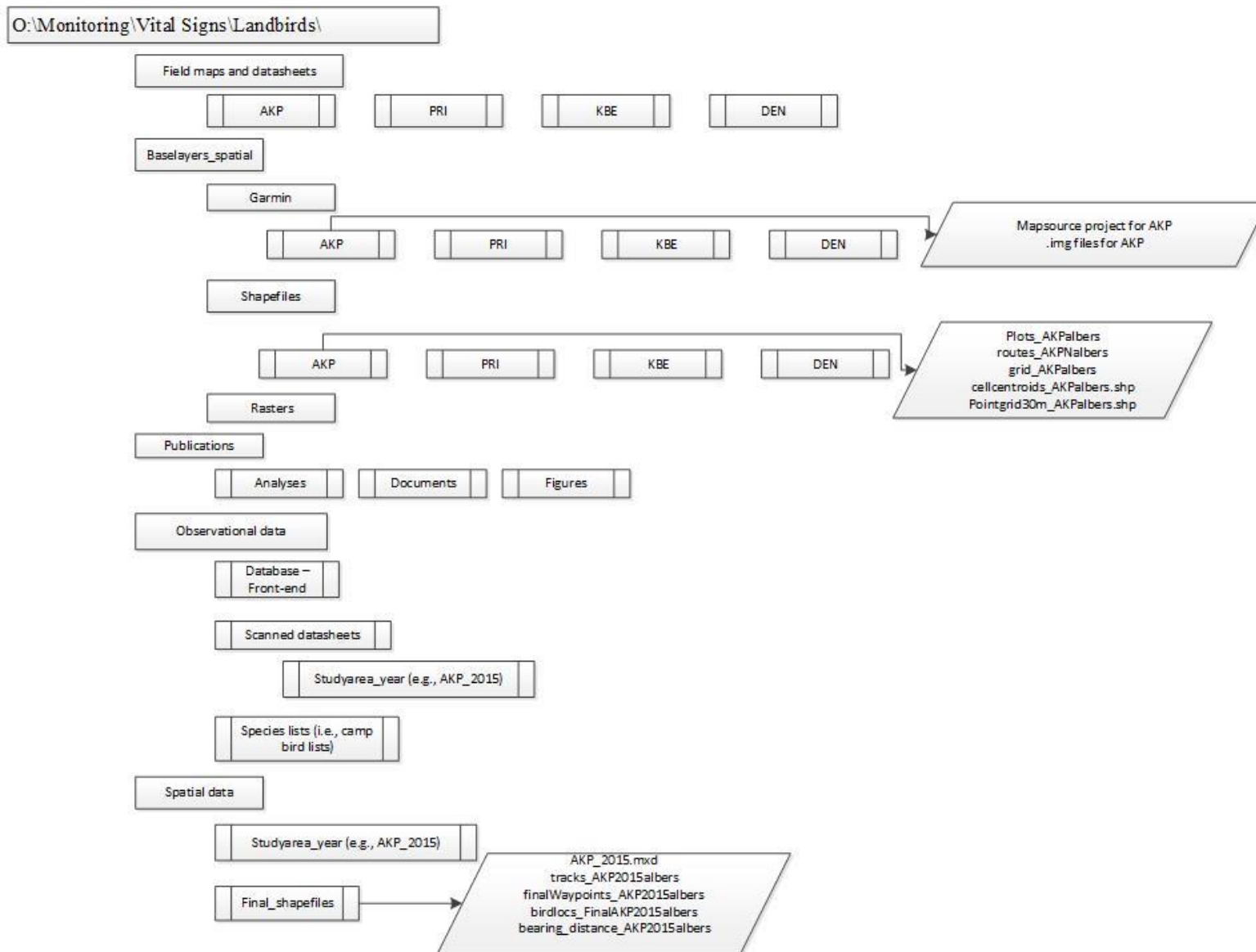


Figure 13. File structure for the ARC landbird monitoring located here: O:\Monitoring\Vital Signs\Landbirds\.

4 Personnel requirements and training

Surveys will be conducted by two-person teams comprised of one experienced bird surveyor and one data recorder. The minimum field crew size is four although having two additional crew members during a portion of the field season (i.e., 3, 2-person teams) permits visiting a portion of sites 4 times. It is optimal to have 3, 2-person teams during the period of peak detectability (~May 31-June 12). The crew must have 2-3 individuals experienced with aural and visual identification of Alaskan landbirds, one of which acts as the crew leader. The data recorder positions do not require bird identification and are essentially internship-type positions or are filled by NPS staff enlisted as short-term help (~2 weeks in the field camp).

The project leader is an NPS wildlife biologist (GS-9 or greater level). The crew leader position may be filled by the project leader or a GS-6/7 biological technician. Major functions to be performed by the project leader are 1) hiring; 2) logistics including aviation contracting; 3) field preparation; and 4) data analysis and reporting. Data analysis requires familiarity with R and hierarchical models.

The field crewmembers will also need to complete routine safety training common to all NPS seasonal employees (bear safety and shotgun certification, basic aviation safety, first aid, CPR, and safety check-in procedures of the NPS units involved).

At least one of the bird survey positions can begin in early May. The data recorder positions can begin in mid-May (a week before going into the field) and extend to mid-July. Crew members focus on data entry and proofing in July after returning from the field to Fairbanks. This process can be completed by mid-July when 2-3 people are working steadily on it for two weeks.

5 Operational requirements

5.1 Site access

The Anaktuvuk Pass study area is located on Nunamiut Corporation and Arctic Slope Regional Corporation (ASRC) inholdings. We have permission from both corporations to conduct surveys on these lands, but the project leader must notify both several months ahead of conducting surveys. All products (reports, manuscripts, and outreach materials) related to the surveys near Anaktuvuk Pass should be provided to both corporations. Anaktuvuk Pass is accessible by commercial air.

The Primus Creek airstrip is accessed by C-206 via a 2.5-3.5 hour flight from Fairbanks or a 1.5 hour flight from Kotzebue. The Kelly Bench airstrip is accessed by C-206 via a 45 minute flight from Kotzebue. We have taken four crewmembers, gear, and approximately half of the season's food to the Primus Creek site in one C-206 and one C-185 trip. We then had several flights in June to switch out crewmembers and resupply food. Demobilizing the camp requires 3, C-206 roundtrips.

6 Literature Cited

- Allredge, M. W., T. R. Simons, K. H. Pollock, and K. Pacifici. 2007a. A field evaluation of the time-of-detection method to estimate population size and density for aural avian point counts. *Avian Conservation and Ecology* 2(2):13.
- Allredge, M. W., K. H. Pollock, T. R. Simons, J. A. Collazo, and S. A. Shriner. 2007b. Time of detection method for estimating abundance from point count surveys. *Auk* 124:653–664.
- Amundson, C. L., J. A. Royle, and C. M. Handel. 2014. A hierarchical model combining distance sampling and time removal to estimate detection probability during avian point counts. *Auk* 131:476–494.
- Both, C. and M. E. Visser. 2001. Adjustment to climate change is constrained by arrival date in a long-distance migrant bird. *Nature* 411:296–298.
- Buckland, S. T. 2006. Point-transect surveys for songbirds: robust methodologies. *Auk* 123:45–357.
- Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling. Oxford University Press, Oxford, UK.
- Chandler, R. B., J. A. Royle, and D. I. King. 2011. Inference about density and temporary emigration in unmarked populations. *Ecology* 92(7):1429–1435.
- Degroot, K., and J. McMillan. 2012. Landbird monitoring in the Arctic Network: Gates of the Arctic National Park and Preserve and Noatak National Preserve (2010 report). Natural Resource Data Series. NPS/ARC/NRDS-2012/315. National Park Service, Fort Collins, Colorado
- Efford, M. G. 2004. Density estimation in live-trapping studies. *Oikos* 106:598–610.
- Efford, M. G., and D. K. Dawson. 2009. Effect of distance-related heterogeneity on population size estimates from point counts. *The Auk* 126:100–111.
- Efford, M. G., and D. K. Dawson. 2012. Occupancy in continuous habitat. *Ecosphere* 3:1–15.
- Farnsworth, G. L., K. H. Pollock, J. D. Nichols, T. R. Simons, J. E. Hines, and J. R. Sauer. 2002. A removal model for estimating detection probabilities from point-count surveys. *Auk* 119:414–425.
- Farnsworth, G. L., J. D. Nichols, J. R. Sauer, S. G. Fancy, K. H. Pollock, S. A. Shriner, and T. R. Simons. 2005. Statistical approaches to the analysis of point count data: a little extra information can go a long way. USDA Forest Service General Technical Report PSW-GTR-191. U. S. Forest Service, Washington, D.C.
- Frakes, B., S. Kingston, and M. Beer. 2015. Inventory and Monitoring Division database standards: September 11, 2015. Natural Resource Report NPS/NRSS/NRR-2015/1035. National Park Service, Fort Collins, Colorado.

- Gilman, S. E., M. C. Urban, J. Tewksbury, G. W. Gilchrist, and R. D. Holt. 2010. A framework for community interactions under climate change. *Trends in Ecology and Evolution* 25:325–331.
- Irving, L. 1960. *Birds of Anaktuvuk Pass, Kobuk, and Old Crow: a study in arctic adaptation*. Smithsonian Institution, Washington, DC, USA.
- Jarvinen, A. 1994. Global warming and egg size of birds. *Ecography* 17:108–110.
- Kéry, M., J. A. Royle, and H. Schmid. 2005. Modeling avian abundance from replicated counts using binomial mixture models. *Ecological Applications* 15:1450–1461.
- Kéry, M., and J. A. Royle. 2016. *Applied Hierarchical Modeling in Ecology: Analysis of Distribution, Abundance and Species Richness in R and BUGS*. Academic Press.
- KNB. 2017. Ecological Metadata Language (EML). Knowledge Network for Biocomplexity. <https://knb.ecoinformatics.org/#external/emlparser/docs/index.html>. 2017–03–06.
- Martin, T. E. and D. M. Finch, eds. 1995. *Ecology and management of neotropical migratory birds: a synthesis and review of critical issues*. Oxford University Press.
- Martin, K., and K. L. Wiebe. 2004. Coping mechanisms of alpine and Arctic breeding birds: extreme weather and limitations to reproductive resilience. *Integrative and Comparative Biology* 44:177–185.
- Merilä, J., and J. Sorjonen. 1994. Seasonal and diurnal patterns of singing and song–flight activity in bluethroats (*Luscinia svecica*). *Auk* 111:556–562.
- Miller, S. D. 2017. Product Archival, Seasonal Closeout and Dataset Certification Procedures for the Arctic and Central Alaska Inventory and Monitoring Networks. Standard Operating Procedure. National Park Service Arctic and Central Alaska Inventory and Monitoring Networks. National Park Service, Fort Collins, Colorado.
- Mizel, J. D., J. H. Schmidt, C. L. McIntyre, and C. A. Roland. 2016. Rapidly shifting elevational distributions of passerine species parallel vegetation change in the subarctic. *Ecosphere* 7(3).
- Mizel, J. D., J. H. Schmidt, and M. S. Lindberg. 2018. Accommodating temporary emigration in spatial distance sampling models. *Journal of Applied Ecology* 55:1456–1464.
- NPS. 2005. Director’s Order #11A: Information and technology management. National Park Service. http://www.nps.gov/policy/DOrders/DO_11A.pdf. Retrieved 2015-08-20.
- NPS. 2005. Director’s Order #11B: Ensuring Quality of Information Disseminated by the National Park Service. National Park Service. <http://www.nps.gov/policy/DOrders/11B-final.htm>. Retrieved 2015–12–08.
- NPS. 2006. *Management Policies 2006*. National Park Service, Washington, DC.

- NPS. 2012. Director's Order #11D: RECORDS AND ELECTRONIC INFORMATION MANAGEMENT. National Park Service. http://www.nps.gov/policy/DOrders/DO_11D.pdf. Retrieved 2015-12-08.
- NPS. 2005. NPS REFERENCE MANUAL RM 66B: HANDLING PROTECTED INFORMATION. Unpublished Draft Policy. National Park Service, Washington, DC.
- NPS. 2006. Management Policies 2006. National Park Service, Washington, DC.
- NPS. 2008a. Data management guidelines for inventory and monitoring networks. Natural Resource Report NPS/NRPC/NRR—2008/035. National Park Service, Fort Collins, Colorado.
- NPS. 2008b. Data and information management plan: Arctic Network Inventory and Monitoring Program. Natural Resource Report NPS/ARC/NRR—2008/053. National Park Service, Fort Collins, Colorado.
- NPS. [No date] Information Quality – Ensuring Objectivity, Utility, and Integrity of Information Used and Disseminated by the National Park Service. <http://www.nps.gov/policy/DOrders/DO11B—Update.htm>
- NPS. 2016. Certification Guidelines for Inventory and Monitoring Data Products. National Park Service, Inventory and Monitoring Division. National Park Service, Fort Collins, Colorado.
- Nichols, J. D., J. E. Hines, J. R. Sauer, J. W. Fallon, J. E. Fallon, and P. J. Heglund. 2000. A double observer approach for estimating detection probability and abundance from point counts. *Auk* 117:393–408.
- Nichols, J. D., L. Thomas, and P. B. Conn. 2009. Inferences about landbird abundance from count data: recent advances and future directions. *In* Thompson, D. L., E. G. Cooch, and M. J. Conroy, editors. *Modeling Demographic Processes in Marked Populations*. Springer, New York.
- Pearce-Higgins, J. W., P. Dennis, M. J. Whittingham, and D. W. Yalden. 2010. Impacts of climate on prey abundance account for fluctuations in a population of a northern wader at the southern edge of its range. *Global Change Biology* 16:12–23.
- Roland, C. A., and S. E. Stehn. 2014. Denali Repeat Photography Project Reveals Dramatic Changes: A Drier, Woodier, and More Densely Vegetated Park. *Alaska Park Science* 12:65.
- Rosenstock, S. S., D. R. Anderson, K. M. Giesen, T. Leukering, and M. F. Carter. 2002. Landbird counting techniques: current practices and an alternative. *Auk* 119:46–53.
- Royle, J. A. 2004. N-mixture models for estimating population size from spatially replicated counts. *Biometrics* 60:108–115.
- Royle, J. A., and R. M. Dorazio. 2006. Hierarchical models of animal abundance and occurrence. *Journal of Agricultural, Biological, and Environmental Statistics* 11:249–263.

- Royle, J. A., and R. M. Dorazio. 2008. Hierarchical modeling and inference in ecology. Academic Press, San Diego, California.
- Royle, J. A. and K. V. Young. 2008. A hierarchical model for spatial capture–recapture data. *Ecology* 89:2281–2289.
- Royle, J. A., M. Kéry, and J. Guelat. 2011. Spatial capture-recapture models for search-encounter data. *Methods in Ecology and Evolution* 2(6):602–611.
- Royle, J. A., R. B. Chandler, R. Sollmann, and B. Gardner. 2013. Spatial capture–recapture. Academic Press, Waltham, Massachusetts, USA.
- Schmidt, J. H., C. L. McIntyre, and M. C. MacCluskie. 2013. Accounting for incomplete detection: what are we estimating and how might it affect long–term passerine monitoring programs? *Biological Conservation* 160:130–139.
- Solymos, P., S. M. Matsuoka, E. M. Bayne, S. R. Lele, P. Fontaine, S. G. Cumming, D. Stralberg, F. K. A. Schmeigelow, and S. J. Song. 2013. Calibrating indices of avian density from non-standardized survey data: making the most of a messy situation. *Methods in Ecology and Evolution* 4:1047–1058.
- Stueve, K. M., R. E. Isaacs, L. E. Tyrrell, and R. V. Densmore. 2011. Spatial variability of biotic and abiotic tree establishment constraints across a treeline ecotone in the Alaska Range. *Ecology* 92:496–506.
- Sturm, M., C. Racine, and K. Tape. 2001. Climate change: Increasing shrub abundance in the Arctic. *Nature* 411:546–547.
- Sturm, M. et al. 2005. Winter biological processes could help convert arctic tundra to shrubland. *BioScience* 55:17–26.
- Suttle, K. B., M. A. Thomsen, and M. E. Power. 2007. Species interactions reverse grassland responses to changing climate. *Science* 315:640–642.
- Tape, K., M. Sturm, and C. Racine. 2006. The evidence for shrub expansion in Northern Alaska and the Pan–Arctic. *Global Change Biology* 12:686–702.
- Thompson, S. J., C. M. Handel, and L. B. McNew. 2017. Autonomous acoustic recorders reveal complex patterns in avian detection probability. *Journal of Wildlife Management* 81:1228–1241.
- Visser, M. E., C. Both, and M. M. Lambrechts. 2004. Global climate change leads to mistimed avian reproduction. *Advances in Ecological Research* 35: 89–110.
- Wilson, S., and K. Martin. 2012. Influence of life history strategies on sensitivity, population growth and response to climate for sympatric alpine birds. *BMC Ecology* 12:9.

7 Appendix A: Data deliverables schedule

Deliverables schedule

Identifier	Deliverable	Format	Schedule	Responsibility
LB01	Routes	Shapefile and comma separated values text file	If revised	PI
LB02	Plots	Shapefile and comma separated values text file	If revised	PI
LB03	Paper data collection forms	Paper	Sample date + 1 year	PI
LB04	Scanned data collection forms	Portable document file	Sample date + 1 year	PI
LB05	Bird Waypoints	Shapefile and comma separated values text file	Sample date + 1 year	PI
LB06	Observer Waypoints	Shapefile and comma separated values text file	Sample date +1 year	PI
LB07	Observational data	Comma separated values text file	Sample date + 1 year	PI

7.1 Deliverable LB01: Routes

Schedule: 2018. Only required if updated.

Responsibility:PI

Description: Spatial dataset containing the bird survey routes.

Format: Shapefile. WGS84.

Specifications: Deliverable LB01 consists of landbird survey routes in two formats. The first format is a line shapefile of the routes used in the current survey. The shapefile is in WGS84 projection and documented with FGDC metadata. The second format is a human and machine readable ASCII text file export of the previous shapefile format. The text file is in WGS1984 Geographic Coordinate System (lat/lon). Suggested file formats include GeoJSON and Comma Separated Values with the polygon feature column represented in Well Known Text.

File naming scheme: Shapefile: STUDYAREAroutesAlbers.shp, example: AKProutesAlbers.shp.

Text file: STUDYAREAroutesAlbers.csv, example: AKProutesAlbers.csv.

Archival plan: Deliverables collected during each seasonal data collection campaign are documented in a single Dataset reference in the NPS IRMA Data Store. Deliverable files are documented with metadata, named appropriately and descriptively, and uploaded as holdings to the Dataset reference described above. Once the seasonal deliverables Dataset reference is complete it is linked as a product of the Lagoons monitoring Project reference (<https://irma.nps.gov/DataStore/Reference/Profile/2219895>). Seasonal closeout is complete when all deliverables in the Data Store are accounted for and meet specifications.

7.2 Deliverable LB02: Plots

Schedule: 2018. Only required if revised.

Responsibility: PI

Description: Spatial dataset containing the bird survey plots. Metadata.

Format: Comma separated values text fileShapefile. WGS84

Specifications: Deliverable LB02 consists of landbird survey plots in two formats. The first format is a polygon shapefile of the current survey's plots. The shapefile is in WGS84 projection and documented with FGDC metadata. The second format is a human and machine readable ASCII text file export of the previous shapefile format. The text file is in WGS1984 Geographic Coordinate System (lat/lon). Suggested file formats include GeoJSON and Comma Separated Values with the polygon feature column represented in Well Known Text.

File naming scheme: Shapefile: STUDYAREApotsAlbers.shp, example: AKPplotsAlbers.shp.

Text file: STUDYAREApotsAlbers.csv, example: AKPplotsAlbers.csv.

Archival plan: Deliverables collected during each seasonal data collection campaign are documented in a single Dataset reference in the NPS IRMA Data Store. Deliverable files are documented with metadata, named appropriately and descriptively, and uploaded as holdings to the Dataset reference described above. Once the seasonal deliverables Dataset reference is complete it is linked as a product of the Lagoons monitoring Project reference (<https://irma.nps.gov/DataStore/Reference/Profile/2219895>). Seasonal closeout is complete when all deliverables in the Data Store are accounted for and meet specifications.

7.3 Deliverable LB03: Paper data collection forms

Schedule: Sample date +1 year

Responsibility: PI

Description: Data collection forms, complete, ordered and annotated.

Format: Paper

Specifications: Data collection forms, complete, ordered and annotated.

File naming scheme: N/A

Archival plan: Archived with project leader

7.4 Deliverable LB04: Scanned data collection forms

Schedule: Sample date +1 year

Responsibility: PI

Description: Scans of data collection forms, complete, ordered, annotated and in a single Portable Document File.

Format: Portable document file

Specifications: Single portable document file containing all the paper data collection forms for the current survey, ordered and annotated.

File naming scheme: TBD

Archival plan: Deliverables collected during each seasonal data collection campaign are documented in a single Dataset reference in the NPS IRMA Data Store. Deliverable files are documented with metadata, named appropriately and descriptively, and uploaded as holdings to the Dataset reference described above. Once the seasonal deliverables Dataset reference is complete it is linked as a product of the Lagoons monitoring Project reference (<https://irma.nps.gov/DataStore/Reference/Profile/2219895>). Seasonal closeout is complete when all deliverables in the Data Store are accounted for and meet specifications.

7.5 Deliverable LB05: Bird waypoints

Schedule: Sample date +1 year

Responsibility: PI

Description: Bird waypoints. Shapefile and human and machine readable text format. WGS1984 GCS. Metadata.

Format: Shapefile and comma separated values text file

Specifications: Deliverable LB05 consists of bird location waypoints in two formats. The first format is a point shapefile of the current survey's concatenated waypoints. The shapefile is in WGS84 projection and documented with FGDC metadata. The second format is a human and machine readable ASCII text file export of the previous shapefile format. The text file is in WGS1984 Geographic Coordinate System (lat/lon). Suggested file formats include GeoJSON and Comma Separated Values with the polygon feature column represented in Well Known Text.

File naming scheme:

Shapefile: STUDYAREAYEARbirdlocsAlbers.shp, example: AKP2015birdlocsAlbers.shp.

Text file: STUDYAREAYEARbirdlocsAlbers.csv, example: AKP2015birdlocsAlbers.csv.

Archival plan: Deliverables collected during each seasonal data collection campaign are documented in a single Dataset reference in the NPS IRMA Data Store. Deliverable files are documented with metadata, named appropriately and descriptively, and uploaded as holdings to the Dataset reference described above. Once the seasonal deliverables Dataset reference is complete it is linked as a product of the Lagoons monitoring Project reference (<https://irma.nps.gov/DataStore/Reference/Profile/2219895>). Seasonal closeout is complete when all deliverables in the Data Store are accounted for and meet specifications.

7.6 Deliverable LB06: Observer waypoints

Schedule: Sample date +1 year

Responsibility: PI

Description: Observer waypoints. Shapefile and human and machine readable text format. WGS1984 GCS. Metadata.

Format: Shapefile and comma separated values text file

Specifications: Deliverable LB06 consists of observer waypoints in two formats. The first format is a point shapefile of the current survey's concatenated waypoints. The shapefile is in WGS84 projection and documented with FGDC metadata. The second format is a human and machine readable ASCII text file export of the previous shapefile format. The text file is in WGS1984 Geographic Coordinate System (lat/lon). Suggested file formats include GeoJSON and Comma Separated Values with the polygon feature column represented in Well Known Text.

File naming scheme:

Shapefile: STUDYAREAYEARobswyptsAlbers.shp, example: AKP2015obswyptsAlbers.shp.

Text file: STUDYAREAYEARobswyptsAlbers.csv, example: AKP2015obswyptsAlbers.csv.

Archival plan: Deliverables collected during each seasonal data collection campaign are documented in a single Dataset reference in the NPS IRMA Data Store. Deliverable files are documented with metadata, named appropriately and descriptively, and uploaded as holdings to the Dataset reference described above. Once the seasonal deliverables Dataset reference is complete it is linked as a product of the Lagoons monitoring Project reference

(<https://irma.nps.gov/DataStore/Reference/Profile/2219895>). Seasonal closeout is complete when all deliverables in the Data Store are accounted for and meet specifications.

7.7 Deliverable LB07: Observational data

Schedule: Sample date +1 year

Responsibility: PI

Description: Observational data entered into the landbirds monitoring database and exported into a comma separated values text file. Metadata.

Format: Comma separated values text file

Specifications: TBD.

File naming scheme: TBD

Archival plan: Deliverables collected during each seasonal data collection campaign are documented in a single Dataset reference in the NPS IRMA Data Store. Deliverable files are documented with metadata, named appropriately and descriptively, and uploaded as holdings to the Dataset reference described above. Once the seasonal deliverables Dataset reference is complete it is linked as a product of the Lagoons monitoring Project reference

(<https://irma.nps.gov/DataStore/Reference/Profile/2219895>). Seasonal closeout is complete when all deliverables in the Data Store are accounted for and meet specifications.

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.

NPS 953/144713, April 2018

National Park Service
U.S. Department of the Interior



[Natural Resource Stewardship and Science](#)

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525