National Park Service
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Monitoring Breeding Landbirds in National Parks of the Gulf Coast Network

Protocol Narrative

Natural Resource Report NPS/GULN/NRR—2018/1765

ON THE COVER

Prothonotary Warbler, *Protonotaria citrea*, in a sweetgum tree, *Liquidambar styraciflua*, at Vicksburg National Military Park, Mississppi.

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Natural Resource Report NPS/GULN/NRR—2018/1765

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Change History

Version numbers will be incremented by a whole number (e.g., version 1.3 to version 2.0) when a change is made that significantly alters project requirements, procedures, continuity of the data, or interpretation of the data. Version numbers will be incremented by decimals (e.g., version 1.6 to version 1.7) when there are minor modifications that do not affect project requirements, procedures, data continuity or data interpretation.

Revision Date	Author	Changes Made	Reason for Change	New Version #

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Executive Summary

This protocol narrative describes the purpose, objectives and methods used for monitoring breeding landbirds in Gulf Coast Network parks. The diverse bird species that reside and breed in the Gulf Coast region are an important attraction for many park visitors. As regional landscapes change and climate patterns shift, however, bird populations may be threatened. The network's monitoring objectives for breeding landbirds are to document species richness and composition during annual visits to the parks and assess long-term trends in occupancy and the relative abundance or density for the most-common species.

Six parks within the Gulf Coast Network conduct annual avian monitoring using point-count surveys: Big Thicket National Preserve, Gulf Islands National Seashore, Jean Lafitte National Historical Park and Preserve, Palo Alto Battlefield National Historical Park, San Antonio Missions National Historical Park, and Vicksburg National Military Park. A minimum of 21 point-count and maximum of 33 point-count locations are monitored at each park. The Natchez Trace Parkway is not included in this monitoring program because the entire length of the park is actively monitored by the North American Breeding Bird Survey. Padre Island National Seashore is not included in this protocol because pilot data collection on the barrier islands resulted in very low numbers and few species of the landbirds targeted for this monitoring protocol. Only the mainland units of Gulf Islands National Seashore are included for this same reason.

Landbird monitoring by the Gulf Coast Network targets common breeding species by sampling each of 179 permanent point-count locations twice per season, using variable circular plot methods. This parallels the approaches taken by other Inventory and Monitoring (I&M) networks (e.g., Northeast Temperate Network, Eastern Rivers and Mountains and Great Lakes Network) as well as the U.S. Fish and Wildlife Service, which allows for broader-scale comparisons. Sampling is conducted annually during the breeding season of most landbirds found within the area covered by the parks included in the protocol (May and June).

The Gulf Coast Network conducts bird surveys using point-count observation methods. An observer navigates to the point-count location by GPS, and over a 10-minute period, records the number of individuals seen or heard of each bird species. The observer also records the distance of each bird from the observer's location and the minute the bird was first observed. Distances are recorded in bands of 0–25 meters (0–82 feet [ft]), 25–50 meters (82–164 ft), 50–100 meters (164–328 ft) and greater than 100 meters (328 ft). Once a bird is detected and recorded, it is removed from further consideration, reducing the probability that any individual bird is counted twice. Each point is re-sampled between two and four weeks after the initial sample.

Monitoring birds in parks not only provides crucial information on the birds themselves, but can also be indicative of habitat changes within the parks. These data will also contribute to regional or national databases that further our understanding of continental bird population trends and provide a broader context for park-specific data.

Acknowledgments

The network thanks Dan Twedt for his major contribution in planning, developing and helping implement its bird monitoring project, which is the basis for this protocol. The network also thanks Matt Marshall of Eastern Rivers and Mountains Network (ERMN) and the Northeast Temperate Network (NETN) for providing guidance and direction based on their existing landbird monitoring protocols.

Background and Objectives

Background and History

The mission of the National Park Service (NPS) is to manage park resources "unimpaired for the enjoyment of future generations" (NPS Organic Act of 1916). To achieve this, the NPS must know the conditions of its natural resources—past and present—over the long term. The National Parks Omnibus Management Act of 1998 specifically mandated the NPS complete baseline inventories and monitor for change over time, which it does in part through a program called Vital Signs Monitoring. This approach tracks the status of a park's natural resources in over 270 NPS units by monitoring a subset of the flora, fauna or underlying processes that serve as indicators of ecosystem health and response to stressors (Fancy et al. 2009).

National Park Service Vital Signs Monitoring is implemented programmatically through its Inventory and Monitoring Division (IMD). The IMD has divided the country into 32 regional networks, which are groupings of parks based on geography and similar natural resource characteristics. Parks within the same network share IMD funds and professional staff, with the intent of fostering collaboration, information exchange, and economies of scale. All 32 network offices follow the same program development and implementation strategy (Fancy et al. 2009), which includes the network's Vital Signs Monitoring plan and a series of detailed, peer-reviewed, monitoring protocols that describe how data are to be collected, managed, analyzed, and reported (Oakley et al. 2003). These documents form the foundation necessary for meeting the programmatic goals of networks in the Inventory and Monitoring Division. As stated by Fancy et al. (2009), these goals are to:

1. "determine the status and trends of selected indicators of park ecosystem conditions" for improved decision-making and collaboration;
2. "provide early warning of abnormal conditions" to allow for timely mitigation and reduced management costs;
3. "provide data to better understand" dynamic park ecosystems and serve as reference points;
4. "provide data to meet certain legal and Congressional mandates;" and
5. "provide a means of measuring progress toward performance goals."

The Gulf Coast Network (GULN) is one of the IMD networks, and it covers a broad region in the southern United States with eight National Park Service units (Table 1; Figure 1). Beginning in 2002, the network underwent an extensive scoping process with park staff and other stakeholders to identify key resources and stressors to GULN park ecosystems (Segura et al. 2007). Nineteen top-priority vital signs were selected for long-term monitoring, and among them are breeding landbirds. In this protocol, as in others (e.g., Gostomski et al. 2010; Faccio et al. 2015), the term landbird applies to relatively small birds of terrestrial ecosystems, excluding raptors and fowl-like birds (see full definition for landbirds in the "Rationale" section below). This protocol narrative details the network's landbird sampling strategy, which addresses the three monitoring objectives listed below.

Bird monitoring has previously been conducted in GULN parks (Hays 2001, 2004; Scully 2006), but not with the intention of providing quantitative inference at the landscape or cross-network scale. In these earlier efforts, surveyed sites were selected on a discretionary basis, according to park interest or opportunity rather than following a statistically-sound sampling design (Twedt 2012; Segura et al. 2007). In contrast, this protocol records presence and relative abundance of breeding landbirds at randomly selected points within parks or park units, allowing for inference at broader spatial scales. Although bird monitoring is considered important in all eight of the Gulf Coast Network's parks, only six parks are included in this protocol. The Natchez Trace Parkway (NATR) is not included based on a written recommendation in the Avian Monitoring Plan for the Gulf Coast Network (Twedt 2012), upon which much of this protocol is based. The exclusion of this long, linear park was recommended because the length of the park is already well covered by North American Breeding Bird Survey routes, providing the park with data on birds located along this route (Sauer et al. 2017). Additionally, pilot data collected on the barrier islands at both Padre Island National Seashore (PAIS) and Gulf Islands National Seashore (GUIS) resulted in low numbers of few species. Consequently, this protocol is not implemented at Padre Island NS and is only implemented on the mainland units of Gulf Islands NS.

Table 1. Names, acronyms, sizes and habitat types of parks within the Gulf Coast Network of the National Park Service. The total area of land managed within the network is more than 101,790 hectares (251,529 acres). The network is headquartered in Lafayette, Louisiana. Of the eight parks, the Natchez Trace Parkway and Padre Island National Seashore are not covered by the breeding landbird monitoring protocol.

Park	Acronym	Administrative boundary area (hectares)	Habitats
Vicksburg National Military Park, Mississippi	VICK	706	Upland deciduous forest, managed grassland
Palo Alto Battlefield National Historical Park, Texas	PAAL	696	Coastal salt prairie, Tamaulipan thornscrub
San Antonio Missions National Historical Park, Texas	SAAN	190	Riparian and upland forests, scrubland, and grassland
Padre Island National Seashore, Texas	PAIS	52,784 (total); 23,516 (land)	Coastal shore and dunes, marsh, grassland, and chenier*
Big Thicket National Preserve, Texas	BITH	43,385	Riparian, pine, and deciduous forests
Gulf Islands National Seashore, Florida and Mississippi	GUIS	55,846 (total); 4,968 (land)	Coastal shore and dunes, marsh, grassland, and chenier*

*Chenier is a sandy beach ridge that is part of a larger plain consisting of cheniers separated by mudflats, marshes, or swamps.

Table 1 (continued). Names, acronyms, sizes and habitat types of parks within the Gulf Coast Network of the National Park Service. The total area of land managed within the network is more than 101,790 hectares (251,529 acres). The network is headquartered in Lafayette, Louisiana. Of the eight parks, the Natchez Trace Parkway and Padre Island National Seashore are not covered by the breeding landbird monitoring protocol.

Park	Acronym	Administrative boundary area (hectares)	Habitats
Jean Lafitte National Historical Park and Preserve, Louisiana	JELA	7,202	Marsh, swamp, bottomland hardwood forest
Natchez Trace Parkway, Mississippi, Alabama and Tennessee	NATR	21,127	Pine and deciduous forests, managed grassland

*Chenier is a sandy beach ridge that is part of a larger plain consisting of cheniers separated by mudflats, marshes, or swamps.

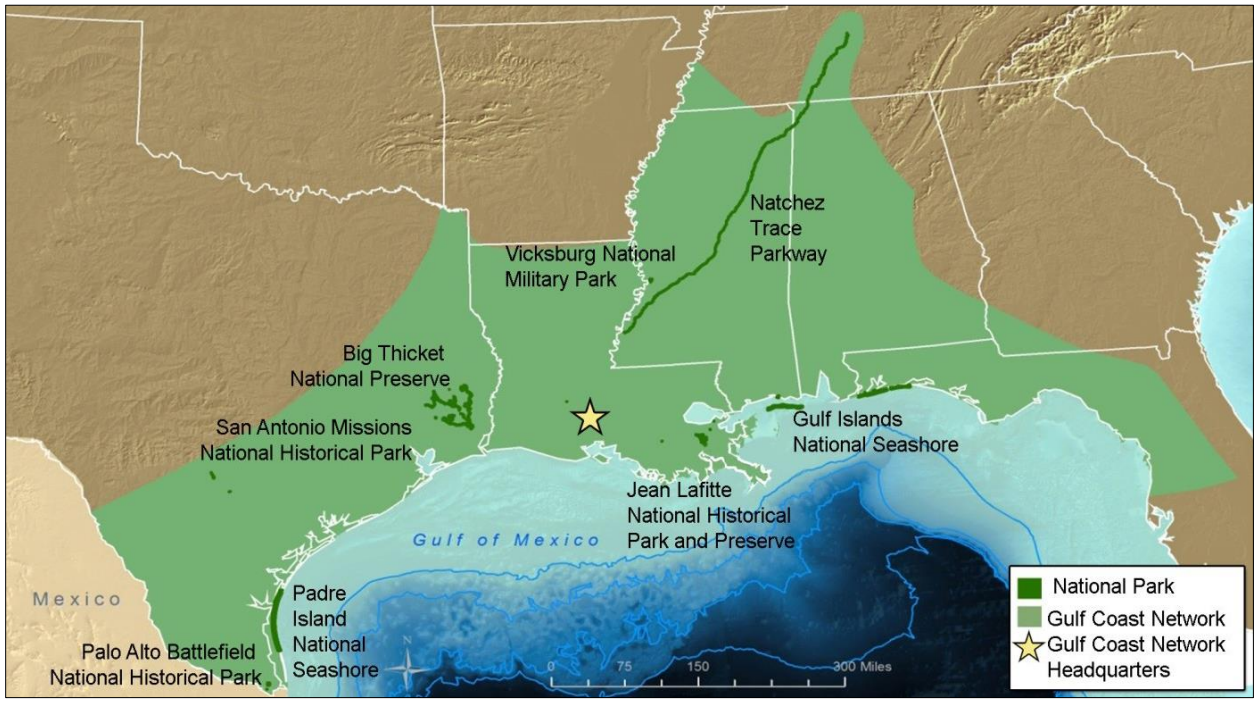

Figure 1. The Gulf Coast Network (GULN) includes eight national park units which are shaded dark green. The network's geographic area is shaded in light green. The network headquarters (Lafayette, Louisiana) is indicated with a yellow star. The parks not included in the breeding landbird monitoring protocol are Natchez Trace Parkway and Padre Island National Seashore.

Ecosystems of Network Parks Being Monitored

Big Thicket National Preserve

Big Thicket National Preserve is in eastern Texas, and consists of nine distinct land units and six intervening water corridors. The preserve covers an area of roughly 43,000 hectares (106,255 acres

[ac]) known for its rich biological diversity. This diversity is a result of the geographic convergence of eastern hardwood forests, coastal plains, and midwestern prairie. Due to the challenges of protocol implementation over such a large and ecologically diverse area, only the centrally-located Turkey Creek unit is covered in this protocol. Discussions with park managers resulted in focusing on this unit rather than spreading the effort across the preserve. The Turkey Creek unit includes some longleaf pine savannahs, baygall wetlands, pine sandhills, cypress sloughs, and pitcher plant bogs, but is largely dominated by pine oak forests on gentle slopes (15–30 meters above sea level or 49.2–98.4 feet above sea level).

Gulf Islands National Seashore

Gulf Island NS covers shoreline, inland habitats and barrier islands in both Mississippi and Florida. The park includes significant aquatic and terrestrial natural resources; however, the aquatic habitats (80% of the park) and barrier islands are not covered in this protocol. The approximately 5,000 hectares (12,355 ac) of emergent habitats are divided between Florida (GUIS-FL) and Mississippi (GUIS-MS) districts. The Mississippi District encompasses four barrier islands (Horn Island, Petit Bois Island, East Ship Island and West Ship Island) that are accessible only by boat. These islands are vegetated to varying degrees, with a few areas even supporting tall pines. The islands are otherwise characterized by dunes, scrub-shrub habitats and marshes. The Davis Bayou Area is the only mainland area in the Mississippi district. It contains bayhead swamps, wet pine flatwoods, pine savannah and mixed hardwood forests and is the only unit included in this protocol in Mississippi. The Florida District encompasses portions of Santa Rosa Island and Perdido Key, as well as the Naval Live Oaks Area on the mainland. The Naval Live Oaks Area is characterized by oak scrub, pine savannahs and forests dominated by pine, oak or a mix and is the only unit included in this protocol in Florida. The other two Florida units are primarily dunes, scrub-shrub habitats, beaches and marshes.

Jean Lafitte National Historical Park and Preserve

Jean Lafitte NHP&P is divided among six units distributed throughout south Louisiana, but only the Barataria Preserve harbors significant natural vegetation. This preserve contains more than 7,000 hectares (17,297 ac) of marsh, swamp, scrub-shrub wetland and bottomland hardwood forest. The dominant vegetation types are cypress-tupelo swamps and fresh-water/brackish marshes. Most of these habitats are difficult to access and require the use of an airboat. The bottomland hardwood forests and adjacent swamp can be more easily accessed from trails, roads and levees. These areas are the primary targets for bird monitoring in this protocol (Figure 2).

Figure 2. Yellow-throated warblers are among the species of landbirds known to breed in the Barataria Unit of Jean Lafitte National Historical Park and Preserve.

Palo Alto Battlefield National Historical Park

Palo Alto Battlefield National Historical Park is a relatively small park at 696 hectares (1,719 ac). Its main habitats are coastal salt prairie (dominated by *Spartina spartinae* [Gulf cordgrass]) and Tamaulipan thornscrub. The thornscrub includes a diverse mix of thorny shrubs and some cacti (e.g., *Opuntia englemanni* [prickly pear]). Areas of honey mesquite (*Prosopis glandulosa*) often border or intermix with the thornscrub habitats.

San Antonio Missions National Historical Park

Although primarily a historical park showcasing missions along the San Antonio River, the park does include some wildlife habitat within the 190-hectare (469-ac) property. These habitats include riparian zones and associated acequias, upland forest and woodlands, shrubland and grassland. The park has several narrow linear corridors and small isolated units of park ownership.

Vicksburg National Military Park

Of the 706 hectares (1,744 ac) that make up Vicksburg National Military Park, approximately 80 percent of land cover is mixed mesophytic forest. Periodic mowing or burning maintain the remaining land cover as lawn or taller non-native grasses (Somershoe et al. 2006). Forest types include sweetgum-pecan-water oak forest, cherrybark-water oak forest and tulip tree-oak forest. There are also ruderal forest areas with black locust, invasive chinaberry tree and invasive Chinese privet.

Rationale for Monitoring Breeding Landbirds

Landbirds were specifically identified as high priority in the *Gulf Coast Network Vital Signs Monitoring Plan* (Segura et al. 2007), and they are a frequent target for long-term monitoring elsewhere (e.g., Gostomski et al. 2010; Faccio et al. 2015). Breeding birds were selected as a focus of the network because these species spend more time and make longer use of park ecosystems,

providing park managers with information on the condition of park resources. Landbirds also span multiple trophic levels within vertebrate communities and can be sensitive to a broad suite of environmental changes. As a result, monitoring these taxa can be informative as indicators of ecosystem health and habitat change (Maurer and Heywood 1993). The landbird monitoring protocol for the Northeast Temperate Network (Faccio et al. 2015) lists these additional reasons why landbirds are a preferred taxonomic group for monitoring:

1. "They are the most easily and inexpensively detected and identified vertebrate animals."
2. "A single survey method is effective for many species."
3. "Accounting and managing for many species with different ecological requirements promotes conservation strategies at the landscape scale (Hutto and Young 2002)."
4. "Many reference data sets and standard methods are available (Ralph et al. 1993, 1995)."
5. "The response variables (numbers and types of bird species recorded during point counts) are fairly well understood."

For the purposes of this protocol, a bird is classified as a breeding landbird based on both its taxonomic order and the times of year that it uses park resources. The Gulf Coast Network defines landbirds as the order Passeriformes plus seven other orders from the traditional grouping called near-passerines (Table 2). The near-passerine orders used here follow Pyle (1997), except that the Gulf Coast Network includes parrots (see Unwin 2011), but not raptors (Accipitriformes and Falconiformes), owls (Strigiformes), rails (Gruiformes) or sandpipers (Charadriiformes). Although only the passerine and near-passerine orders are targeted, all bird species detected during a monitoring event are recorded. Monitoring events take place during May or June, which should exclude most landbirds not potentially breeding in or near the park. The goal is to focus on the year-round residents and summer breeders that spend extended periods of time using the park ecosystems and to reduce detections of the non-breeding species such as winter visitors, vagrants, or birds passing through during migration.

The Gulf Coast Network limits its sampling scope to this subset of birds because these birds were determined to spend more time on the park resources, making them more likely to reflect the overall condition of park resources. Among the non-targeted groups, shorebirds are frequently monitored by parks or through nationwide programs (Simons and Woodrey 1990). Parks may serve as important stop over points for migratory species. However, the parks decided to focus on breeding birds since migratory species are less likely to depend on park resources for extended periods of time. Raptors and vultures are highly mobile, wide-ranging and typically monitored using different methodologies at a national level (McCarty and Bildstein 2005). Similarly, marsh birds, such as rails and bitterns, may be important members of the bird communities in some GULN parks (e.g., Jean Lafitte NHP&P, Gulf Island NS), but they require specific methods for successful monitoring (Ribic et al. 1999).

Table 2. The eight landbird orders that are the focus of the GULN monitoring protocol, if the species is present in the park during the breeding season. These orders are the passerines plus near-passerines, with 'near' referring to ecological similarity rather than phylogenetic relatedness.

Order of birds	Common name of order
Columbiformes	Pigeons and Doves
Psittaciformes	Parrots
Cuculiformes	Cuckoos
Caprimulgiformes	Nightjars
Coraciiformes	Kingfishers
Piciformes	Woodpeckers
Apodiformes	Hummingbirds and Swifts
Passeriformes	Songbirds

Measurable Objectives

This protocol is implemented to monitor the status of breeding landbird communities and occupancy trends of common species in GULN parks. The goals are to inform management decisions affecting park resources that breeding landbirds rely upon and to provide data comparable with other regional or nationwide projects (Faccio et al. 2015; Gostomski et al. 2010; Knutson et al. 2008).

- Objective 1: Determine the composition of native and non-native landbird communities that are detectable using point-count methodologies during the breeding season at GULN parks.
- Objective 2: Determine occupancy and the relative abundance of all species (per monitoring point) and the density of each park's commonly detected species (per hectare). A species is considered commonly detected if it is recorded more than 40 times per year for at least three years.
- Objective 3: Determine long-term trends in occupancy and relative abundance or density of commonly-detected species at each park.

Sampling Design

According to the GULN avian monitoring plan by Twedt (2012), cost-effective bird monitoring in GULN parks requires: (1) an efficient, probabilistic sampling design, and (2) sampling methods that are straightforward, and can be carried out consistently across different observers and diverse habitats. Both of these components must also combine to yield quantitative data on avian populations that can be readily analyzed using standard and specialized analytical tools such as generalized linear mixed models on density estimates, with offsets for detectability (e.g., Sólymos et al. 2013a), hierarchical N-mixture models (e.g., Schmidt et al. 2013) and occupancy analyses for species that are less frequently seen (e.g., Fiske and Chandler 2011).

To meet these requirements, the Gulf Coast Network uses point counts from fixed locations, sampled twice per year, to monitor breeding landbirds in its parks. The network chose to sample the same points each year because trend estimates are more precise when the same points are visited, and because most parks in the network are small enough that good spatial coverage is achieved without complex designs, such as panels or new random draws each year. Additionally, site establishment and access are less complex and a shorter time-frame is required for reporting trends, relative to multi-year panel designs.

To select these permanent points, the Gulf Coast Network used a randomized sampling design based on the whole park's administrative boundary at the time of initial point selection or polygons around targeted units within parks. In both cases, the sampling frame excludes narrow buffers around park boundaries, and points are required to be at least 200–250 meters apart. The network chose to distribute points as a simple random draw from within park boundaries, rather than targeting specific habitats or areas, to allow for extrapolation over the whole sampling frame for the park. For three parks, the sampling frame was a buffered polygon around the whole park, allowing for park-wide inference. For the remaining three parks, the network selected one or more contiguous units of the park as the sampling frame, to prevent excessive travel time, or to accommodate safety or park management interest. In one case (Jean Lafitte NHP&P), the sampling frame was buffered corridors along trails and roads, due to challenges with access into flooded areas of the park. For all six parks, the points were drawn from the whole sampling frame, but if a point was on or within 50 meters (164 ft) of a road, parking lot, or building, the next available alternate point was used instead. Following these preferences and constraints, each park was allocated between 21 and 33 point-count locations.

The Variable Circular Plot for Point Counts

The Gulf Coast Network monitors landbirds using a modification of the variable circular plot design, following recommendations of Twedt (2012). Variable circular plots are commonly used for monitoring birds, including several other IMD networks (e.g., Heartland Network, Peitz et al. 2008; Great Lakes Network, Gostomoski et al. 2010; Northeast Temperate Network, Faccio et al. 2015; Eastern Rivers and Mountains Network, Marshall et al. 2016). In the simplest version of this sampling methodology, birds are surveyed at pre-selected points for a fixed amount of time (usually 3–10 minutes), and the observer records the distance between point center and each bird seen or heard (Reynolds et al. 1980). Using this "distance sampling" approach (Buckland et al. 2001), it is

possible to estimate bird detection probabilities, which can then be used to estimate bird densities. Although in concept this method is suitable for a range of habitats, there are challenges to successful implementation. For example, accurate bird-distance estimates are a key assumption of the models for bird abundance, yet the ability to estimate distances will vary, depending on the observer's skill and the habitat. In dense forests and shrublands, for example, birds may be heard from a considerable distance, but the range of accurate distance estimation may be severely restricted (Alldredge et al. 2007; Simons et al. 2009). Additionally, an observer may flush birds or cause them to stop singing while traveling through dense, noisy brush, which violates two other assumptions of distance-sampling models: (1) all birds at each point are detected, and (2) birds do not move in response to the observer prior to detection.

The Gulf Coast Network addressed the challenges of the standard variable circular plot design with three additions to their design. The first two additions should improve the abundance estimates made through distance and time-removal methods, and the third addition makes it possible to use occupancy or N-mixture models instead (or as well) for monitoring status and trends in birds. First, the network uses distance annuli rather than exact estimates of the distance to a detected bird, thus increasing the repeatability of estimates among different, trained observers (see also Rosenstock et al. 2002). The distance bands are 0–25 meters (0–82ft), 25–50 meters (82–164 ft), 50–100 meters (164–328 ft), and greater than 100 meters (328 ft). Second, the network records each bird only once (at first detection) during a 10-minute observation period, even if an individual is seen or heard repeatedly over that time period. Following this approach, individual birds are detected and "removed" (i.e., ignored after initial detection) from the population being surveyed, and the data on time of first detection (in 1 minute increments) are used to calculate the probability of a given species being detected within a specified time interval (Farnsworth et al. 2002). The combination of categorical distance estimates and time of first detection are used to determine the radius of effective detection for a given species, its detection probabilities, and ultimately, its density (following Farnsworth et al. 2005; see also Sólymos et al. 2013a; Amundson et al. 2014). To produce reliable abundance estimates, however, the rule-of-thumb sample size for distance sampling data is 80–100 detections per species, made by the same observer within the area and time-period of interest (Buckland et al. 2001). As such, these methods are used to estimate abundance or density only for the more common species in a park, and their detection probability estimates may combine multiple years of data, which are applied to each year's point counts as an offset (following Sólymos et al. 2013a,b).

Although the combined approach described above should improve on estimates made from distance sampling alone, there remains uncertainty as to whether the underlying assumptions can be adequately met in either the distance-only or combined approach (for discussion, see above papers, Johnson 2008; Marshall et al. 2016). Given these challenges and that new analytical approaches are being introduced each year, this protocol aims to collect data in a more generalized and flexible way so alternative analyses may also be used. As such, the network performs a repeat visit to each point within a two-week period in each season, which makes it possible to analyze observations as occupancy (detect/non-detect per point-count event) or superpopulation abundance (e.g., MacKenzie et al. 2002; 2003; Royle and Kéry 2007; Schmidt et al. 2013). Although these modeling approaches

also have key underlying assumptions, they are more suitable to the complex habitat and behaviors that characterize most birds, and the estimates are thereby less prone to bias caused by errors in how (and how well) detection probability is estimated.

The repeat-visit variable circular plot method of this protocol parallels that used by the Northeast Temperate Network Breeding Landbird Monitoring Protocol (Faccio et al. 2015) and Great Lakes Network (Gostomski et al. 2010), Eastern Rivers and Mountains Network (Marshall et al. 2016) and the United States Fish and Wildlife Service (Knutson et al. 2008). The main exception is that band sizes are not exactly the same across all protocols, although they are compatible because they all include the 25-meter (82 ft) and 50-meter distances (164 ft).

Site Selection

The Gulf Coast Networks' approach to site selection adheres to recommendations for landbird monitoring in national parks by Fancy and Sauer (2000).When defining the spatial sampling frame, the population of interest is limited to birds of terrestrial habitats, including forest, shrub, grassland, and desert habitats. Within these terrestrial habitats, survey locations are selected using GIS as simple random points within appropriate areas of whole parks or focal units within parks (Table 3). There is a pre-defined minimum buffer distance of 200–250 meters (656–820 ft) between adjacent locations and 25–50 meters (82–164 ft) around park boundaries. The smaller buffer sizes are used in situations where the original buffers and distances could not accommodate the full set of points within the sampling frame polygon (see Table 3 for park-specific buffer sizes and distances). As stated in Twedt (2012), random selection of survey locations ensures a statistically valid sample from all habitats being monitored, which can be extrapolated to whole-park or whole-unit areas. Additionally, these random locations are co-assigned with vegetation monitoring plots whenever possible (in five of six parks), with the requirement that bird points are offset by 10 meters (32.8 ft) to prevent trampling in the vegetation plot.

Once survey point locations are selected using GIS, the physical locations are established following the procedures in SOP BIRD02 *Establishing Bird Survey Point Locations—Version 1.0* (Granger and Carlson 2018a). Pilot sampling at these locations has been implemented in all parks beginning as early as 2010 (San Antonio Missions NHP; Table 3). Sampling for the final protocol is largely unchanged, with the exception that all points are now sampled two times each year, as opposed to 50% of points being sampled annually in an alternate-year panel design for most parks. Maps of sampling locations and tables of GPS coordinates for each park are provided in SOP BIRD02.

Sample Sizes

The Gulf Coast Network monitors landbirds at 21–33 randomly-selected points per park (Table 3). The total number of points sampled across all parks is 179.

Table 3. The number of annually-sampled point locations and their distribution among parks or major park units. For the first three parks on the list, points are randomly selected locations within the administrative boundary at the time of initial point selection. For the remainder, points are randomly selected locations within focal-unit polygons. For Gulf Island NS, the Florida and Mississippi points were assigned as separate spatial random draws. Maps of point locations, target polygons and GPS coordinates are in SOP BIRD02. Park names marked with an asterisk have a subset of their plots co-located with vegetation monitoring points, with an offset of 10 meters (32.8 ft).

Park	State	First year of data	Number of points	Point distribution within park (within whole parks or targeted units)	Park interior buffer width	Minimum distance between points
Vicksburg National Military Park*	MS	2012	32	Whole-park approach: all undeveloped areas within the administrative boundary at the time of initial point selection	25 m	200 m
Palo Alto Battlefield National Historical Park*	TX	2011	29	Whole-park approach: all undeveloped areas within the administrative boundary at the time of initial point selection	50 m	250 m
San Antonio Missions National Historical Park*	TX	2010	33	Whole-park approach: all undeveloped areas within the administrative boundary at the time of initial point selection: 27 at the main properties in San Antonio and 6 at Rancho de las Cabras near Floresville, TX	25 m	200 m
Big Thicket National Preserve*	TX	2014	32	Targeted unit approach: Turkey Creek unit only	50 m	250 m
Gulf Islands National Seashore*	FL, MS	2012	13 FL, 8 MS	Target unit approach: 13 in the Naval Live Oaks unit, 8 in the Davis Bayou unit.	50 m	250 m
Jean Lafitte National Historical Park and Preserve	LA	2014	32	Modified targeted unit approach: Within the Barataria Unit only, with points restricted to buffered corridors along accessible roads, trails and levees	25 m	200 m

Sampling Frequency and Replication

Each point location is sampled twice per year in late spring or early summer following the procedures in SOP BIRD03—*Conducting Breeding Bird Point Counts* (Granger and Carlson 2018b). All of a park's points are visited within a four-day to two-week period, with 3–8 points completed each day. All points are resampled within two and ten days after the initial sampling and must be conducted between dawn and 10:30 a.m. The timing of the park visit must be between 1 May and 30 June, although the optimal dates are between 15 May and 15 June. This timing is set to capture most species during their breeding seasons (Twedt 2012).

Power Analysis and Statistical Targets

The second and third monitoring objectives in this protocol focus on the occupancy of most birds and the relative abundance or density of common birds in each park, and they ask whether these variables increase or decrease over time. Using the pilot data collected by the network, it is possible to evaluate whether the data collected under this protocol's design are likely to be sufficient to make meaningful estimates of density (counts per hectare) and to detect trends in this metric over time. The Gulf Coast Network addresses these questions using the statistical targets and power analyses presented below. The estimates and analyses are based on preliminary data from distance and time-removal models only, because approaches involving occupancy and N-mixture models are still under development. For the current approach, common species are used instead of rare ones because detectability cannot be estimated accurately from a few observations. A slightly broader range of species can be analyzed using occupancy models, and the rarest species are generally out of the scope of this protocol. This protocol also does not use metrics such as species richness and diversity for trend analyses, because rare species at a site may go undetected in any given year due to random chance. See Cheng (2016) and Cheng (2017) for power analysis discussions on similar issues in GULN amphibian monitoring.

For density estimates, the Gulf Coast Network sets the following statistical target: the 95% confidence intervals around the annual density estimates should be no greater than ±0.5 birds per hectare, based on a three-year average for a given species. Whenever that target is not met, the network will re-examine whether that bird species is sufficiently common or whether a different analytical approach should be taken.

For trend analyses, the question of real change detection can be addressed using power analyses on pilot data. The Gulf Coast Network has available a pilot data set of point counts from Palo Alto Battlefield NHP, with annual sampling events at the same 29 points from 2011–2016, although analyses begin in 2013 to allow for detection probability estimates that year. For a power analysis on these data, the network sets the type I error rate at 10% (i.e., probability that change is detected when none exists; often called alpha or significance level), the type II error rate at 20% (i.e., probability that true change is not detected; one minus type II error = statistical power), and the minimum detectable effect size at 40% cumulatively over a pre-selected interval. In other words, a key expectation of the design is that sample sizes are sufficient to allow detection of at least a 40% increase or decrease in density or relative abundance with 80% power and a false positive rate of 10%.

Following these standards, the Gulf Coast Network performed a suite of power analyses to determine whether the sample size of 29 points per year in the pilot data set could meet GULN targets for trend detection at Palo Alto Battlefield NHP. The number of years during which data were collected prior to trend analyses was set at six, nine or twelve years. The key variables were the annual density estimates (number per hectare) for each of the three most common species: eastern meadowlark (*Sturnella magna*; 326 detections over 4 years), northern mockingbird (*Mimus polyglottos*; 239 detections) and mourning dove (*Zenaida macroura*; 204 detections). The density value for each point was adjusted using an offset based on per-species detection probabilities and effective detection radii, following the approach described in SOP BIRD06 *Data Analysis and Reporting—Version 1.0*

(Carlson and Segura 2018). Power analyses were completed using methods and R code of Miller and Mitchell (2014), with slight modifications to accommodate variability estimates over several years rather than two years of data. The results of these analyses, shown in Table 4, indicate the annual sample of 29 was sufficient to meet pre-assigned targets for detecting declines or increases in all three species after 12 years, and for one species, after only six years. In other words, the pilot study's effort would allow detection of a 40% change in density of eastern meadowlarks, mourning doves or northern mockingbirds over 12 years, with over 80% power and a false-positive rate of 10% (Table 4). This suggests that trend analyses on these common species would become increasingly valid beyond the fourth reporting interval (after 12 years of data), but prior to that, the results for some species should be viewed with caution. Additionally, it should be noted that the pilot design and preliminary power analyses did not include repeat visits to points within a season, although this is now a feature of the protocol. Given that the new design should effectively double sampling effort within each park, there should be more power to detect trends, and more species may be considered common. The degree to which power is improved under the new design will be ascertained in a future power analysis once more data are available.

Table 4. Results of power analyses for detecting trends in density (no. per ha) of the three most common bird species at Palo Alto NHP over either a 6, 9 or 12 year period. Findings are reported in terms of statistical power for detecting at least a 40% change the time interval of the study. The first percentage is for a 40% increase, and the second is for a 40% decrease. The alpha level was set at 0.1. The target is greater than or equal to 80% power.

Bird species	Power to detect a 40% increase or decrease over 6 years	Power to detect a 40% increase or decrease over 9 years	Power to detect a 40% increase or decrease over 12 years
Eastern Meadowlark	95 or 94%	97% or 94%	100% or 100%
Northern Mockingbird	61% or 63%	76% or 78%	81% or 83%
Mourning Dove	74% or 68%	75% or 78%	83% or 84%

Field Methods

Field Methods

Observers are referred to *A Land Manager's Guide to Point Counts of Birds in the Southeast* (Hamel et al. 1996) for documentation on general methods of conducting point counts for breeding birds. The SOP BIRD03 (Granger and Carlson 2018b) provides additional instructions relevant to the GULN approach and explains how to collect data on time of first detection and distance between the observer and the bird, which are not included in Hamel et al.'s (1996) methods.

Field Schedule and Preparations

Each park is sampled during a narrow time span each year—for four to fourteen days between May 15 and June 15—so advance preparation is essential. Due to the complex skill set required for monitoring breeding landbirds, this protocol only engages highly-qualified personnel trained and available to accomplish the field work. All landbird monitoring for the Gulf Coast Network is performed by expert cooperators, contractors or NPS biologists with point count experience. Recruitment and training in protocol application are coordinated by the protocol lead with occasional support from staff at the parks. Field personnel are recruited well in advance of sampling, and survey materials and protocols are provided at least one month prior to the start of the field season. Also prior to their first sampling visit, the field observer must have a meeting (remote or in person) with the GULN protocol lead to review field procedures and SOPs BIRD01 (*Safety—Version 1.0* [Segura et al. 2018]), BIRD02 and BIRD03. Particular attention must to be paid to ensure consistent use of the field data form, GPS and range finder as well as to ensure a shared understanding of how times, distances and IDs are recorded. Research permits and clearances required for accessing park grounds outside of business hours (about 4:00 to 4:30 a.m.) are coordinated with each park's management and established prior to monitoring.

Sampling Methods

Permanent point-count stations are identified and established as described above (see previous Site Selection section). When allowed by the park, the locations are permanently marked for easier encounter by field observers. General guidelines for conducting landbird point-count surveys are provided by Hamel et al. (1996) and Huff et al. (2000). Specific details for conducting point counts of breeding birds within GULN parks are provided in SOP BIRD03. A brief summary of field procedures is included below.

Each random survey point is visited twice per year by at least one observer. Surveys must be performed in the morning, from 30 minutes before sunrise to four hours after sunrise, and they are not conducted during heavy rain or high winds as defined in SOP BIRD03. A single observer watches and listens for birds of any species for a 10-minute period. When an individual bird is detected for the first time, the observer records the species identity by its four-letter code (Pyle and De Sante 2017), the time (within 1-minute intervals), and the distance from the observer to the bird (within four distance annuli). Individual birds are recorded only once per 10-minute survey, upon their first detection.

The Gulf Coast Network provides datasheets to field personnel, which must be printed on weatherproof paper prior to conducting surveys. A blank datasheet is included as Figure S3.1 in SOP BIRD03. Field personnel are required to use the datasheets provided and populate all necessary fields completely and accurately. Prior to departing a survey point location, personnel must check that all data are entered correctly on the datasheet. This is a field-based verification step and initiates the datasheet QA/QC lifecycle (as described in Data Management and Process Workflow below as well as SOP BIRD05—*Data Management and Quality Assurance/Quality Control* [Granger and Carlson 2018c]).

Quality Control Visits

Over a three-year period, the Gulf Coast Network conducts a quality control visit to each park, with two or three parks visited each year. This visit consists of a qualified GULN staff person or contracted expert joining the observer for a full day of field work and simultaneously recording their own point-count data at each point that is visited. These double-observer samples are used to determine consistency of bird distance estimates and bird identifications. See SOP BIRD05 for more information (Granger and Carlson 2018c).

End of Season Procedures

After all field data for a given season are collected, the protocol lead follows up with the field crew leader to ensure that datasheets are complete and returned to the network in a timely manner. All field personnel are required to complete a post-sampling check of the datasheets and then sign and date the datasheet as reviewed. If field personnel are cooperators or contractors, they scan and email the datasheets to the network protocol lead and mail the paper datasheets. The protocol lead conducts an additional review of contractor and cooperator work and addresses any issues before initialing the sheets as accepted. Scanned, accepted datasheets are delivered to the network data manager for further processing (see “Data Management and Process Workflow” later in this narrative). As appropriate, the protocol lead will also follow up with cooperators, contractors, and park staff to thank them for their support, and to provide summaries of data when available.

Data Management

Overview of Data Management Workflow for the Gulf Coast Network

An increasing demand for detailed, high quality data and information about natural resources and ecosystem functions requires a team working together to steward data and information assets. Knowledgeable individuals from scientific, administrative, and technological disciplines must work in concert throughout the data management life cycle. This collaboration ensures that data are collected using appropriate methods, and that resulting data sets, reports, and other derived products are well managed, credible, representative and available for current and future needs. As such, data stewardship responsibilities apply to all personnel who handle, view, or manage data. Within the Gulf Coast Network, all office personnel play key roles in information management, although the GULN data manager holds the primary responsibility for managing and processing landbird monitoring data after datasheets have been completed and returned to the GULN office. The overall strategy for the network is described in the *Gulf Coast Network Data Management Plan* (Granger 2007). The GULN Data Management Plan also contains appended guidance documents on various information management topics.

Project Information Management Overview

Project information management may be best understood as an ongoing or cyclic process, as shown in Figure 3. The stages of this cycle are summarized in the following sections, with specific tasks listed for the breeding landbird project. A full description of this protocol's data management plan and QA/QC practices is in SOP BIRD05 *Data Management and Quality Assurance/Quality Control* (Granger and Carlson 2018c).

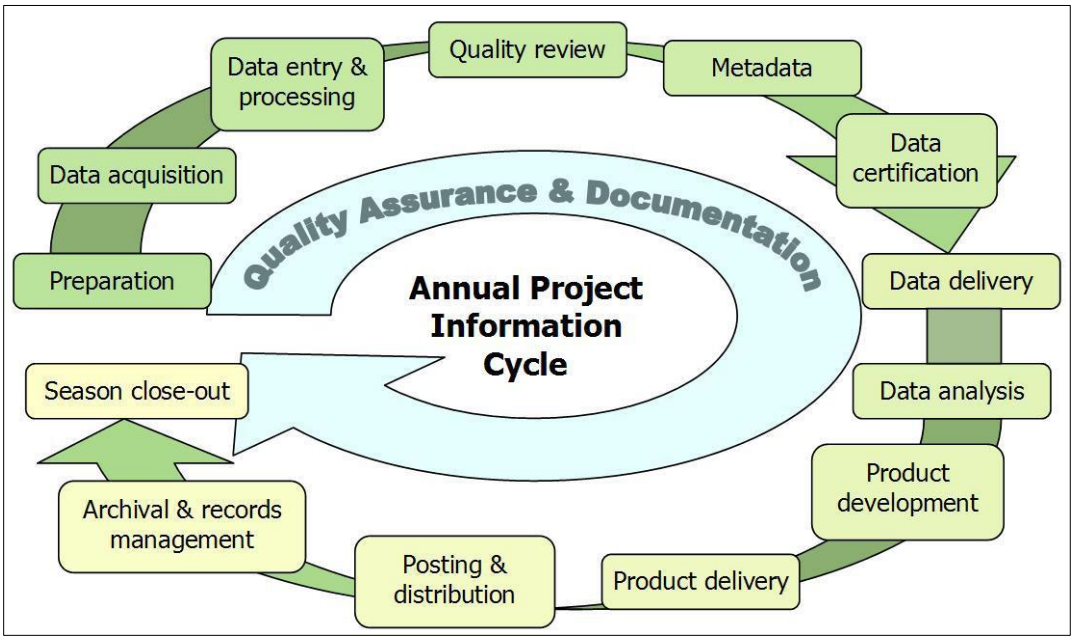

Figure 3. Flow diagram of the cyclical stages of project information management. Note that quality assurance and documentation are thematic and not limited to any particular stage of the information life cycle.

Data Management and Process Workflows

The data management workflow for breeding landbirds is as follows (see also Table 5):

- **Preparation**—trip logistics are planned, supplies are assembled following equipment lists, and paper datasheets are printed (see SOP BIRD03—*Conducting Breeding Bird Point Counts*; Granger and Carlson 2018b).

- **Data acquisition**—Data are collected by the observer on paper datasheets, in accordance with instructions in SOP BIRD03. The final products from this step are raw datasheets.

- **Datasheet review/verification**—Prior to departing the field site, field personnel review the datasheet for completeness. The final products from this step are verified paper datasheets (see SOP BIRD03).

- **Datasheet validation**—The protocol lead and field crew leader (ornithology background required) check each datasheet for realistic entries, and the use of correct and current bird alpha codes. The final products from this step are validated paper datasheets (see SOP BIRD03 and SOP BIRD05).

- **Accepted datasheets**—After the paper datasheets are validated, they are digitally scanned and stored as the final, accepted datasheet (see SOP BIRD05).

- **Data entry, processing, and backup**—All entries that were recorded on the paper datasheets are entered into the GULN landbird monitoring database. This is completed on computers in the GULN office. The final product of this step is a raw, entered data set (see SOP BIRD04 *Data Entry and Validation—Version 1.0* [Granger 2018]).

- **Database verification and quality review**—As data are entered from paper datasheets into the database, multiple verification checks are performed. First, after entering each datasheet into the database, the typist compares the database and datasheet to ensure all typed numbers match what was written. Second, a different staff member reviews all datasheets entered that day to again ensure all typed data match the datasheet. This is the 100% check. Third, either the data manager or protocol lead reviews 10% of all datasheets, again for proper entry from the datasheet. This is the 10% check and also functions as quality review. The final products at this stage are verified and quality-checked data in the database (see SOP BIRD04 and SOP BIRD05).

- **Database validation**—After data are verified as entered correctly, additional validation tests are completed by the protocol lead or a qualified supporting individual to ensure that data in the database are logically consistent and realistic. These steps include plotting data points, calculating summary statistics, and reviewing species lists. At the end of this stage, the products are validated data in the database (SOP BIRD05).

- **Accepted database**—After verification and validation steps are complete, the data are classified as accepted. Once the Quality Assurance Plan (QAP) for this protocol is completed, and all steps in the QAP are completed, the data grade is changed to "certified."

- **Metadata/documentation and data delivery**—All data that are accepted or certified will be accompanied by metadata that describe that data set and document the results of the quality review. The products here are accepted data and the associated metadata, which can then be archived and uploaded to the master project database. These products should be completed within three months of the final sampling event for a given field season database (SOP BIRD05).

- **Data analysis and product development**—Data are summarized, analyzed, and prepared for reports and presentation following the procedures outlined in the "Data Analysis and Reporting" section below. "Status and Trends" reports are created for each park after three years of data collection and then every three years thereafter. The first three of these reports summarize annual findings on each park's landbird community, as described later in this section. For every-other reporting interval, "Status and trends" reports are lengthened to include trend analyses, with results of statistical tests of cross-year trends. See SOP BIRD06—*Data Analysis and Reporting* (Carlson and Segura 2018) for more information.

- **Product posting and distribution**—Finalized products are distributed to parks and other stakeholders, and/or posted to NPS clearinghouses. Report and presentation products will be distributed to stakeholders as they are completed, and these products, in addition to the databases and scanned datasheets, will be posted to IRMA on an annual basis. Database exports will also be uploaded to the Avian Knowledge Network (AKN) under the eastern node (SOP BIRD05). As necessary, these data may be subjected to protected information procedures.

Data Processing and Data Quality Levels

The data processing steps, their associated products, and their frequency of completion are listed in Table 5. This table also introduces the three stages of data processing: raw, provisional, and accepted. Raw data are in their original form, either as a field datasheet, photo, or a raw entry into the database. Provisional data have undergone verification steps but are not suitable for general use. Accepted data are products from the provisional data step that have been validated, documented with metadata, and are fit for analysis and publication. See SOP BIRD05 for additional details.

Table 5. Data processing steps and products for the GULN Landbird Monitoring protocol.

Data type	Data stage (going in)	Processing step	Product name (going out)	Expected frequency of completion
Datasheets	NA	1. Datasheets are filled-in by hand in the field.	Raw datasheets	At the end of each point sampling event
Datasheets	Raw	2. Datasheets are reviewed for completeness at the end of fieldwork.	Reviewed/verified datasheets	At the end of each point sampling event
Datasheets	Provisional	3. Datasheets are reviewed by the field crew leader and/or protocol lead for spelling, current taxonomy, and realistic values.	Validated datasheets	At the end of each field sampling day or within a week
Datasheets	Accepted	4. Datasheets are digitally scanned.	Scanned, validated, and accepted datasheets	At the end of each field sampling day or within a week
Datasheets	Accepted	5. Paper datasheets are managed as long-term records.	Local storage of accepted datasheets	Within three months of field season's end
Datasheets	Accepted	6. Scanned field forms are published to NPS Data Store or IRMA.	Offsite archive and publication of accepted datasheet	Within one year of field season's end
Landbird monitoring database	NA	1. Accepted datasheets are entered into the database.	Raw, entered data sets	Within several weeks of the field sampling day
Landbird monitoring database	Raw	2. Data verification during data entry: typist checks his/her own work for accurate transcription of each page.	Partially verified data sets	Within several weeks of the field sampling day
Landbird monitoring database	Raw	3. Data verification post-data entry: another staff member performs a 100% check for accurate transcription.	Partially verified data sets	Within several weeks of the field sampling day
Landbird monitoring database	Provisional	4. Data verification post-data entry: data manager/protocol lead performs a 10% check of all datasheets for a given field season for accurate transcription.	Verified data	Within one month of field season's end

Table 5 (continued). Data processing steps and products for the GULN Landbird Monitoring protocol.

Data type	Data stage (going in)	Processing step	Product name (going out)	Expected frequency of completion
Landbird monitoring database	Provisional	5. Protocol lead or qualified individual creates summary statistics and plots data to identify and flag outliers	Partially validated data	Within three months of field season's end
Landbird monitoring database	Provisional	6. Protocol lead or qualified individual reviews species lists and checks IDs for unexpected records.	Validated data	Within three months of field season's end
Landbird monitoring database	Accepted	7. Validated data are accepted and metadata are created for the data set. *If all steps in an approved Quality Assurance Plan are also completed, they can become certified data.*	Accepted data and the associated metadata	Within three months of field season's end
Landbird monitoring database	Accepted	8. Database backends of accepted or certified data are published to NPS Data Store or IRMA.	Offsite archive and publication	Within one year of field season's end
Landbird monitoring database	Accepted	9. Data are analyzed, and reports are written based on the results.	'Status and Trends" reports	After three years of data collection on the park, using accepted or certified data

Data Archiving

Instructions for archiving and posting data are included in SOP BIRD05. To summarize, after digital products are processed and approved (for reports) or accepted/certified (for data sets), the data manager archives them and prepares for posting them to Integrated Resources Management Application (IRMA). IRMA is the NPS clearinghouse for natural resource data and metadata. The types of products that are posted on IRMA for this project include Microsoft Excel exports of annual data sets from the NPS GULN Landbird Monitoring Database (annually), the Status and Trends reports (every three years), and digital scans of data sheets.

The timing of posting new products to IRMA is annually, if not more often. Products on IRMA can be shared with the public or classified as restricted access only. Public access is given to final, approved reports or to data sets that are accepted or certified and from which protected data have been withheld. Restricted access on IRMA may be used for provisional products or protected information. The GULN data manager has created a GULN Landbird Monitoring Project that houses

all products uploaded to IRMA. Refer to the IRMA website for upload and product linking instructions.

When any product is posted on IRMA, the data manager creates for it a separate reference record that is specific to the IRMA platform, following instructions on the IRMA website. The reference record contains citation information, relevant metadata and keywords. This is done for all products including reports, other publications, data sets, or set of field sheets. The digital version of the product is uploaded in association with that reference, making it available for discovery. Most products are organized by park, unless they apply to multiple parks. Finally, where appropriate, the data manager also extracts species observations and imports them into other platforms. One platform is NPSpecies, which is the NPS database and application for maintaining park-specific species lists and observation data. NPSpecies is a component of IRMA. The other platform the network uses to share bird monitoring data is the Avian Knowledge Network (AKN).

Protected Information Procedures

Currently, none of the breeding landbirds species recorded during GULN point counts are listed as threatened or endangered by the U.S. Fish and Wildlife Service (USFWS), although several are included on the USFWS's regional lists of Birds of Conservation Concern (USFWS 2008). Because of the transient nature of most birds, the network does not currently classify any of their point locations or bird monitoring data as protected information, although this is conditional on coordination with park staff and approval from each Superintendent. Instructions for managing protected data are included in the Data Management SOP BIRD05.

Procedure for Revising the Protocol

Over time, revisions to both the protocol narrative and SOPs are expected. Careful documentation of changes to the protocol and a library of previous protocol versions are essential for maintaining consistency in data collection and for appropriate treatment of the data during data summary and analysis.

The steps for changing the protocol (either the protocol narrative or the SOPs) are outlined in SOP BIRD 07 *Protocol Revisions—Version 1.0* (Carlson 2018). The protocol narrative and each SOP contain a revision log to fill out each time the narrative or an SOP is revised. In this log, the GULN staff person briefly documents when and why the change was made and assigns a new version number. Revised protocol narratives must also be assigned a new report number by the National I&M Program Publication Manager. The new version of the SOP or protocol narrative must then be posted to the IRMA Data Store as well as archived in the appropriate GULN vital signs protocol folder on the GULN network drive.

Data Analysis and Reporting

A full description of this protocol's plan for data summaries, analysis and reporting is provided in SOP BIRD06 *Data Analysis and Reporting—Version 1.0* (Carlson and Segura 2018). The sections below provide an overview of the steps in describing and analyzing bird monitoring data. They also describe how and how often data and results are reported. The GULN protocol lead is responsible for ensuring analyses and reports are completed as scheduled, and in most cases the protocol lead performs these duties him- or herself. As necessary, outside experts may be contacted to assist with certain statistical analyses or interpretations that require additional or local knowledge of avian ecology.

Annual Data Export

Based on park feedback during the pilot phase, written annual reports are not included in the GULN Breeding Landbird monitoring protocol. Instead, the network provides a simple database export of a table listing the species seen during the past year's sampling event and the number recorded of each.

Park Status and Trends Reports

The Gulf Coast Network performs a detailed suite of analyses and produces a Status and Trends Report after three years of data collection. This report is a combination of the short-term "Status" reports and the more detailed "Trends" reports seen in other protocols, with the caveat that the first such report on bird monitoring does not include the trend analysis section. Writing for the Status and Trends Report begins after the database has passed validation steps to become an accepted or certified database, typically three months after the end of that year's field season.

The SOP BIRD06 describes the sections and key analyses of the Status and Trends Report. In summary, the report includes a general overview of the project's objectives, duration and methods used in the park. After the first reporting interval has passed, the methods section also describes how trend analyses were conducted. The report also describes relevant vegetation data from plots that are co-located with bird monitoring points in most parks (e.g., percent canopy openness; stand regeneration, basal area and tree mortality; tree and shrub species composition; and the presence of any plant species known to be important to monitored landbird species). It may also summarize weather (windiness, clear versus cloudy and temperature) and noise conditions recorded at survey point locations over the reporting interval. If any unusual conditions or events occurred on the park, these are also noted. The remainder of the report is dedicated to the project's results for breeding landbird detection during the period of interest, in the components listed later in this section. Finally, there is a conclusions section that discusses these findings in the context of previous reports and in relation to park management concerns and potential environmental stressors that may be driving observed patterns.

Results Sections for the Report

The report includes the following results components:

- A complete list of all bird species detected, including those most relevant to the monitoring protocol (breeding landbirds, as defined in the protocol narrative introduction) and non-

monitored species that are incidentally detected during the point-count event. For subsequent summary statistics, only data on breeding landbirds are reported.

- Annual summaries of the three previous years of data including:
    - The number of individuals seen of each species and their relative abundance (number seen divided by the number of point-count locations; as a table).
    - The proportion of point-count locations where at least one individual of that species was seen (as a table).
- Annual estimates of population density for each common bird species over the three-year period (in a table). Inclusion in this table requires being detected more than 40 times per year for at least three years. If a species was detected at least 80 times per year, annual estimates are corrected using a detection probability offset from that year's data alone. For species with fewer than 80 detections per year, detection probability offsets may be calculated by combining observation data for that year plus the previous two years to achieve a sufficient sample size for the model's requirements. The detection probability offsets are prepared and applied to count data following the R code provided in Sólymos et al. (2013b) or a comparable approach. An alternative to estimating density or abundance through distance and time-removal models is estimating superpopulation abundance using N-mixture models, potentially following Schmidt et al. (2013) or similar.
- Graphical depiction of changes in relative abundance or density (corrected with detection probability estimates, as described above) of the focal common species for that park.
- Graphical depiction of species richness for each year and cumulatively over the three-year period.
- After six years of data collection, statistical analyses of trends over years for the focal common species for that park.

Statistical Analyses for the Report

As explained in SOP BIRD06, the Gulf Coast Network performs cross-year trend analyses on at least six years of data using generalized linear mixed models (e.g., R package lme4; Bates et al. 2015) or another comparable approach that is deemed appropriate at the time of analyses. For examples of the varying approaches that are available at this protocol's writing, see Sólymos et al. (2013a,b) or Amundson et al. (2014). Generalized linear models are broadly suitable for testing for trends in density or relative abundance of the commonly detected species (as defined above), with each focal species analyzed separately. Because only the most common species are used in these models, the estimates can be improved using offsets based on pre-calculated detection probabilities for that year or the past several years, following Sólymos et al. (2013a,b). For each model, the response variable is either the number of individuals per point-count location or the density (number per hectare). The main fixed effect is year, to test for a net increase or decrease over time (six or more consecutive years). Where appropriate, the point-count location is included as a random effect, as detailed in SOP

BIRD06. Covariates may include vegetation metrics, weather variables, the specific observer or noise data measured at individual point locations.

If estimates from distance and time removal models are deemed inadequate, the network will use alternative approaches for estimating metrics and performing trend analyses. These alternatives include Bayesian hierarchical N-mixture models for estimating superpopulation abundance (Schmidt et al. 2013) or occupancy modelling approaches for estimating occurrence (number of points with 1+ detection out of all sampling points). Occupancy models can follow a likelihood-based approach (e.g., MacKenzie et al. 2002; 2003) or a Bayesian approach (e.g., Royle and Kéry 2007). Models can be implemented in freeware programs including R package unmarked (Fiske and Chandler 2011), WinBUGS (Spiegelhalter et al. 2004; or in R, through R2WinBUGS; Sturtz et al. 2005), or JAGS (Plummer 2003). For a recent overview of occupancy modelling methods, see MacKenzie et al. (2017).

The primary trend analyses for will be based on data beginning in 2019, when the final design will be implemented in each park. Whenever possible, pilot data are included in the primary analysis.

Personnel Requirements and Training

Roles and Responsibilities

The protocol lead, typically a designated Gulf Coast Network staff member, coordinates the breeding landbird monitoring program. This duty includes working with park resource managers for necessary permissions, obtaining and sharing updates on park conditions and potential issues for fieldwork, and establishing support from park staff during the monitoring effort. As Gulf Coast Network breeding landbird monitoring sites are often co-located with vegetation monitoring sites, it is expected that changes in logistics and field conditions are also communicated between the landbird protocol lead and vegetation protocol lead as issues arise. The breeding landbird protocol lead is also responsible for advertising and recruiting contractors and cooperators that have the skill level needed to identify breeding landbirds by sight and sound. The protocol lead remains in contact with contractors and cooperators as necessary during and after each field season. Other duties of the protocol lead include providing training materials, park contact information, data sheets, and field equipment. If fieldwork is completed by a contractor or cooperator, the protocol lead also completes the post-field validation step on all datasheets, signs them, and then provides them to the GULN data manager. After data sets are entered into the database and have become accepted or certified, the protocol lead completes or ensures the completion of all data analyses and reports.

The *data manager* receives the datasheets from the protocol lead and is then responsible for remaining steps of data entry, QA/QC, storage, archiving, posting, and product distribution (see "Data Management" section above).

Each *park's resource manager* or other designated personnel is expected to provide support to field personnel on park-specific issues, including access, trail or area closures, and whether or not certain species observations or point-count locations should be classified as protected data.

The *field crew leader* is responsible for completing all field work, communicating with the park in a timely manner for scheduling and park access, maintaining communications with the protocol lead and providing datasheets once they are completed and reviewed post-fieldwork. All field personnel are responsible for ensuring that monitoring is conducted as safely as possible. Any safety concerns must be brought to the attention of the protocol lead and NPS staff. Everyone conducting field work is expected to review SOP BIRD01 *Safety—Version 1.0* (Segura et.al. 2018). It is particularly important that park resource managers know when field personnel are in the park, which is accomplished through the required check-in and check-out procedures. For additional information, see SOP BIRD01.

Field Personnel Qualifications

All observers conducting the Gulf Coast Network Breeding Landbird Monitoring Program must be capable of identifying the vast majority of breeding landbirds (at least 99%) likely to be encountered by both sight and sound. Multiple studies have indicated that differences among observers can introduce a great deal of bias during trend analyses of songbird populations (Kepler and Scott 1981; Ralph et al. 1995). Additionally, observers must be proficient at estimating the number of individual birds detected and their horizontal distance from the observer. Field personnel must also be capable

of hiking over variable terrain and arriving at their study site by 5:00 a.m. on survey mornings. Field personnel are also encouraged to obtain certification in basic first aid and CPR.

Training Procedures

As noted above, contracted or in-house observers must already possess a high degree of skill in breeding landbird identification and experience collecting time and distance sampling to participate in monitoring for the Gulf Coast Network. To train new observers in the specifics of the GULN approach, all field personnel are required to read the protocol narrative and the three SOPs associated with field work: BIRD01, BIRD02, and BIRD03. Reading the remaining SOPs is also recommended. Finally, observers must also read appropriate sections of Hamel et al. (1996). Prior to their first sampling visit, observers must have a meeting (remote or in person) with the GULN protocol lead to review field procedures and SOPs BIRD01, 02 and 03. Particular attention must to be paid to ensure consistent use of the field data form, GPS and range finder as well as to ensure a shared understanding of how times, distances and IDs are recorded. Using the provided laser rangefinder, observers must spend time practicing distance estimation in different habitat conditions, so they get a feel for its limitations and calibrate their ability to estimate distance. In particular, they should listen for birds, estimate the distance, and then attempt to visually locate and measure the actual distance. Finally, field personnel are provided with a list of breeding landbird species likely to be encountered at the park where they work.

Operational Requirements

Annual Workload and Field Schedule

Annual implementation of the breeding landbird monitoring plan involves several people, including the Gulf Coast Network's protocol lead and staff, park resource managers, and contracted or in-house field personnel. Annual workload responsibilities vary widely, ranging from approximately 70–80 days for the network staff, to 10–30 hours per park for field personnel and most park resource managers. The time and expenses associated with field work are detailed separately for each park in the "Budget Considerations" section later in this narrative.

Contracting and Agreements

Observer vacancies must be filled by March of each year to allow preparations ahead of the sampling field season. Contracts and/or agreements must be approved and in place before the vacancy is considered filled. The network requires all observers be qualified birders with the skill level necessary to conduct time and distance point counts. The network gives preference to qualified observers located close to each of the parks, to reduce travel expenses and allow for more flexibility if there are weather delays. Qualified observers may belong to a range of governmental or non-governmental organizations, and after these individuals are selected, the appropriate funding instrument is engaged. Because of the close coordination with network staff, organizations affiliated with the Gulf Coast Cooperative Ecosystems Studies Unit (CESU), for example, a cooperative agreement is appropriate. For initiating these types of agreements, the latest guidance should be solicited from the Gulf Coast Network CESU coordinator. If an observer is a qualified birder and is able to provide the work for under $10,000, a contract with payment using a government credit card may be used. This does not require routing through the NPS contracts and agreements office as it is considered a fee-for-service micro purchase.

Currently all park projects have contracts or agreements in place to conduct the bird surveys. Cooperative agreements have their own deadlines to be met if a modification or new agreement needs to be established. The Gulf Coast Network program manager serves as the Agreements Technical Representative (ATR) and is responsible for maintaining the agreements. At the end of a field season, each observer is asked to reassess their commitment to collecting data for the next field season. If they do not wish to continue, they are asked for recommendations for other qualified people. The network manager may also contact the park resource manager or the Gulf Coast CESU coordinator for help with locating potential qualified personnel.

The time commitment for completing cooperative agreements and contracts can range widely, from approximately two to three days up to three weeks annually, depending on the number of vacancies that need filling, the funding instrument used, and the amount of correspondence with potential observers.

Field Season

The effort required for Gulf Coast Network breeding landbird monitoring can be divided into two parts: field work and office work. For field work, each survey point at each park site is visited twice per year by field personnel. This work is primarily completed through either a professional service

micro-purchase contract or a cooperative agreement. At least two weeks prior to each sampling trip, the field crew leader contacts the park to confirm dates and availability of field support, if needed. Once every three years, the crew leader is accompanied by a second observer for a full day of QC, double-observer sampling. In these instances, advanced scheduling is particularly important to accommodate the second person. Once the trip is scheduled, the crew leader spends part of a day preparing equipment and printing data sheets just before departure. Data collection for a given park sample takes place across several morning visits, on consecutive days whenever possible. Sampling is delayed during severe weather and conditions that affect bird detectability. This includes, but is not limited to, high wind, rain, and loud noise.

The field crew leader is responsible for coordinating with park staff to acquire any necessary clearances for entry, notifying park security if need be, or otherwise ensuring access to park property during early morning hours (4:00 to 4:30 a.m.) in order to start surveys at approximately 5:00 a.m. Shortly after completing the survey (preferably the same day), observers review the data sheets, sign, and scan for backup. Scans must be emailed to the protocol lead. Originals are then mailed to the GULN office.

Establishing and maintaining point counts at parks is the responsibility of the protocol lead, which will require periodic visits to parks to assess site consistency and sampling integrity. The time and expenses associated with field work are detailed separately for each park in the "Budget Considerations" section.

Data Entry Quality Assurance/Quality Control

Data entry into the Gulf Coast Network breeding landbird database is primarily the responsibility of the network data management staff. The protocol lead provides completed fieldsheets that have passed the post-field validation step to data management staff, who complete data entry. The protocol lead also contacts observers who have not returned completed fieldsheets to solicit their prompt delivery.

Quality assurance/quality control (QA/QC) is primarily the responsibility of the protocol lead (or other qualified personnel) in collaboration with the data manager. The protocol lead reviews each datasheet for realistic entries and correct use of four-letter codes in a post-field validation step. Each sheet is signed as valid by each custodian as it changes hands from field observer to protocol lead to data management staff, producing an accepted datasheet. Once data are entered into the database, the QA/QC process includes comparing original fieldsheets to database entries for discrepancies, and once corrected, marking records in the database as verified or provisional. Additionally, data will be validated prior to conducting any analyses or preparing reports (see SOP BIRD04—*Data Entry and Validation* [Granger 2018] and SOP BIRD05—*Data Management and Quality Assurance/Quality Control* [Granger and Carlson 2018c]).

There is wide variation among parks in the approximate time required annually for data management staff to complete data entry and QA/QC responsibilities. An estimate of 20 hours per park is applied for budgeting purposes.

Reporting

The reporting schedule for the Gulf Coast Network Breeding Landbird Monitoring Project includes time-steps for basic summaries of breeding landbird monitoring data, their analysis, and the primary report type that is produced. Annually, a simple summary table is provided to each park, which includes numbers of each species seen per park, directly exported from the database. This export is completed and delivered to the park by the data manager within three months after database validation is complete. After three years of data collection, the network provides a full report on the status and trends of monitored landbirds to each park. These full reports provide in-depth descriptions and summaries of findings for that reporting interval, as well as comparisons with past reporting intervals. Beginning with the second report, a section will be added for trend analyses. The full status and trends reports are published on the National Park Service's Integrated Resource Management Applications (IRMA) portal within six months after the end of the third consecutive year. The results therein can also be used in other publications (SOP BIRD06).

Data analysis and reporting is performed by the network staff in the network offices. The protocol lead is responsible for leading data analysis and interpreting results for reporting. The protocol lead coordinates staff members and allocates tasks, selects data for analysis, identifies analytical processes to be performed and performs them. When necessary, the protocol lead also consults with outside experts for assistance with analysis and interpretation. Finally, the protocol lead prepares figures and tables for the Status and Trends Reports and writes or coordinates the writing of the complete Status and Trends Report. Database extraction and preparation will be done under the supervision of the network data manager. The expected time commitment for the protocol lead to complete the reporting phase is approximately 3–4 weeks once every third year.

Budget Considerations

Budgets for parks vary widely depending on the park, the logistics for getting to the sampling sites, and the funding instrument (Table 6). In general, it is more difficult to find cooperators to collect data where access is the most challenging. The resulting cooperative agreements are more expensive and time consuming for all involved parties. Cooperative agreements and contract documents are stored on the network server at U:\Program_Files\Project_Manager\Contracts and Agreements\Active Contracts and Agreements (available to network employees).

Table 6. Park-specific estimates of costs for protocol implementation on the six GULN parks where breeding landbirds are monitored. These costs are based on the actual 2017 costs incurred during the pilot implementation phase of the project where each point was sampled one time. Repeat sampling is assumed to double the cost. The number of days needed to complete the sampling at each park is dependent on access, logistics, and weather.

Park	Days to Complete Each Visit	Number of Points	Estimated Cost for 2 Visits	Contracting Instrument
Vicksburg National Military Park	3–4	32	$15,200	Interagency Agreement
Palo Alto Battlefield National Historical Park	4–6	29	$4,400	CESU Task Agreement
San Antonio Missions National Historical Park	4–11	33	$1,500	Service Contract
Big Thicket National Preserve	12–14	32	$6,000	Service Contract
Gulf Islands National Seashore	FL: 4 MS: 4	FL: 13 MS: 8	$9,000	CESU Task Agreement
Jean Lafitte National Historical Park and Preserve	4–6	32	$2,000	Service Contract
Total Implementation Costs	**–**	**–**	**$38,100**	**–**

The network incurs the cost of contract management, startup costs to establish sampling points, field personnel to conduct field QA/QC, and all data entry, data QA/QC, and reporting. Table 7 contains estimates of these costs to the network.

Table 7. Estimated annual operating cost (based on FY2016 dollars) for GULN personnel during implementation of the GULN Breeding Landbird Monitoring protocol.

Type	No. of Days	Cost per Day	Total Cost	Notes
Biological technician (GS7/1 or equivalent)	14	$215	$3,010	Establishment of permanent sites prior to initial sampling.
GULN Network Ecologist (GS12/2)	14	$394	$5,516	Data analysis and reporting. Costs for 3 year reporting cycle are annualized to 7 days per year, plus an additional 7 days for annual data summaries.
GULN Data Manager (GS11/8)	46	$392	$18,032	Time is split between data management (36 days) and contract coordination (8 days).
Biological technician (GS7/1 or equivalent)	42	$215	$9,030	Time is split between data entry (36 days) and three QA/QC visits to parks each year (6 days).
Total Annual Personnel Costs	**–**	**–**	**$35,588**	Note that this annual total does not include the one-time site establishment cost noted above.

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