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Natural Resource Stewardship and Science

Streamside Bird Monitoring Protocol for the Eastern Rivers and Mountains Network

Protocol Narrative Version 3.0

Natural Resource Report NPS/ERMN/NRR—2016/1224

ON THE COVER
Ovenbird (*Seiurus aurocapilla*) is among the most frequently encountered bird species in the ERMN.
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Streamside Bird Monitoring Protocol for the Eastern Rivers and Mountains Network

Protocol Narrative Version 3.0

Natural Resource Report NPS/ERMN/NRR—2016/1224

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Revision History

The streamside bird monitoring protocol consists of a narrative (this document) and Standard Operating Procedures (SOPs) that outline specific aspects of the monitoring protocol. The latest versions of the SOPs and additional supporting information can be accessed online at the National Park Service's Eastern Rivers and Mountains Network website (http://science.nature.nps.gov/im/units/ermn).

The narrative and each SOP have respective revision history logs to document changes in the protocol. The following revision history log is for the narrative.

Version numbers will be incremented by a whole number (e.g., Version 1.0 to 2.0) when a change is made that significantly affects requirements or procedures. Version numbers will be incremented by decimals (e.g., Version 1.3 to Version 1.4) when there are minor modifications that do not affect requirements or procedures included in the protocol. Rows are added to the log as needed for each change or set of changes tied to an updated version number.

Revision History Log

Version	Date	Revised by	Changes	Description/Justification
3.0	April 2016	Matt Marshall	Published Version 3.0	Version 3.0 is the current reference for the ERMN Streamside Bird Monitoring Protocol. Version 3.0 fully documents the new sampling design and site selection methodology at New River Gorge NR, Gauley River NRA, and Delaware Water Gap NRA. Version 3.0 incorporates results of power analyses to assess detectible levels of change in streamside bird community condition. Version 3.0 clarifies and documents that all sampling sites now consist of three replicate point count stations (beginning with 2013 data collection) rather than 2 – 5 point count stations per site under Versions 1.0 and 2.0. SOPs associated with Version 3.0 also document minor data collection procedures starting in 2013 and any departures from the 2007–2012 data collection procedures.
2.0	September 2012	Matt Marshall	Published Version 2.0	Unless otherwise specified in Version 3.0, all data associated with Versions 1.0 and 2.0 are considered “pilot data” and not part of the monitoring period of record for reasons specified in Version 3.0. Specialized surveys for Louisiana Waterthrush described in Version 1.0 were discontinued in Version 2.0. The duration of each point count increased from 5 minutes to 10 minutes beginning with Version 2.0 (2011 data collection). SOPs associated with Version 2.0 document data collection procedures starting in 2011 and any departures from the 2007–2010 data collection procedures. Peer review comments of draft Version 1.0 were incorporated into published Version 2.0.
1.0	February 2010	Matt Marshall	Finalized as Version 1.0 - DRAFT	The primary purpose of finalizing Version 1.0 in *draft* form was to fully document the protocol and SOPs used during data collection for the years 2007–2010 which included specialized surveys for Louisiana Waterthrush. All data collected under Version 1.0 were considered “pilot data” and not part of the monitoring period of record for this protocol.

Executive Summary

The National Park Service has initiated a long-term ecological monitoring program known as "Vital Signs Monitoring" to provide the minimum infrastructure to allow more than 270 national park system units to identify and implement long-term monitoring of their highest-priority indicators of resource condition. This protocol outlines the justification and procedures for streamside bird monitoring within the Eastern Rivers and Mountains Network – one of 32 ecoregional "networks" of parks that were grouped by geography and shared natural resource characteristics.

"Streamside bird" refers to the breeding bird community surrounding streams. The area sampled in this protocol is along park streams that are typically forested including a closed canopy over the stream. Therefore, the "streamside" bird community sampled is synonymous with what other monitoring programs refer to as "forest birds", "breeding birds", and "landbirds". The important difference, and the purpose of including the term "streamside", is not the bird community *per se*, rather that the physical area sampled (and area of inference) is limited to the land area surrounding streams in each park.

Preserving the condition of park resources, including streamside birds, unimpaired in perpetuity is the fundamental management objective of the National Park Service. Indeed, this "anti-degradation" or "no decline in condition" management objective captures the essence of the NPS mission and forms the underpinnings of the National Park Service ecological monitoring program. The purpose of the streamside bird monitoring protocol is to collect and analyze data and report information that will help park management maintain or improve the ecological condition of the streamside bird community.

Primary monitoring objectives of the streamside bird monitoring protocol are to:

1. estimate status and trends in occupancy, density, and other indices of abundance for bird species along wadeable streams;
2. estimate status and trends in a measure of biotic integrity (i.e., the Bird Community Index) for bird communities along wadeable streams; and
3. compare these trends in condition, occupancy, density, and other indices of abundance to regional and continental trends.

Point count surveys are the most widely used quantitative method of monitoring bird populations and are used for this protocol as well. The survey technique involves using a standardized methodology to record ("count") all birds seen or heard during a fixed amount of time at count locations ("points"). The resultant counts are used as an index of population abundance and these data can be used to estimate abundance, density, and occupancy.

The streamside bird monitoring protocol consists of a narrative (this document) and Standard Operating Procedures (SOPs) that outline specific aspects of the monitoring protocol. The latest versions of the SOPs and additional supporting information can be accessed online at the National Park Service's Eastern Rivers and Mountains Network website (http://science.nature.nps.gov/im/units/ermn).

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List of Key Acronyms

ALPO	Allegheny Portage Railroad National Historic Site
BLUE	Bluestone National Scenic River
DEWA	Delaware Water Gap National Recreational Area
ERMN	Eastern Rivers and Mountains Network
FONE	Fort Necessity National Battlefield
FRHI	Friendship Hill National Historic Site
GARI	Gauley River National Recreational Area
I&M	Inventory and Monitoring
JOFL	Johnstown Flood National Memorial
NB	National Battlefield
NERI	New River Gorge National River
NHS	National Historic Site
NMem	National Memorial
NPS	National Park Service
NR	National River
NRA	National Recreation Area
NSR	National Scenic River
SOP	Standard Operating Procedure
SRR	Scenic and Recreational River
UNT	Unnamed Tributary
UPDE	Upper Delaware Scenic and Recreational River

Background and Objectives

Background and History

Knowing the condition of natural resources in national parks is fundamental to the National Park Service (NPS) mission to manage park resources "unimpaired for the enjoyment of future generations." Park managers are confronted with increasingly complex and challenging issues that require broad-based understanding of the status and trends of park resources as a basis for making decisions and working with other agencies and the public for the long-term protection of park ecosystems. The purpose of natural resource monitoring in parks is to collect scientifically sound information regarding the current status and long-term trends in the composition, structure, and function of park ecosystems, and to determine how well current management practices are sustaining those ecosystems (Fancy et al. 2009). Use of monitoring information will increase confidence in managers' decisions and improve their ability to manage park resources, and will allow managers to confront and mitigate threats to the park and operate more effectively in legal and political arenas.

The NPS has initiated a long-term ecological monitoring program known as "Vital Signs Monitoring" to provide the minimum infrastructure to allow more than 270 national park system units to identify and implement long-term monitoring of their highest-priority measurements of resource condition (Fancy et al. 2009). The term 'vital signs' refers to a relatively small set of information-rich attributes that are used to track the overall condition or 'health' of park natural resources and to provide early warning of situations that require intervention. Vital signs are defined as a subset of physical, chemical, and biological elements and processes of park ecosystems that are selected to represent the overall health or condition of park resources, known or hypothesized effects of stressors, or elements that have important human values (Fancy et al. 2009). The broad-based, scientifically sound information obtained through this systems-based monitoring program will have multiple applications for management decision-making, research, education, and promoting public understanding of park resources.

NPS Vital Signs Monitoring is implemented programmatically through 32 ecoregional 'networks' or groupings of parks linked by geography and shared natural resource characteristics. The network approach, through shared funding and professional staff, also facilitates collaboration, information sharing, and economies of scale.

To be relevant to current management issues and anticipate future issues, monitoring programs must be scientifically credible and produce quality data that is readily accessible and explicitly linked to management decision-making processes. To meet those criteria, explicitly stated goals and objectives are critical. The NPS established (Fancy et al. 2009) programmatic goals for all 32 networks as they plan, design, and implement integrated natural resource monitoring. These goals are to:

1. determine the status and trends of selected indicators of park ecosystem conditions to make better-informed decisions and to work more effectively with other agencies and individuals for the benefit of park resources;

2. provide early warning of abnormal conditions of selected resources to help develop effective mitigation measures and reduce costs of management;
3. provide data to better understand the dynamic nature and condition of park ecosystems and to provide reference points for comparisons with other, altered environments;
4. provide data to meet certain legal and Congressional mandates related to natural resource protection and visitor enjoyment; and
5. provide a means of measuring progress towards performance goals.

The complex task of developing a monitoring program requires a front-end investment in planning and design to ensure that monitoring will meet the critical information needs of each park and produce scientifically credible data that are accessible to managers and other researchers in a timely manner. To that end, each network follows an explicit program development and implementation strategy (Fancy et al. 2009) that includes a peer reviewed monitoring plan (Marshall and Piekielek 2007) 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).

This protocol outlines the justification and procedures for streamside bird monitoring within the Eastern Rivers and Mountains Network (ERMN). The ERMN includes nine parks in New York, New Jersey, Pennsylvania, and West Virginia (Figure 1), which together encompass nearly 91,000 ha and more than 700 perennial stream and river km within authorized boundaries of the parks. The network includes four smaller parks in central and southwestern Pennsylvania that have a primarily cultural or historical focus. These cultural parks are Allegheny Portage Railroad National Historic Site (NHS), Johnstown Flood National Memorial (NMem), Fort Necessity National Battlefield (NB), and Friendship Hill National Historic Site (NHS). The remaining five comparatively large parks preserve segments of large rivers and generally extend to ridgetops surrounding the river sections. These river parks are Upper Delaware Scenic and Recreational River (SRR), Delaware Water Gap National Recreation Area (NRA), New River Gorge National River (NR), Gauley River NRA, and Bluestone National Scenic River (NSR).

In addition to streamside birds, the ERMN has developed monitoring protocols for vegetation and soils (Perles et al. 2014), stream benthic macroinvertebrates Tzilkowski et al. 2016a), early detection of invasive species (Keefer et al. 2014), weather and climate (Marshall et al. 2012), rare riparian plant communities (e.g., Perles et al. 2011), and river water quality and quantity (Tzilkowski et al. 2016b).

Rationale for Monitoring Birds

One intent of the ERMN monitoring program is to evaluate status and trends of the condition of streams (and their contributing watersheds) flowing into and through member parks (Marshall and Piekielek 2007). Stream and watershed condition are evaluated, in part, using measures of ecosystem integrity, including streamside bird communities (this protocol), benthic macroinvertebrate communities, (Tzilkowski et al. 2015a), and watershed land use, type, and configuration (Marshall and Piekielek 2007).

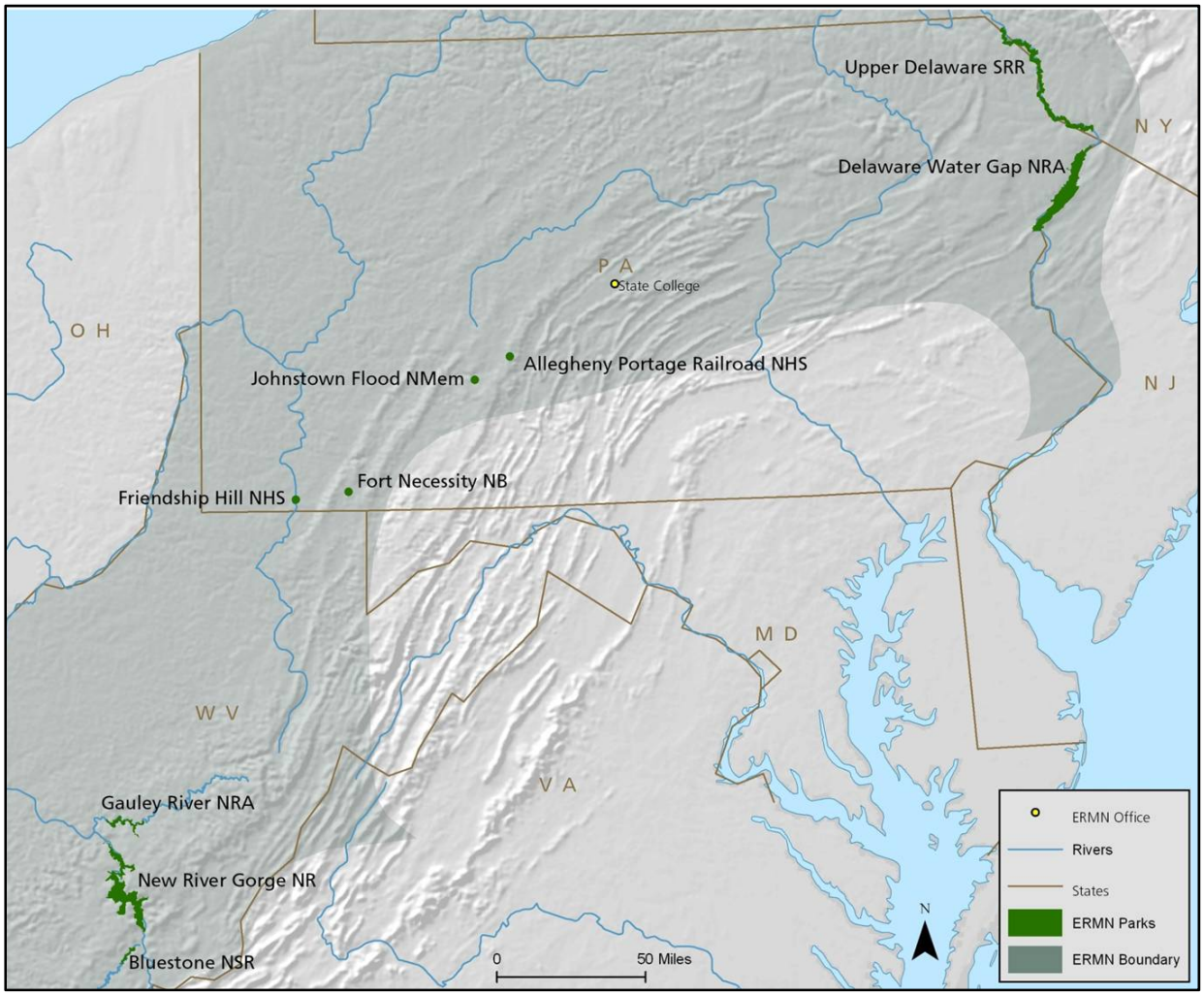

Figure 1. National parks in the Eastern Rivers and Mountains Network (ERMN).

The primary stressors of interest across the ERMN include habitat loss and fragmentation from development (e.g., residential, commercial, energy) inside and outside park boundaries, over-browsing by white-tailed deer (*Odocoileus virginianus*), invasions of nonnative plants, pests, and pathogens with concurrent changes in plant communities, and acid and nutrient deposition with concurrent changes in soil and water quality (Rentch 2006). Monitoring spatial and temporal patterns in the occurrence (i.e., occupancy, density, and/or indices of abundance) of select bird species or guilds that are known to respond to landscape and smaller-scale changes may serve as indicators of forest, stream, watershed, and park conditions.

Breeding birds are an important component of park ecosystems, have been extensively studied, and exhibit numerous characteristics that support their use as cost-effective ecological indicators (O'Connell et al. 2000, Roberge and Angelstram 2006). In particular, their high body temperature, rapid metabolism, and prominent position in most food webs make them good indicators of local and regional ecosystem change. Components of the bird community also respond in predictable and well-documented ways to ecological gradients such as extent of forest cover (O'Connell et al. 2000),

intensity of acidic deposition (Hames et al. 2002), and importantly, effects of habitat loss and fragmentation (Robinson and Wilcove 1994, Faaborg et al. 1995, Robinson et al. 1995, Rosenberg et al. 1999).

Birds are also attractive as ecological indicators because 1) they are the most easily and inexpensively detected and identified vertebrate animals, 2) their taxonomy is well known, 3) a single survey method is effective for many species, 4) many reference datasets and standard methods are available (Ralph et al. 1993, 1995), 5) multi-agency groups focused on bird monitoring are working to align objectives, coordinate monitoring efforts, and identify information gaps in North America (Pashley et al. 2000; Bart and Ralph 2005; Hutto and Ralph 2005, Lambert et al. 2009), and 6) accounting and managing for many species with different ecological requirements promotes conservation strategies at the landscape scale (Maurer 1993, Hutto and Young 2002).

Moreover, birds are a high profile group with wide public interest and many parks provide information on the status and trends of the park's avian community through their interpretive materials and programs. NPS hosts more visitors each year than any other federally managed lands (NABCI 2011) and one in five Americans watches birds, contributing $36 billion to the U.S. economy in 2006 (Carver 2009), illustrating the influential role the NPS can play interpreting various ecological stories through birds.

Streamside Birds

"Streamside birds" refers to the breeding bird community surrounding streams. The area sampled in this protocol is along park wadeable streams which are typically (but not always) forested including a closed canopy over the stream. Therefore, the streamside bird community sampled (Marshall et al. 2013) is comparable to what other NPS monitoring programs refer to as "forest birds" (Ladin et al. 2011), "breeding birds" (Goodwin and Wakamiya 2010), and "landbirds" (Faccio et al. 2010, Gostomski et al. 2010, Knutson et al. 2008). The important difference, and the purpose of including the term "streamside", is not the bird community *per se*, rather that the physical area sampled (and area of inference) is limited to the land area surrounding wadeable streams in each park. Additional rationale for focusing monitoring on the bird community along streams, a description of the wadeable stream target sampling area for each park, and how sampling sites were selected are described in the Sampling Design section below.

Measureable Objectives

Monitoring objectives were established to meet the overarching vital signs programmatic goals and the rationale for monitoring streamside birds, while clearly articulating what data will be collected and the desired outcome of the protocol. The monitoring objectives are coupled with sampling (or statistical) objectives and with park management objectives (Elzinga et al. 1998) in an iterative process. In this way, monitoring will not be a stand-alone activity, but, instead, an adaptive component of a larger process of natural resource management and decision making (Nichols and Williams 2006, Lovett et al. 2007).

Preserving the condition of park resources, including streamside birds, unimpaired in perpetuity is the fundamental management objective of the NPS (NPS 2006). Indeed, this "anti-degradation" or

"no decline in condition" management objective captures the essence of the NPS mission and forms the underpinnings of the NPS ecological monitoring program (Fancy et al. 2009). The purpose of the streamside bird monitoring protocol is to collect and analyze data and report information that will help park management maintain or improve the ecological condition of the streamside bird community.

Primary monitoring objectives of the streamside bird protocol are to:

1. estimate status and trends in occupancy, density, and other indices of abundance for bird species along wadeable streams;

2. estimate status and trends in a measure of biotic integrity (i.e., the Bird Community Index; O'Connell et al. 2000) for bird communities along wadeable streams; and

3. compare these trends in condition, occupancy, density, and other indices of abundance to regional and continental trends.

The NPS management objective of "no decline in the condition of park resources" was formalized as a sampling objective of having sufficient power (i.e., 80%) to detect a 1% annual decline in the condition of the streamside bird community (or species occupancy status, abundance, density, etc., as appropriate) along wadeable streams in a given park (or at individual "index" sites) within ten years of monitoring (see Sampling Frequency, Replication, and Detectible Level of Change section below).

While this respective management, monitoring, and sampling objective apply to all parks in which this protocol is implemented, site selection (and the scope of statistical inference) differed among parks. At the three larger network parks (Delaware Water Gap NRA, Gauley River NRA, and New River Gorge NR) the intent is to make park-specific inferences regarding status and trends of the wadeable stream target area based on randomly selected sites. At the remaining parks, "index" sites were non-randomly selected at the downstream end of the available wadeable stream sections. In these cases, status and trend inferences are limited to each index site (more fully described in the Sampling Design section below).

Sampling Design

Overview

Seventy-eight sites were selected for sampling in the six parks in which the streamside bird monitoring protocol is implemented. Each site was defined as a discrete 100 m segment of wadeable stream. All 68 sampling sites at Delaware Water Gap NRA and New River Gorge NR were selected using a random, probability based design with the intent of making park-specific inferences regarding status and trend of average resource condition of the wadeable stream target area based on these randomly selected sites. The remaining 10 sites (4 at Bluestone NSR and 2 each at Allegheny Portage Railroad NHS, Fort Necessity NB, and Friendship Hill NHS) were deliberately placed at the downstream end of the few streams in each park. In these cases, status and trend inferences are limited to each index site. Sampling, in the form of 10 min point counts, occurs annually but sites were divided into two sampling panels so that each site is sampled every other year; consequently, it takes two years to sample all 78 sites. Each site consists of three spatially replicated point count stations spaced 200 to 250 m apart; adjacent and parallel to the stream. Each site is sampled four times (temporal replicates) during the appropriate sampling years.

Parks Included

The streamside bird monitoring protocol is implemented at all ERMN parks except Upper Delaware SRR, Gauley River NRA, and Johnstown Flood NMem. Upper Delaware SRR was not included due to its limited area of publicly owned land. Establishing sampling sites on private lands involves substantial risk of lost investment because the NPS does not control accessThe authorized boundary of Upper Delaware SRR encompasses approximately 26,000 ha; however, only about 12 ha are owned by the NPS. Furthermore, only 5% of the land (approximately 1,225 ha) within the authorized boundary is held by public entities (i.e., federal government, Commonwealth of Pennsylvania, State of New York, or Sullivan County Parks). Similarly, Gauley River NRA is not currently included because only 12% (1.7 km) of the total wadeable stream length (13.9 km) within the authorized boundary occurs on public land; the remainder occurs on private inholdings. However, due to the enabling legislation and ability to acquire land over time, sampling should occur within Gauley River NRA once sufficient land has been acquired by the NPS. Johnstown Flood NMem was not included because South Fork Little Conemaugh River (SFLCR), which flows through Johnstown Flood NMem, was too large to meet the wadeable stream definition (see below). A second tributary to SFLCR did meet the wadeable stream criteria, but is a prohibitively short segment (< 80 m on NPS land) to sample for any water-based ERMN protocol.

History of Protocol and Sampling Design Development

Development of the streamside bird monitoring protocol began in 2007 and the first data were collected from March to July of that year (Figure 2) following the procedures outlined in Version 1.0 of the protocol (Mattsson and Marshall 2010). Version 1.0 of the protocol was used for the next three years (2008 to 2010). Two major changes to the protocol occurred since 2010 and are reflected in Versions 2.0 (Marshall et al. 2012) and 3.0 (this protocol), respectively. Despite these changes, data were collected each year since 2007.

Version 1.0 (Mattsson and Marshall 2010) of the protocol stemmed directly from the approved ERMN Monitoring Plan (Marshall and Piekielek 2007), which specified that this monitoring protocol should focus on Louisiana Waterthrush (*Parkesia motacilla*) as an avian indicator of stream condition. The Louisiana Waterthrush is a riparian obligate bird species that breeds and forages along forested streams of the eastern United States (Mattsson et al. 2009) and the protocol was designed to include specialized surveys for this species. Moreover, the sampling design and site selection scheme established for the streamside bird monitoring protocol was intended to be the common design for benthic macroinvertebrate sampling sites, along with providing the framework (i.e., contributing watersheds) for estimating changing landscape characteristics (Marshall and Piekielek 2007). Collocation of streamside bird monitoring sites with sampling sites for other vital signs is intended to provide multiple lines of evidence to better evaluate trends in ecosystem condition at local and landscape scales with terrestrial and aquatic components.

For these two primary reasons (using Louisiana Waterthrush as an indicator species and the desire to develop a common sampling design for other stream-based monitoring protocols) the sampling frame was identified as the network of wadeable, perennial streams within the authorized boundary of each ERMN park and sampling sites were placed along streams.

Considerable discussion on these design considerations (and field methods) occurred during two workshops in January 2007 among scientists, resource managers, and collaborators from the ERMN (network and park personnel), NPS Water Resource Division, U.S. Geological Survey (USGS), The Pennsylvania State University, University of Georgia, Powdermill Nature Reserve, and Oklahoma State University. A summary of these workshops and participants is available in Appendix F.

Beginning in 2011 (and reflected in Protocol Version 2.0; Marshall et al. 2012), the specialized surveys that focused exclusively on Louisiana Waterthrush were discontinued based on an analysis of competing costs versus information gained (Appendix F). However, point count surveys located along streams for the entire streamside bird community continued and changed in duration from a 5 minute count to the current 10 minute count for consistency with most other point count protocols. It should be noted that Louisiana Waterthrush remains particularly well-sampled, despite the decision to discontinue specialized surveys, because point count stations are located along streams (where this species establishes its breeding territories).

The second major change to the protocol occurred in 2013 and involved a redesign of the sampling site selection methodology at Delaware Water Gap NRA, Gauley River NRA, and New River Gorge NR. A summary of the review process and key decisions that led to a new sampling design is in Appendix F. The current protocol (Version 3.0) reflects the new sampling design and new sampling sites at these two parks. Concurrent with these changes, it was also decided to suspend sampling on private land at Gauley River NRA until that land comes under NPS ownership (see Parks Included section above). In addition, all sampling sites (defined below) now (as of 2013 data collection) consist of three point count stations (rather than the 2 – 5 stations per site described in Versions 1.0 and 2.0).

The 2007 – 2012 data collected under Versions 1.0 and 2.0 of this protocol are summarized in Marshall et al. (2013) but should be considered "pilot data" due to the changes described above. These pilot data are amenable to certain analyses but there will be no attempt to formally merge the 2007-2012 data with data collected beginning in 2013 (partial sampling) and 2014 (with the exception of 7 index sites at Allegheny Portage Railroad NHS, Fort Necessity NB, Friendship Hill NHS, and Bluestone NSR where the location and data collection methods have not changed since 2011; described in the Sample Site Summary section below).

Figure 2. Jennifer Dupree and Jason Liddle establishing point count stations on Slater Creek at New River Gorge NR, March 2007.

Sampling Approach and Target Population

Point count surveys are the most widely used quantitative method of monitoring bird populations (Ralph et al. 1995, Bart 2005, Rosenstock et al. 2002). The survey technique involves using a standardized methodology (Ralph et al. 1995) to record ("count") all birds seen or heard during a fixed amount of time at count locations ("points"). Resultant counts are used as an index of population abundance. Tens of thousands of point counts are conducted annually in North America across a spectrum of scales, from short-term studies to long-term continental-scale surveys such as the Breeding Bird Survey (BBS; Sauer et al. 2008), and across federal, state, and private land

management agencies (Simons et al. 2007). Point counts are used in this protocol for consistency with these other programs and to utilize the substantial literature on field methods and approaches to data analysis.

Because some birds present during the point count period are not actually detected, it is important to conduct point counts in a way that allows estimation of a detection probability in order to adjust the raw counts. At least five different methods of estimating detection probabilities on avian point counts are available: (1) distance sampling (Buckland et al. 2001); (2) multiple-observer methods (Nichols et al. 2000, Alldredge et al. 2006); (3) time-of-detection methods (Farnsworth et al. 2002, Alldredge et al. 2007); (4) double sampling (Bart and Earnst 2002); and (5) repeated-count methods (Royle and Nichols 2003, Kery et al. 2005).

Conceptually, the probability of detection has two components: (1) the probability that a bird is available for detection (i.e., if detections are auditory, the probability that the bird sings or produces some audible cue during the count period); and (2) the probability of detecting a bird given that it is available (i.e., sings; Diefenbach et al. 2007). Different methods estimate different components of the detection process. For example, distance sampling and multiple-observer approaches assume that all birds on a given sample plot are available (sing during the count period), and they estimate the probability of detection, given availability. Time-of-detection and repeated count methods each provide unique estimates of the product of availability and detection given availability, but they cannot separate the two components (Simons et al. 2007).

Despite these recent theoretical advances in understanding of detection probabilities and new methods for estimating it in the field, some proposed remedies are themselves deficient and/or dependent on assumptions that are rarely met (Johnson 2008). The intent of this protocol is to conduct point counts in a generalized manner to allow a variety of subsequent analytical approaches as this area of scientific investigation improves and changes over time. That said, this protocol will not employ the prohibitively labor and cost intensive double-sampling and multiple-observer approaches but it will allow other analytical approaches and methods.

For this protocol, bird detections are placed into three distance bands (≤50 m, 51–75 m, and >75 m) allowing analysis by distance sampling methods. Additionally, each 10 min point count is divided into 1 min intervals, and observers record each interval in which they detect each bird facilitating analysis by time-of-detection methods. Recording detections in this manner will also enable grouping of data for direct comparisons to other monitoring programs that use 3 min or 5 min point counts (e.g., the BBS; Sauer et al. 2008). Multiple, independent, point counts are conducted at each sampling site within a sampling season allowing repeated-count analysis methods as well. Additional information is provided in the Field Methods and Data Analysis and Reporting sections below.

Point count sampling for this protocol is limited to the breeding season (mid-May through July) for eastern North America resident and neotropical (Central America, South America, and the Caribbean) migratory bird species that are known to breed or may potentially breed in the streamside sampling area (see below). Members of the Orders Passeriformes (perching birds including songbirds) and Piciformes (woodpeckers) are particularly well sampled and constitute the target

population. While detections of nocturnal raptors (Strigiformes), diurnal raptors (Accipitriformes), waterfowl (Anseriformes), waders (Peleconiformes), and turkey and grouse (Galliformes) do occur, they constitute less than 1% of all detections which effectively precludes these groups from any meaningful status and trends analyses.

Sampling Frame and Sample Site Definition

It was our intent to develop a sampling frame that could be used consistently across multiple ERMN monitoring protocols and would allow sampling co-location among protocols when possible. The following approach was used to define the sampling frame for the three protocols (river water quality, stream benthic macroinvertebrates, and streamside birds) related to flowing surface waters. All flowing surface waters were delineated using ArcGIS and then placed into size categories according to upstream contributing area (i.e., catchment or watershed size); summarized in Table 1. A complete description of the methods and data used to define these categories is provided in Appendix A.

All surface waters with a contributing area ≥100.0 km^2 at their mouth (i.e., outpour point) or at the park boundary (if a stream/river flows out of the park) were categorized as "rivers" and are monitored as described in the River Water Quality Monitoring Protocol (Tzilkowski et al. 2016b). All surface waters with a contributing area ≤2.0 km^2 were defined as "ephemeral" or "intermittent" streams (Paybins 2003; M. Marshall, C. Tzilkowski, and A. Weber, *pers. obs.*) and not included in the sampling frame of any ERMN protocol. This criterion was relaxed to ≤1.0 km^2 at two of the smallest ERMN parks (Table 1) to sample as much of the limited amount of available surface waters as possible. All surface waters with contributing area between 2 and 100 km^2 were categorized as "wadeable streams" and included in the common sampling frame for the benthic macroinvertebrate monitoring protocol (Tzilkowski et al. 2016a) and streamside bird monitoring protocol (this protocol).

Monitoring bird and benthic macroinvertebrate communities in or along "rivers" was not considered because these larger, deeper waters cannot be waded safely or crossed on foot (if at all) and would require different sampling methods. Moreover, other agencies monitor benthic macroinvertebrates in the New and Delaware Rivers. After considerable discussion concerning whether or not to sample "ephemeral" streams, (Appendix F) it was decided they would not be sampled because the substantial variability inherent in such systems would likely preclude meaningful trend detection. Instead the decision was to focus available resources on "wadeable streams".

Field methods differ between the two wadeable stream-based protocols (i.e., streamside birds and benthic macroinvertebrates), but the smallest common sampling unit is a fixed 100 m stream reach. As such, the entire wadeable stream network was divided into discrete 100 m units from which sampling sites could be selected (i.e., the sampling frame; Appendices A and B). Each potential sampling site has a unique site identifier and site name consisting of the stream name and a number. The number refers to distance (in 100 m units) from the stream mouth. For example, the site named "Big Branch 10" is 10 units or 1,000 m upstream of the confluence of Big Branch and the New River (Figure 4).

Sampling is physically confined to the selected 100 m reaches for benthic macroinvertebrates and described elsewhere (Tzilkowski et al. 2016a). Sampling (i.e., 10 min point counts) for the streamside bird protocol includes three point count stations spaced 200 to 250 m apart (for a total of three spatially replicated point counts per site). One of the three point count stations (typically the middle station) is located immediately adjacent to the center of the selected 100 m stream segment. Point count stations are located up to 25 m perpendicularly away from the stream (either side depending on access and safety) to avoid excessive stream noise interfering with bird detections. Field crews subjectively made this determination at the time of site establishment but the station location remained fixed thereafter. Moreover, the effective bird detection distance is approximately 100 m (M. Marshall, *pers. obs.*). Therefore, the target population and the area of inference is the community of breeding birds (primarily the Orders Passeriformes and Piciformes) within 125 m of the wadeable stream network (or index sites) in each park. All references in the protocol and associated reports to "streamside birds" are meant to imply this target population and area of inference.

Point count stations are numbered 1 through 3 starting with the downstream-most station. The suffix "L" or "R" for left and right, respectively, is added to the point count station identifier to signify which side of the stream the station is located (while facing upstream). For example, "3L" means that point count station 3 is on the left side of the stream (Figure 3).

For additional information see the Field Methods section below.

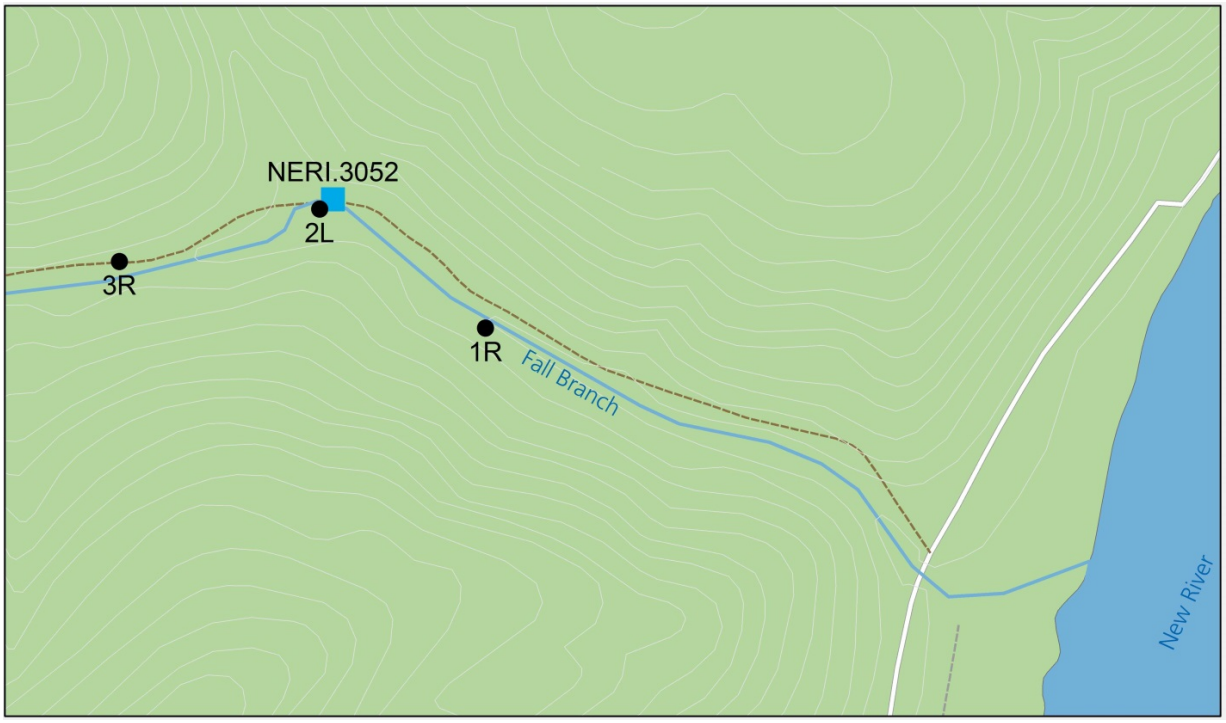

Figure 3. Example of a streamside bird sampling site with three point count stations (black circles) spaced 200 m apart. Point count station 2L is located immediately adjacent to the randomly selected 100 m stream reach where sampling for the benthic macroinvertebrate protocol occurs (blue square). The site depicted is Fall Branch 07 (NERI.3052) at New River Gorge NR.

Table 1. Size category, name, park, contributing area (Area), length in park, and relevant monitoring protocol for flowing surface waters in the Eastern Rivers and Mountains Network.

Category	Name	Park	Area (km2)	Length in park (km)	Protocol
Large River	New River	New River Gorge NR	17,815	90.4	River Monitoring
	Delaware River	Delaware Water Gap NRA	10,213	69.9	
	Delaware River	Upper Delaware SRR	7,989	123.4	
Medium River	Gauley River	Gauley River NRA	3,347	42.1	River Monitoring
	East Branch	Upper Delaware SRR	2,188	<0.1	
	West Branch	Upper Delaware SRR	1,735	0.1	
	Lackawaxen River	Upper Delaware SRR	1,557	0.9	
	Bluestone River	Bluestone NSR	1,139	18.5	
	Meadow River	Gauley River NRA	945	9.5	
	Brodhead Creek	Delaware Water Gap NRA	670	<0.1	
	Mongaup River	Upper Delaware SRR	543	1.7	
Small River	Bushkill Creek	Delaware Water Gap NRA	409	4.9	River Monitoring
	Piney Creek	New River Gorge NR	352	1.3	
	Callicoon Creek	Upper Delaware SRR	292	2.3	
	Shohola Creek	Upper Delaware SRR	224	0.5	
	Flat Brook	Delaware Water Gap NRA	171	19.3	
	Glade Creek	New River Gorge NR	164	9.9	
	Manns Creek	New River Gorge NR	151	9.1	
	Equinunk Creek	Upper Delaware SRR	150	0.7	
	SFLCR[a]	Johnstown Flood NMem	136	0.9	
	Peters Creek	Gauley River NRA	136	2.7	
	Tenmile River	Upper Delaware SRR	127	1.0	
	Dunloup Creek	New River Gorge NR	125	6.5	
	Calkins Creek	Upper Delaware SRR	115	0.8	
	Lick Creek	New River Gorge NR	101	1.3	
Wadeable Stream	see below	New River Gorge NR	≥ 2	112.3	BMI[b] and Streamside Bird Monitoring
	see below	Delaware Water Gap NRA	≥ 2	80.6	
	see below	Gauley River NRA	≥ 2	13.0	
Wadeable Stream (continued)	see below	Bluestone NSR	≥ 2	6.2	BMI[b] and Streamside Bird Monitoring (continued)
	see below	Allegheny Portage Railroad NHS	≥ 2	3.7	
	see below	Johnstown Flood NMem	≥ 2	<0.1	
	see below	Fort Necessity NB	≥ 1	2.3	
	see below	Friendship Hill NHS	≥ 1	1.2	
Ephemeral Stream			<1 or <2		Not sampled

[a] South Fork of the Little Conemaugh River

[b] Benthic macroinvertebrate

Sample Site Selection and Statistical Inference

Seventy-eight sampling sites were selected for monitoring streamside birds and benthic macroinvertebrates along wadeable streams (Table 2). Both protocols are implemented at all sites.

Sample site selection differed between the three largest parks (Delaware Water Gap NRA, New River Gorge NR, and Gauley River NRA) and the remaining four parks included in the wadeable stream-based protocols. Due to their larger size and cumulative stream length, only a subset of the many 100 m stream reaches could be sampled at the three largest parks. Consequently, a probability based design was employed to ensure unbiased and statistically rigorous inferences about wadeable stream conditions in each respective park unit (Appendix B).

Table 2. Number of sampling sites for each park included in the streamside bird monitoring protocol. All sites included in each panel are sampled during the same year. Panels are sampled on alternate years taking two years to sample all 78 sites. TBD = to be determined.

Location	Panel 1	Panel 2	Total	Sampling Design
Delaware Water Gap NRA	16	16	32	Random
New River Gorge NR	18	18	36	Random
Gauley River NRA	TBD	TBD	TBD	Random
Bluestone NSR	4	0	4	Index
Allegheny Portage Railroad NHS	0	2	2	Index
Fort Necessity NB	0	2	2	Index
Friendship Hill NHS	0	2	2	Index
Total	38	40	78	

Randomly chosen sampling sites at Delaware Water Gap NRA (n = 32) and New River Gorge NR (n = 36) were selected from the respective park's sampling frame using a generalized random tessellation stratified (GRTS) design (Stevens and Olsen 2004). The intent of using the GRTS design was to generate a spatially balanced, uniform dispersion of sampling sites over the area of interest (i.e., the wadeable stream sampling frame). A complete description of the site selection process for these parks is provided in Appendix B; moreover, sampling sites at each park are discussed below in the Sample Site Summary. Note that while candidate sites for Gauley River NRA have been selected using the GRTS algorithm, sampling sites will not be evaluated and finalized until sufficient land has been acquired by NPS.

The random site selection strategy was not applicable to ERMN parks other than Delaware Water Gap NRA, Gauley River NRA, and New River Gorge NR due to inherent park characteristics (e.g., small parcel size, linear park shape, land ownership patterns) and because, in general, too few streams and limited stream length (Table 1) were available for a logical random approach. To maximize coverage of the few stream segments in these parks, all wadeable streams were considered and 10 non-random "index sites" were established toward the downstream end of each available stream (4 at Bluestone NSR and 2 each at Allegheny Portage Railroad NHS, Fort Necessity NB, and Friendship Hill NHS). By definition, data from non-random index sites cannot be combined and analyzed to make a statistical inference to sections of streams that were not sampled. Each index site will be evaluated independently.

Sampling Frequency, Replication, and Detectable Levels of Change

Sampling occurs annually but is divided into two panels such that each site is sampled every other year (taking two years to sample all 78 sites; Table 2). Half of the respective sampling sites at Delaware Water Gap NRA and New River Gorge NR are in each panel. All sites at the remaining four parks are sampled every other year.

Several levels of temporal and spatial replication are incorporated into the sampling design. Because most birds vocalize (i.e., sing or produce other audible cues) in bouts rather than continuously (Poole 2005), and because most species differ in their vocalizing rate, temporal replication is used to account for this potential detection bias by reducing within-year variability (Link et al. 1994, Carlson and Schmiegelow 2002). Conducting repeat point counts at each point count station provides a means by which to account for birds that were unavailable during a previous or subsequent count; therefore, each sampling site is visited two times per year between May and July. During each visit, an observer traverses the stream reach twice (i.e., once traveling upstream and once traveling downstream) stopping at each point count station to conduct the 10 min point count and associated data collection. Each time the reach is traversed is referred to as a "pass." By waiting 10 min between passes, each pass is considered an independent sample. Therefore, each site is sampled four times during the sampling year (two visits per year and two passes per visit).

The finest temporal sampling scale is one minute during a10 min point count. Some analyses, such as the time-of-detection method, use these intervals and associated bird detections to model different singing rates and bouts to account for possible detection biases. These intervals are nested within the four repeat counts described above, which offers the possibility of several types of hierarchical analyses.

In addition to temporal replication, this protocol includes two levels of spatial replication: (1) multiple (i.e., three) replicate point count stations per site and for Delaware Water Gap NRA, New River Gorge NR, and Gauley River NRA (2) replicate sites within the respective sampling frames (i.e., parks). Having multiple point count stations at each sampling site improves precision of site-specific parameter estimates whereas having multiple sites at each park will increase precision estimate at the park (wadeable stream target area) level.

Optimal allocation (precision of parameter estimates sufficient to meet protocol objectives) of spatial and temporal replicates depends on several factors and sources of variability. The initial number of sites, panels, and levels of replication in this version of the protocol were based on prior experience (2007 to 2012 sampling seasons), available funding (i.e., two seasonal technicians), time constraints (six week sampling window), sampling constraints (i.e., sampling multiple parks in multiple states each year), and field logistics (i.e., travel times between sites, parks, etc.).

Preliminary statistical simulations were performed to evaluate if the level of sampling described above is sufficient to meet Monitoring Objective 2 (status and trends in a measure of biotic integrity for bird communities along wadeable streams) and the associated statistical/sampling objective (80% power to detect a 1% annual decline in the average condition of the streamside bird community along wadeable streams within ten years of sampling). The results suggest that this objective should be met

and moreover, the sampling design likely has sufficient power to detect a 0.5% annual decline in community condition within five years at both Delaware Water Gap NRA and New River Gorge NR (Appendix C) and should be met at most index sites at Allegheny Portage Railroad NHS, Bluestone NSR, Fort Necessity NB, and Friendship Hill NHS (Appendix D).

Sample Site Summary

The following sections provide a summary of sampling sites in the six park units where the protocol is implemented.

Delaware Water Gap National Recreation Area

Established in 1965, Delaware Water Gap NRA encompasses approximately 28,000 ha of mountains, forest, and floodplain on both sides of a 70 km (43 mi) segment of the Delaware River in Pennsylvania and New Jersey. The sampling frame consists of 60.7 km of wadeable stream (Appendix A) and 32 sites were selected for streamside bird monitoring (Table 3, Figure 4; Appendix B). Sampling intensity is approximately one site per 1.9 km of wadeable stream with 3.2 km of wadeable stream (5%) sampled throughout the park.

Table 3. Unique site identifier (ID), site name, sampling panel, and the year the site was established for 32 sampling sites at Delaware Water Gap NRA.

ID	Name	Panel	Year Established
DEWA.3011	Adams Creek 14	1	2014
DEWA.3012	Adams Creek 33	1	2014
DEWA.3001	Caledonia Creek 13	1	2014
DEWA.3003	Deckers Creek 03	1	2014
DEWA.3004	Dingmans Creek 05	1	2014
DEWA.3015	Dingmans Creek 39	1	2014
DEWA.3008	Dingmans Creek 57	1	2014
DEWA.3005	Dunnfield Creek 03	1	2014
DEWA.3013	Little Bushkill Creek 01	1	2014
DEWA.3020	Mill Creek 25	1	2014
DEWA.3007	Spackmans Creek 08	1	2014
DEWA.3018	Toms Creek 07	1	2014
DEWA.3006	Toms Creek 20	1	2014
DEWA.3002	Van Campen Creek 12	1	2014
DEWA.3014	Vancampens Brook 43	1	2014
DEWA.3010	Vancampens Brook 95	1	2014
DEWA.3027	Adams Creek 03	2	2015
DEWA.3039	Adams Creek 21	2	2015
DEWA.3031	Dingmans Creek 30	2	2015
DEWA.3033	Dunnfield Creek 26	2	2015
DEWA.3035	Hornbecks Creek 15	2	2015

Table 3 (continued). Unique site identifier (ID), site name, sampling panel, and the year the site was established for 32 sampling sites at Delaware Water Gap NRA.

ID	Name	Panel	Year Established
DEWA.3036	Mill Creek 12	2	2015
DEWA.3032	Raymondskill Creek 13	2	2015
DEWA.3029	Sand Hill Creek 08	2	2015
DEWA.3034	Toms Creek 03	2	2015
DEWA.3022	Toms Creek 25	2	2015
DEWA.3023	UNT Dingmans Creek 07	2	2015
DEWA.3026	UNT Vancampens Brook 05	2	2015
DEWA.3025	Vancampens Brook 22	2	2015
DEWA.3038	Vancampens Brook 76	2	2015
DEWA.3028	White Brook 15	2	2015
DEWA.3030	Yards Creek 07	2	2015

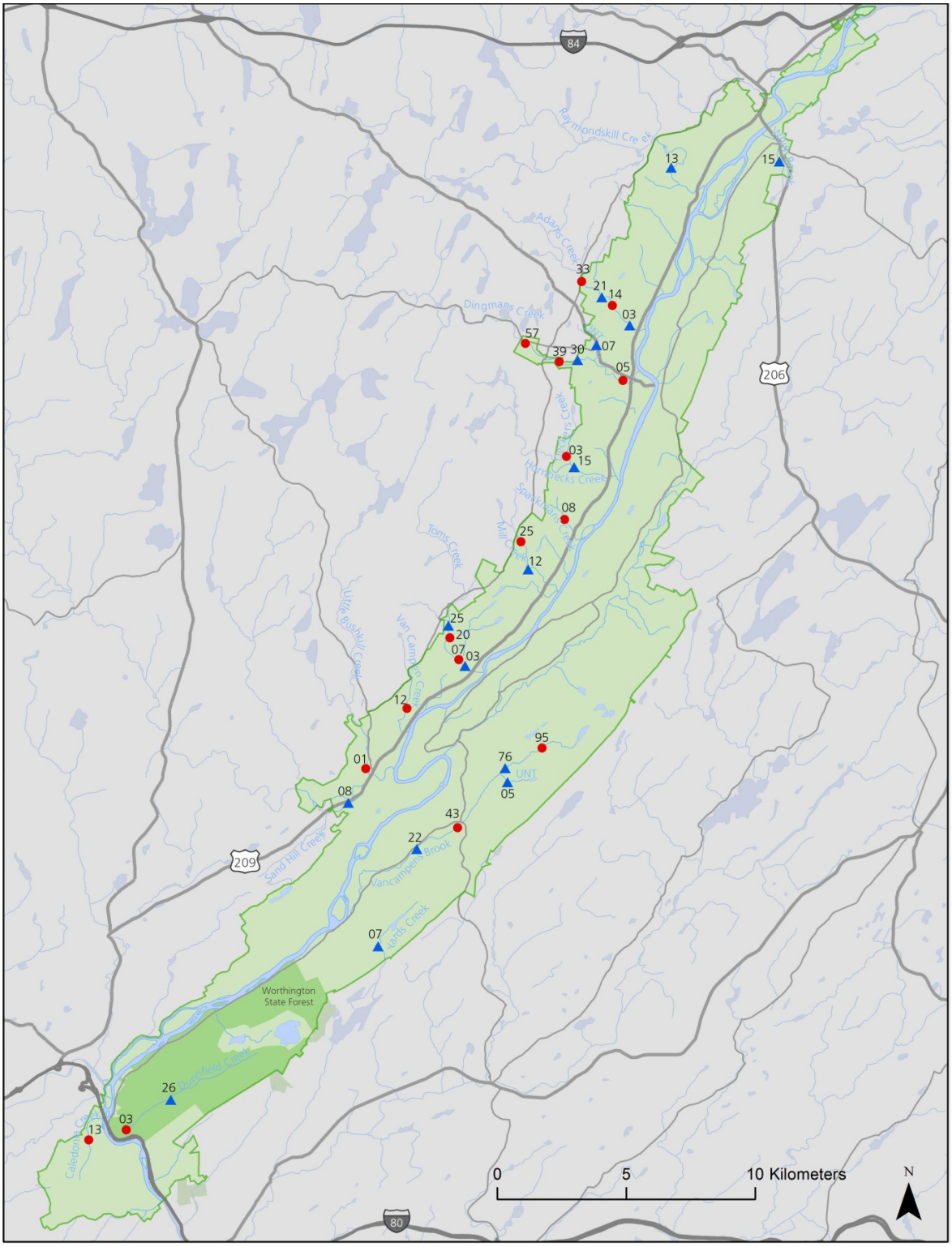

Figure 4. Location of 32 sampling sites selected for monitoring streamside birds at Delaware Water Gap NRA. Red circles indicate 16 sites sampled in Panel 1; Blue triangles indicate 16 sites sampled in Panel 2. Numbers refer to the site names in Table 3.

New River Gorge National River

Established in 1978, New River Gorge NR encompasses more than 28,300 ha of rugged mountainous terrain along a 90.4 km (56 mi) segment of the New River in West Virginia. The sampling frame consists of 100.8 km of wadeable stream (Appendix A) and 36 sites were selected for streamside bird monitoring (Table 4, Figure 5; Appendix B). Sampling intensity is approximately one site per 2.8 km of wadeable stream with 3.6 km of wadeable stream (3.5%) sampled throughout the park.

Table 4. Unique site identifier (ID), site name, sampling panel, and the year the site was established for 36 sampling sites at New River Gorge NR.

ID	Name	Panel	Year Established
NERI.3038	Arbuckle Creek 02	1	2014
NERI.3024	Big Branch 10	1	2014
NERI.3042	Bucklick Branch 03	1	2014
NERI.3005	Buffalo Creek 16	1	2014
NERI.3021	Fire Creek 17	1	2014
NERI.3018	Keeney Creek 10	1	2014
NERI.3037	Laurel Creek 47	1	2014
NERI.3044	Laurel Creek 08	1	2014
NERI.3026	Little Laurel Creek 06	1	2014
NERI.3011	Meadow Creek 17	1	2014
NERI.3043	Meadow Creek 39	1	2014
NERI.3001	Meadow Fork 01	1	2014
NERI.3016	River Branch 04	1	2014
NERI.3032	River Branch 06	1	2014
NERI.3009	Slater Creek 20	1	2014
NERI.3034	UNT 21 New River 01	1	2014
NERI.3041	UNT Laurel Creek 03	1	2014
NERI.3036	UNT to Fall Branch 02	1	2014
NERI.3054	Arbuckle Creek 05	2	2015
NERI.3064	Batoff Creek 07	2	2015
NERI.3072	Big Branch 09	2	2015
NERI.3069	Buffalo Creek 04	2	2015
NERI.3077	Dowdy Creek 02	2	2015
NERI.3050	Ephraim Creek 08	2	2015
NERI.3052	Fall Branch 07	2	2015
NERI.3082	Keeney Creek 15	2	2015
NERI.3085	Laurel Creek 61	2	2015
NERI.3074	Manns Creek 24	2	2015
NERI.3075	Meadow Creek 12	2	2015
NERI.3059	Meadow Creek 58	2	2015
NERI.3065	Meadow Fork 06	2	2015

Table 4 (continued). Unique site identifier (ID), site name, sampling panel, and the year the site was established for 36 sampling sites at New River Gorge NR.

ID	Name	Panel	Year Established
NERI.3080	Mill Creek 01	2	2015
NERI.3048	Mill Creek 12	2	2015
NERI.3058	Richlick Branch 17	2	2015
NERI.3053	Slater Creek 13	2	2015
NERI.3049	UNT to Buffalo Creek 06	2	2015

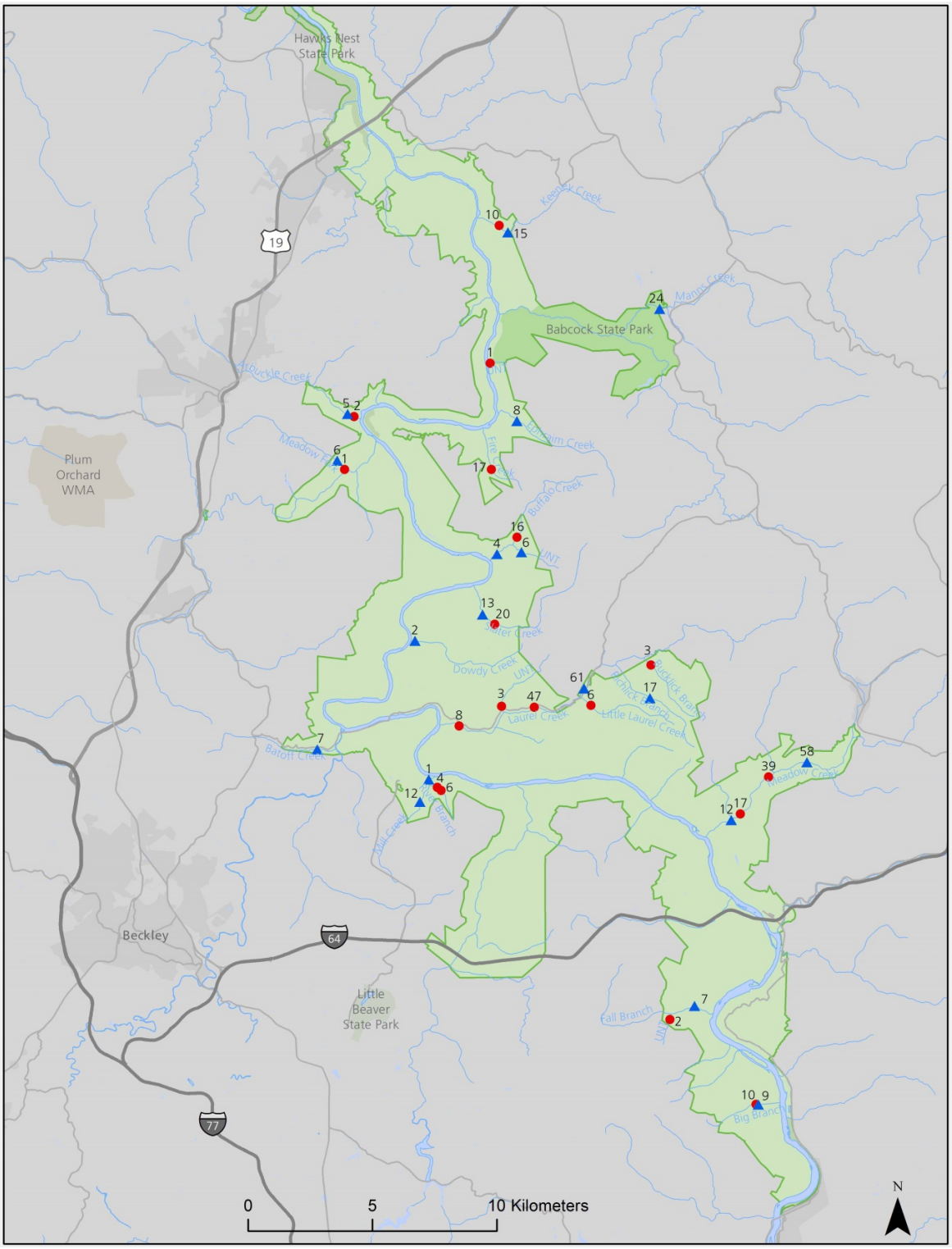

Figure 5. Location of 36 sampling sites selected for monitoring streamside birds at New River Gorge NR. Red circles indicate 18 sites sampled in Panel 1; Blue triangles indicate 18 sites sampled in Panel 2. Numbers refer to the site names in Table 4.

Bluestone National Scenic River

Established in 1988, Bluestone NSR encompasses more than 1,600 ha of Bluestone Gorge and 18.5 km (11.5 mi) of the Bluestone River in southern West Virginia. Six stream segments totaling 6.2 km met the wadeable stream criteria defined above (catchment area between 2 and 100 km^2); four of those stream segments have index (i.e., non-randomly chosen) sampling sites located near their confluence with Bluestone River (Table 5, Figure 6). Two sites were established in 2011 and landowner permission to access Jarrell Branch (BLUE.1004) was granted in 2012. The site along Indian Branch (BLUE.1001) was assumed to be unsafe for sampling in 2009 but was re-evaluated and safely included and sampled in 2014. Landowner permission to access the fifth potential site (Tony Hollow; BLUE.1005) has not yet been granted. The final section of wadeable stream is prohibitively short to sample (<250 m) and not included.

Despite the requirement for private landowner permission for access, each site is located within the authorized park boundary on federally owned land.

The three sites established prior to 2014 were sampled every year including 2014. Subsequent to the 2014 field season each site will be sampled every other year as described above.

Pilot data were collected at the Mountain Creek and Little Bluestone River sites in 2009 and 2010. Data collected between 2009 and 2012 are summarized in Marshall et al. (2013).

Table 5. Unique site identifier (ID), site name, sampling panel, and the year the site was established for five sampling sites at Bluestone NSR.

ID	Name	Panel	Year Established
BLUE.1001	Indian Branch	1	2014
BLUE.1002	Mountain Creek	1	2011
BLUE.1003	Little Bluestone River	1	2011
BLUE.1004	Jarrell Branch	1	2012
BLUE.1005	Tony Hollow	1	TBD

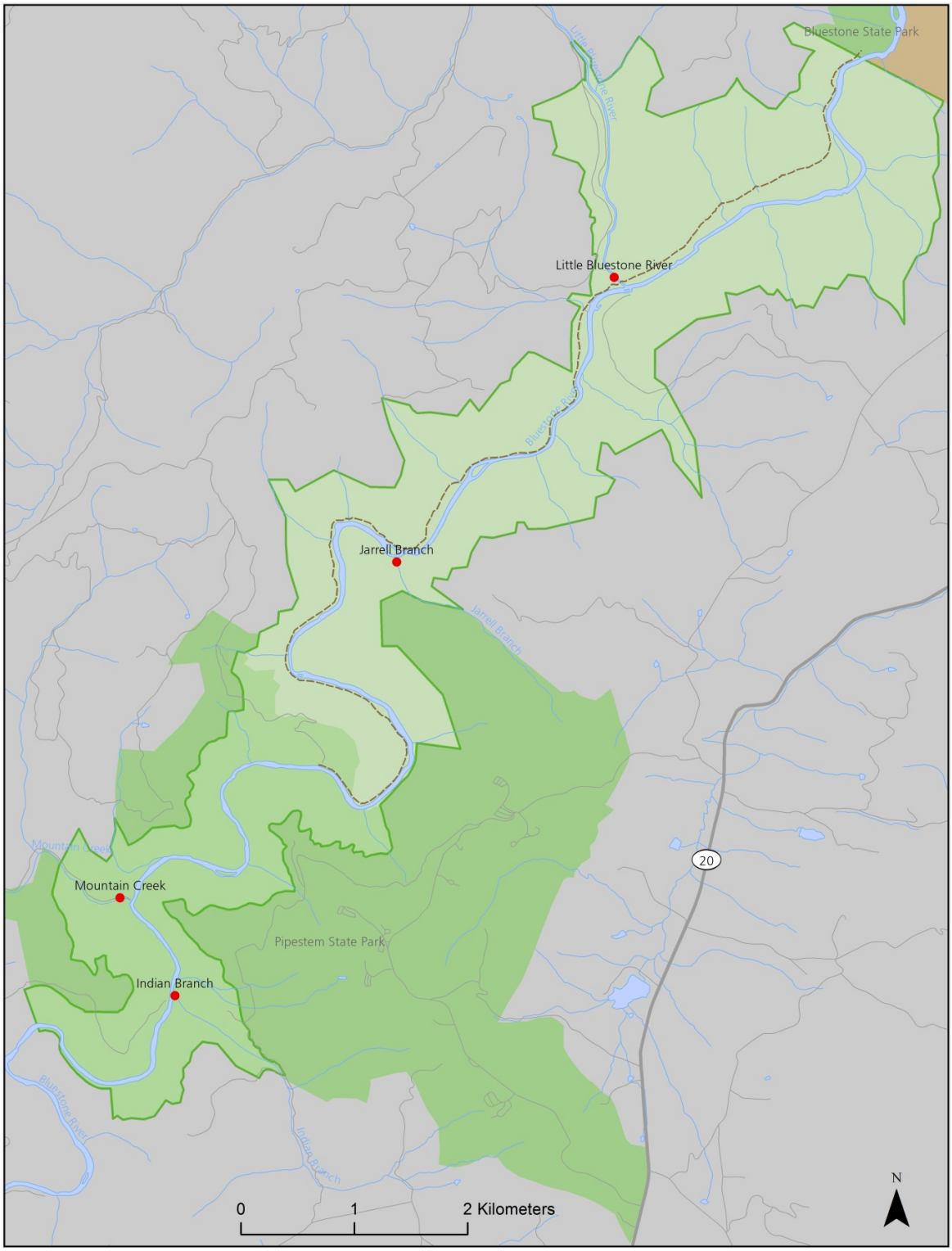

Figure 6. Location of four sampling sites selected for monitoring streamside birds at Bluestone NSR.

Allegheny Portage Railroad National Historic Site

Established in 1964, Allegheny Portage Railroad NHS encompasses slightly more than 485 ha of land area in central Pennsylvania to preserve and commemorate the historic Allegheny Portage Railroad. The park's main unit is located within the Blair Gap Run watershed which, along with its natural resource values, serves as a municipal water supply for the cities of Altoona and Hollidaysburg, Pennsylvania. Two streams totaling 3.7 km met the wadeable stream criteria defined above (catchment area between 2 and 100 km2) and both have non-random, index sampling sites located near the downstream end of their stream segments (Table 6, Figure 7). Streamside bird monitoring began in 2011 at Millstone Run (ALPO.1001) and occurred annually through 2013. Sampling began in 2013 at Blair Gap Run (ALPO.2001).

Beginning with the 2014 field season each site will be sampled every other year as described above.

Pilot data were collected at the Millstone Run site annually between 2007 and 2010. Data collected between 2007 and 2012 are summarized in Marshall et al. (2013).

Table 6. Unique site identifier (ID), site name, sampling panel, and the year the site was established for two sampling sites at Allegheny Portage Railroad NHS.

ID	Name	Panel	Year Established
ALPO.1001	Millstone Run	2	2011
ALPO.2001	Blair Gap Run	2	2013

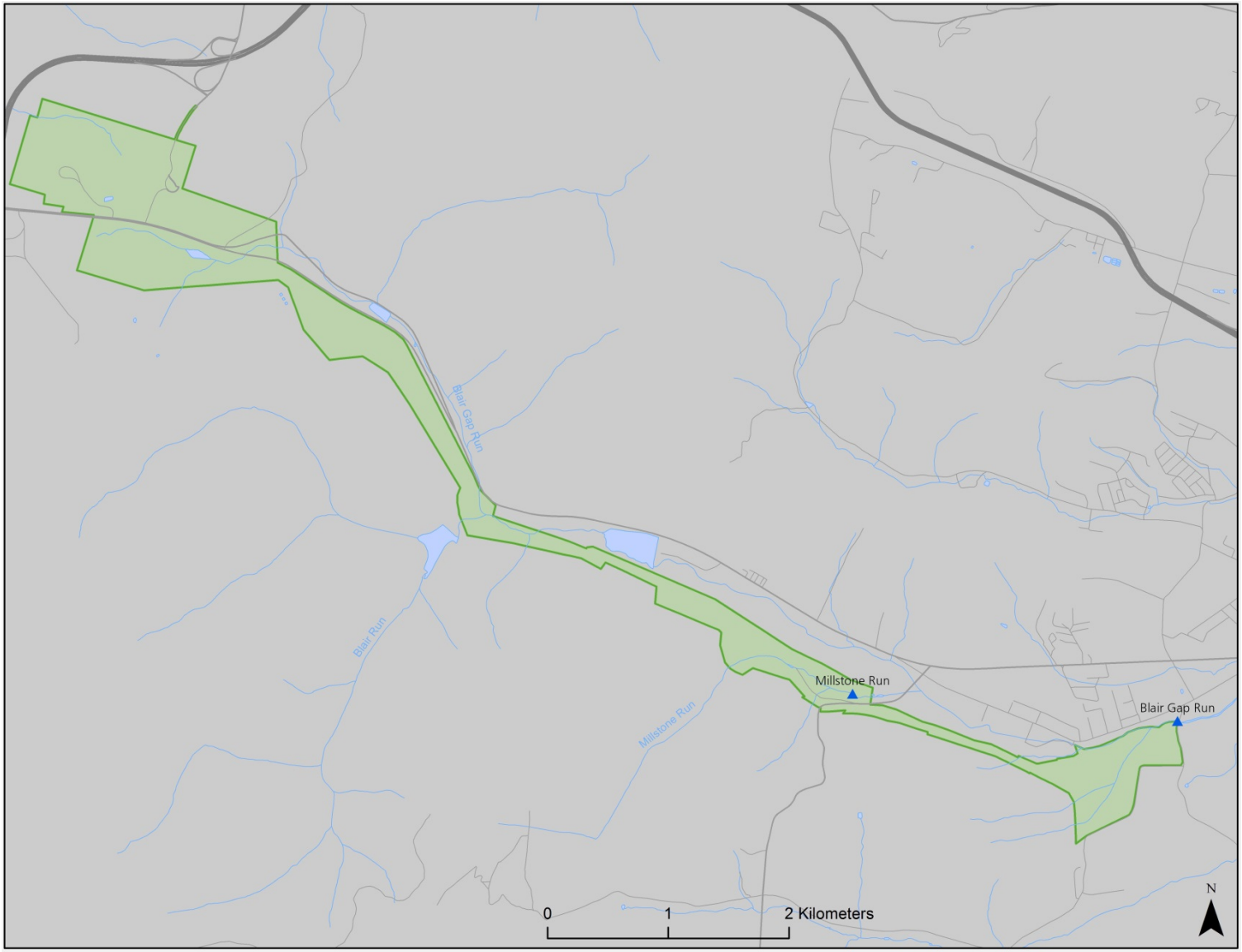

Figure 7. Location of 2 sampling sites selected for monitoring streamside birds at Allegheny Portage Railroad NHS.

Fort Necessity National Battlefield

Established in 1931, Fort Necessity NB encompasses slightly more than 360 ha of land area in southwest Pennsylvania to preserve and commemorate the early career of George Washington and the battle of Fort Necessity. Three streams totaling 2.3 km met the wadeable stream criteria defined above (catchment area between 1 and 100 km2) – two of those streams have non-random, index sampling sites located near the downstream end of the stream segment (Table 7, Figure 8). One stream (UNT to Braddock Run) at the Braddock's Grave park unit was a prohibitively short segment to sample.

Streamside bird monitoring began in 2011 at UNT to Great Meadows Run (FONE.1002) and occurred annually through 2013. Sampling began in 2013 at Great Meadows Run (FONE.2001).

Beginning with the 2014 field season each site will be sampled every other year as described above.

Pilot data were collected the UNT to Great Meadows Run site annually from 2008-2010. Data collected between 2008 and 2012 are summarized in Marshall et al. (2013).

Table 7. Unique site identifier (ID), site name, sampling panel, and the year the site was established for two sampling sites at Fort Necessity NB.

ID	Name	Panel	Year Established
FONE.1002	UNT to Great Meadows Run	2	2011
FONE.2001	Great Meadows Run	2	2013

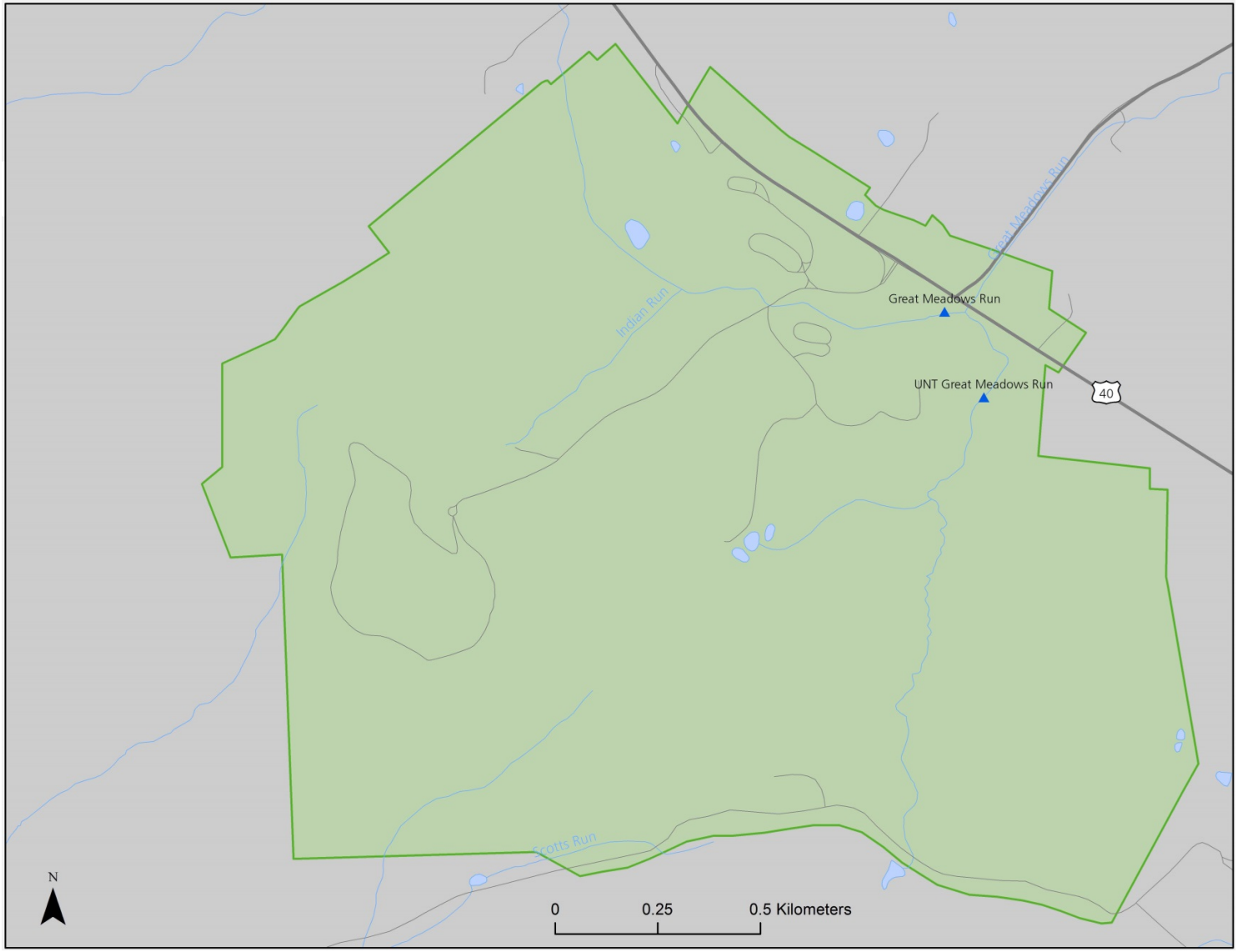

Figure 8. Location of 2 sampling sites selected for monitoring streamside birds at Fort Necessity NB.

Friendship Hill National Historic Site

Established in 1978, Friendship Hill NHS encompasses roughly 273 ha of land area along the Monongahela River in southwest Pennsylvania to commemorate and interpret Albert Gallatin, U.S. Secretary of Treasury for thirteen years under Presidents Jefferson and Madison. Two streams totaling 1.2 km met the wadeable stream criteria defined above (catchment area between 1 and 100 km2) – and both have non-random, index sampling sites located near the downstream end of the stream segment (Table 8, Figure 9).

Streamside bird monitoring began in 2011 at both sites and occurred annually through 2013. Beginning with the 2014 field season each site will be sampled every other year as described above.

Pilot data were collected at both sites annually from 2008 – 2011. Data collected between 2008 and 2012 are summarized in Marshall et al. (2013).

Table 8. Unique site identifier (ID), site name, sampling panel, and the year the site was established for two sampling sites at Friendship Hill NHS.

ID	Name	Panel	Year Established
FRHI.1001	Ice Pond Run	2	2011
FRHI.1002	Dublin Run	2	2011

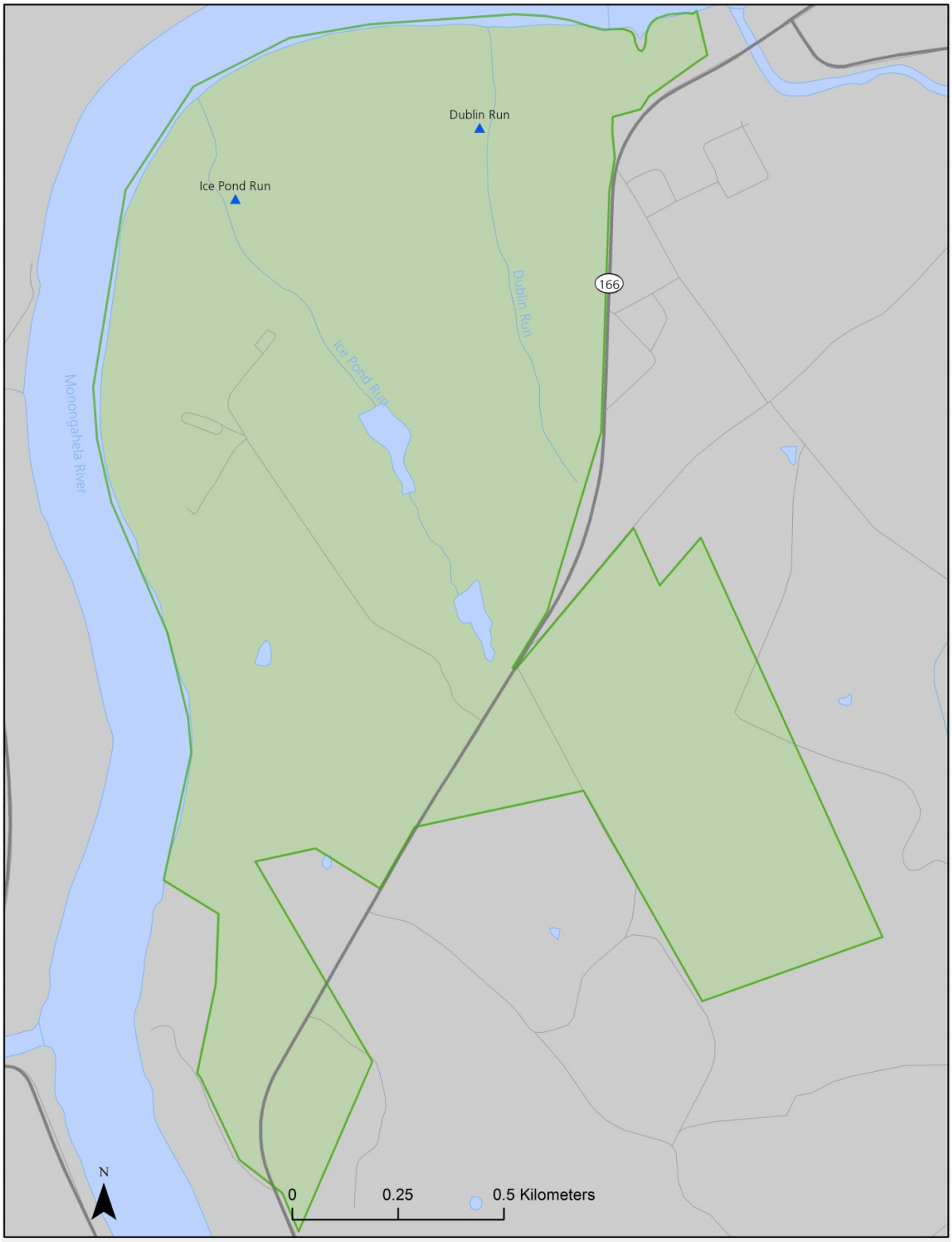

Figure 9. Location of two sampling sites selected for monitoring streamside birds at Friendship Hill NHS.

Field Methods

Field Season Preparation

Monitoring described in this protocol occurs annually from mid-May through early July. The ability to successfully complete the field portion of the protocol hinges upon thorough advanced planning, which includes: preparation of equipment, maps, field forms, and databases; advertising, hiring, and training field crews; and securing housing and vehicles among other responsibilities. Details on each of these activities are described in the Operational Requirements section below and associated protocol standard operating procedures (SOPs).

Conducting Streamside Bird Surveys

The details of conducting the point counts and filling out the associated datasheets are described in SOP 2 – Field Crew Training and Safety.

Point Counts

The basic procedure for conducting point counts is to navigate to the site and first point count station and record ambient noise and vegetation measurements. Then conduct the 10 min point count and navigate to the next station. Repeat this process until the first pass is complete, wait 10 min and begin the second pass. Crew members do not record vegetation measurements on the second pass (it is assumed that these values do not change between passes of the same visit) but ambient noise is recorded each pass. During point counts, the following information for each individual bird detected is recorded: 1) species identity; 2) type of detection (e.g., song, call, drumming, visual); 3) the distance band of first detection (<50 m, 50–75 m, or >75 m of the point count station); 4) each 1 min interval the bird is detected; 5) if the bird is a juvenile; and 6) if the bird is flying over the canopy at the time of detection.

Each visit begins at sunrise and ends 4.5 hours after sunrise. Ideally, the visits are rotated among observers to account for observer biases; however, this is not always the case due to logistical and personnel constraints.

Vegetation and Ambient Noise Measurements

Historic land-use, geology, soil and climate (along with more contemporary wind-generated tree-fall gaps, floods, landslides, lightning, drought, and insect-defoliations) play important roles in shaping the structure and composition of vegetation communities along streams in the ERMN (Rentch 2006) and thereby the composition of associated streamside bird assemblages (Greenberg and Lanham 2001, Saunders et al. 2006, Bowen et al. 2007). Periodic assessments of vegetation structure and composition surrounding each point count station are conducted and described in SOP 2 – Field Crew Training and Safety.

Ambient or background noise can have effects on the spatial distribution, singing behavior, and detectability of birds (Lengagne and Slater 2002, Slabbekoorn and Smith 2002). While these effects have been demonstrated in response to anthropogenically generated noise such as roads and associated vehicle traffic (e.g., Petricelli and Blickley 2006), natural noise effects remain less understood. In mountainous regions such as the ERMN, noise generated by streams (e.g., riffles and

waterfalls) may be sufficient to affect bird behavior and does affect the ability to hear vocalizing birds (i.e., detectability). Hand-held decibel meters are used to quantify ambient noise are described in SOP 2 – Field Crew Training and Safety.

Data Management

One of the most important goals of the NPS I&M Program is to integrate natural resource inventory and monitoring information into park planning, management, and decision-making. Collecting data on specific natural resources such as streamside birds is only the first step toward improving our understanding of park ecosystems. Sound data management practices enable us to analyze, synthesize, and model data, transforming them into useful information now and in the future. This section outlines the series of steps taken to ensure data stewardship, longevity, and information sharing.

Database Design

The ERMN Streamside Bird Monitoring Database is a custom relational database developed in Microsoft Access to store all data collected for the streamside bird monitoring protocol. The database consists of tables, queries, data-entry forms, and built-in reporting tools. The database builds on the Natural Resource Database Template which is a set of core database tables and the standard for the NPS I&M Program. The database is divided into two components: 1) one for entering, editing, and error-checking the current field season's data (i.e., the "field" or "working" database copy), and 2) another that contains the complete set of accepted data for the monitoring project (i.e., the "master project database"). Each database component (working and master) is based on an identical underlying data structure (tables, fields, and relationships) and both components have an associated front-end database application ("user interface" with forms, queries, etc.). Each field crew is provided with their own copy of a working database into which they enter and quality-check data for the current season (see below) but do not have access to prior years' data. Once data for the current field season have been accepted by the protocol lead, they will be uploaded into the master database, which is then used to inform all reporting and analysis. This upload process is performed by the data manager using a series of pre-built append queries.

Data Entry, Verification, and Acceptance

All data collected as part of the ERMN Streamside Bird Monitoring Program are entered directly into a working database by the observer who collected the data. Data entry consists of transferring raw data from field forms into the database - the procedures of which are covered during training and described in SOP 2 – Field Crew Training and Safety. Each data entry form is patterned after the structure of the field form and has built-in components such as pick lists and validation rules to test for missing data or illogical combinations. Although the database permits users to view the raw data tables and other database objects, users other than the protocol lead and data manager are required to only use these pre-built forms as a way of ensuring the maximum level of quality assurance.

Data verification immediately follows data entry and involves checking the database records against the original field data forms for accuracy. Data verification is necessary to ensure that values recorded on the field forms and keyed into the database match (i.e., there are no transcription errors or missing values). Verification occurs first by having the observer visually "proof" their own database records against their own field forms and then by having a second crew member (often working in pairs to check each other's data) also check that the field forms match the database

records. There are separate “check boxes” on the data entry form of the database to indicate that these two steps are complete. Finally, the proofed and checked data are sent to the protocol lead (on a weekly basis during the field season) where he/she then checks for completeness and logical consistency visually and through queries. The working database application facilitates the verification process by showing the results of pre-built queries that check for data integrity, data outliers and missing values, and illogical values.

The protocol lead compiles any questions or concerns regarding the data in a Microsoft Word document (called a “data review log”) referring to each issue by site, visit, and record number. The protocol lead sends the data review log to field crews within five days of receiving a database submission so that crews have sufficient time to address the concerns before submitting their next bout of data entry the following week. Once all discrepancies are resolved (documented in writing in the data review log) and fixed in the database, the data for that visit is “checked” as approved by the protocol lead. Not all errors and inconsistencies can be fixed, in which case a description of the resulting errors and why edits were not made is then documented and included in the data review log.

Ideally, data are entered and proofed the day of collection to help ensure accurate recollection of confusing, unclear, or incomplete records. Indeed, daily data entry and proofing is expected of field crew members. If this is not feasible, then this must be accomplished as soon as possible but certainly within one week of data collection.

Data acceptance is a benchmark that indicates that: (1) data are complete for the period of record; (2) they have undergone and passed the quality assurance and quality control checks (“verification” as described above); and (3) they are documented and in a condition for archiving, posting, and distribution as appropriate. Acceptance is not intended to imply that the data are completely free of errors or inconsistencies which may or may not have been detected during quality assurance reviews. To ensure that only quality data are included in reports and other project deliverables, the data acceptance step is an annual requirement for all data. The protocol lead (roles and responsibilities are described in the Operational Requirements section below) is responsible for accepting the data and providing it to the data manager. It is at this point that the data are appended to the master project database and archived (along with the data review log). Again, only accepted data are used to inform analysis and reporting.

Metadata Procedures

Data documentation is a critical step toward ensuring that data sets are usable for their intended purposes well into the future. This involves the development of metadata, which can be defined as structured information about the content, quality, condition, and other characteristics of a data set. Additionally, metadata provide the means to catalog and search among data sets, thus making them available to a broad range of potential data users. At the conclusion of field seasons, the protocol lead and data manager will be jointly responsible for completed metadata.

Data Backups and Archiving

Data backups and archiving occur at several points and in multiple ways in the data management process. The most basic level is to ensure that daily records entered into the field database are not

lost. Upon closing/exiting the working database, the user will be prompted to make a backup of the underlying data. It is recommended that this be done on a regular basis – perhaps every day that new data are entered – to save time in case of mistakes or database file corruption. The most recent database backup is sent (by placing it on a secure Web server) to the protocol lead each week as part of the data certification process (described above). In this way, the data are also backed-up in multiple locations. These periodic backups may be deleted once enough subsequent backups are made, and all such backups may be deleted after the data have passed the quality review and been accepted.

The field data forms are also electronically scanned and converted to the .pdf file type at the time of data entry (i.e., field crew members do this daily for their own field forms) and placed on the designated secure Web server. This again, ensures that the raw field forms are also immediately converted to an electronic format and backed-up in multiple locations.

At the completion of the field season and the data acceptance process, the master database, associated metadata, data review logs, electronic scans of field forms, and all other relevant project materials are archived by the data manager (in conjunction with the protocol lead) on the ERMN server which is routinely backed-up including an off-site location. The paper field forms are clearly identified, organized, and filed in the protocol lead's office with all other relevant "hard copy" protocol documents.

Data Dissemination

The majority of data analysis and reporting will be conducted by the protocol lead. All completed reports and articles will be publicly available from multiple sources including the ERMN website (http://science.nature.nps.gov/im/units/ermn/) and the NPS integrated resource management information portal (https://irma.nps.gov/App/Portal/Home).

Requests for other ERMN streamside bird monitoring data should be directed to either the protocol lead or data manager. Each request and potential release of data will be reviewed on a case-by-case basis considering factors such as purpose, audience, data on sensitive species, and other factors.

Data Analysis and Reporting

Recommended Reporting Schedule and Format

Three types of reports will be produced for the ERMN Streamside Bird Monitoring Protocol: 1) summary reports; 2) Resource Briefs; and 3) periodic "variability and trends" reports.

Summary reports will be produced every two years to coincide with the completion of sampling both panels (i.e., all sampling sites). These reports describe current condition of the resource and potentially provide early indications if data are outside the bounds of known variation. The intent is not to be all inclusive of the data available, but to provide a succinct interpretation of the recently completed field seasons' monitoring events and findings (see below). In most instances, the purpose of these reports is to get summary information to park resource managers in a timely manner, and, as such, some of the data and conclusions will be regarded as provisional. Summary reports will generally not include discussion of trends, which will be covered in depth by the "variability and trend" reports. The primary audience is ERMN and member-park natural resource management personnel. It is likely that other researchers, collaborators, and interested parties, including the public, will also utilize these reports on occasion. The target outlet is the NPS Natural Resource Data Series or potentially through a vetted and fully documented "data visualizer". The peer-review process and publishing guidelines for this report series are available at http://www.nature.nps.gov/publications/nrpm/.

Resource Briefs are short (1−4 pages), concise summaries of relevant information. The idea is to produce an "eye-catching", information-rich, executive summary of a longer report in an attempt to reach audiences not inclined to read the full report (e.g., park superintendents, other administrators, and perhaps the public). Peer reviewed and published information will form the basis for all resource briefs.

Periodic (6−10 years) "variability and trends" reports will expand on the annual status reports and provide scientifically defensible analyses of inter-annual variability and spatial and temporal patterns and trends (e.g., long-term trends for individual species and changes in the composition of streamside bird communities over time). These reports are intended to provide high-quality, peer-reviewed data and analyses that can be used in conjunction with other vital signs and/or park-based research projects and monitoring. Further, these comprehensive reports could place the observed results in both a regional and historical context by relating them to published literature, discussing the significance of the results relative to changing environmental factors, and/or providing management recommendations based on these findings when appropriate. The target audience is the same as for the annual reports but will likely be of increased interest to the broader scientific community as well. Peer-review will be more extensive than that which occurs for the annual summary reports. The target outlet is the NPS Natural Resource Technical Report Series. The peer-review process and publishing guidelines for this report series is available at http://www.nature.nps.gov/publications/nrpm/.

These reports, typically authored by the protocol lead but perhaps done in collaboration with a quantitative ecologist/statistician or other avian ecologists, will form the core reporting requirements

and schedule for this protocol. Additional reports, data summaries, and presentations for a variety of purposes will be performed as appropriate. It is likely that many topics covered in these reports will also be submitted to peer-reviewed scientific journals for publication. All published reports will have a record created in the NPS Natural Resource Information Portal (https://irma.nps.gov/Portal) to ensure information sharing through a common, searchable, publically available database.

Recommendations for Routine Data Summaries and Analysis

Perhaps more has been written in the scientific literature on the collection and analysis of bird point count data than about survey methods for any other biological taxon (Sauer and Droege 1990; Nichols et al. 2009). It is beyond the scope of this protocol to provide instructions for each analysis method. That said, data collected with this protocol allow for a wide range of analyses – the recommendations below represent example summaries and analyses that should be conducted to meet protocol objectives (see Measureable Objectives section above). A wide variety of statistical approaches can be used to meet these objectives.

Each summary report should begin with field season summaries that describe and document the accomplishments and significant events of the season (e.g., name of field crew members, number of sites visited, logistical issues, unusual weather, new tree fall gaps or other disturbances, and atypical events like extended periods of rain that delayed surveys). Any changes to the protocol (i.e., the way data were collected) that were implemented that year should also be described to help inform future analysis and interpretation.

Each summary report should also summarize rare species or unusual occurrences that resource managers or other stakeholders (e.g., state agencies or natural heritage programs) may be interested in. This should not be limited to bird observations, since the field crew members spend many hours in the field and in areas where natural resource managers do not frequently visit. For example, an orchid species (*Platanthera orbiculata*) not documented in Delaware Water Gap NRA for more than 30 years was observed (Figure 10) by an avian field technician in 2009 and again in 2012. The protocol lead and data manager will ensure that a record is created for these observations in the NPSpecies module of the NPS Natural Resource Information Portal (https://irma.nps.gov/Portal) to ensure information sharing through a common, searchable, publically available database.

Reporting of invasive species that are part of the ERMN Early Detection of Invasive Species protocol should not be a part of the annual report since this occurs in other ways (Keefer et al. 2014).

The breeding bird composition and distribution should be summarized in each summary report using a variety of tables and graphs, potentially including:

1. tables of all species observed (by park and perhaps by site, as appropriate) with total number of observations/detections;

2. graphs of frequency of occurrence (number or proportion of sites where species/guild was detected) for specific species or guilds; and

3. descriptive statistics that report species relative abundance for specific locations and time periods (e.g., each site and year).

A published example of this type of summary report is Marshall et al. (2013).

More complex analyses of species-specific trends and changes in bird community composition (and condition) over time will be carried out every six to 10 years and presented in "variability and trends" reports. In some cases, consultation with a qualified statistician will be needed at the time of analysis, as statistical methods and software evolve rapidly. Regardless, there is well-developed literature on trend analysis of bird point count data to draw upon when deciding on the analytical approach (e.g., Ralph et al. 1995, Thomas 1996, Nur et al. 1999, Buckland et al. 2001, MacKenzie et al. 2002, MacKenzie et al. 2003, Thompson 2002, Bart et al. 2004, Nichols et al. 2009).

Thomas (1996) summarized the wide variety of statistical approaches for evaluating bird population trends, which generally are some form of regression approaches that model population size (or an index such as relative abundance) versus time. More recently, MacKenzie et al. (2002) described a technique for evaluation of trends in site occupancy rather than population size. Extensions to this general approach (i.e., Royle and Dorazio 2006, Royle and Kery 2007) can be applied to the hierarchical nature of the ERMN streamside bird data collection (i.e., 3 point count stations nested within a site and multiple sampling sites per park). ERMN streamside bird data collection methods also allow alternative approaches to be considered to account for imperfect detection while estimating abundance including repeat counts (Kery et al. 2005), time-of-detection (Alldredge et al. 2007) and distance methods (Thomas et al. 2005). The chosen approaches will allow estimation of parameters (e.g., occupancy, relative abundance, abundance, and density) that are explicitly linked to protocol objectives enabling evaluations of trends through time. Whatever approach is taken will be thoroughly described and documented in the ensuing report.

Figure 10. *Platanthera orbiculata* documented at Delaware Water Gap NRA in 2009 and 2012. Photo by Nicole Flood.

Birds as Indicators of Ecosystem Integrity

Birds are often used as indicators of ecosystem health or integrity and summarizing the "condition" of the bird community and reporting changes in the bird community over time is a primary monitoring objective of this program.

The Bird Community Index (BCI) is an index of biotic integrity (Karr and Dudley 1981) based on the breeding bird communities of the central Appalachians (O'Connell et al. 1998a, 1998b, 2000). The BCI is based on 16 response guilds with each guild broadly classified as "specialist" or "generalist" based on each guild's relationship to specific elements of biotic integrity (Table 8). Each bird species is assigned to a response guild and the BCI ranks the overall bird community detected at a site according to the proportional representation of the species' in the response guilds. Higher BCI scores (indicating higher biotic integrity) describe a community in which specialists are well-represented relative to generalists.

It is important to recognize that the BCI in its current formulation reflects land-use and land-cover types of the central Appalachians (e.g., mature and regenerating forest, pasture and row crop, urban and suburban area, and mined lands), each of which, in the absence of irreversible anthropogenic disturbance, would succeed to forest. Moreover, specialist guilds tend to be associated with extensive forest cover and a taller, more closed-canopy forest. Therefore, the sites with the highest BCI scores reflect bird communities associated with aspects of mature forest structure, function, and composition. For example, sites with higher BCI scores consist of a bird community with fewer omnivores, nest predators/brood parasites, and residents (i.e., generalists); but more bark probers, single-brooded species, and interior-forest obligates (i.e., specialists). Therefore, the biotic or ecological "condition" described by the BCI moves along a disturbance gradient from relatively intact, extensive, mature forest (high biotic integrity and high BCI scores) to highly developed or urban (low biotic integrity and low BCI scores) habitats.

The BCI was developed by O'Connell et al. (1998a, 1998b, 2000) as one component of the U.S. Environmental Protection Agency, Environmental Monitoring and Assessment Program's (EPA-EMAP) Mid-Atlantic Highlands Assessment (MAHA). The BCI is particularly amenable to application by the ERMN Streamside Bird Monitoring Program for several reasons. First, the geographic extent of the MAHA aligns well with that of the ERMN and, as a result, so do the bird species included (Appendix E). This also means that the assessment of biotic integrity based on the bird community for the entire MAHA (O'Connell et al. 2000) provides an unparalleled regional context for comparisons to results within the ERMN. Finally, the sampling approaches employed by both efforts are comparable.

A thorough description of the BCI and how it is calculated is provided in Appendix E and a published example of its application to ERMN streamside bird data is Marshall et al. (2013).

Table 9. Summary of biotic integrity elements, guild categories, response guilds, and guild interpretations used in an index of ecological integrity called the Bird Community Index (BCI; O'Connell et al. 1998a, 1998b, and 2000).

Biotic Integrity Element	Guild Category	Response Guild	Specialist	Generalist
Functional	Trophic	omnivore		X
Functional	insectivore foraging behavior	bark prober	X	
Functional	insectivore foraging behavior	ground gleaner	X	
Functional	insectivore foraging behavior	upper-canopy forager	X	
Functional	insectivore foraging behavior	lower-canopy forager	X	
Compositional	origin	exotic/nonnative		X
Compositional	migratory	resident		X
Compositional	migratory	temperate migrant		X
Compositional	number of broods	single-brooded	X	
Compositional	population limiting	nest predator/brood parasite		X
Structural	nest placement	canopy nester	X	
Structural	nest placement	shrub nester		X
Structural	nest placement	forest-ground nester	X	
Structural	nest placement	open-ground nester	X	
Structural	primary habitat	forest generalist		X
Structural	primary habitat	interior forest obligate	X	

Operational Requirements

This chapter describes the personnel, qualifications, roles, responsibilities, schedule, and funding resources required to implement the streamside bird monitoring protocol.

Personnel Requirements

Implementation of the streamside bird monitoring protocol requires a protocol lead, data manager, field crew member(s), and field crew leader(s). General roles and responsibilities for required personnel are summarized below and in Table 10. Names and contact information for individuals who serve or have served in these roles are provided in SOP 1 – Before the Field Season.

The protocol lead is responsible for overseeing the entire project and implementing the monitoring protocol. This does not mean that he/she plays active roles in each task but knows the rationale and requirements for each task and the responsible party for completing each task. The protocol lead is responsible for field season preparation, including organizing equipment, hiring field crews, conducting trainings, ensuring data entry and quality control, data analysis and reporting, and revising the protocol. The protocol lead may also collect data. Field crew members and field crew leaders are responsible for data collection, data entry, and several levels of data review and quality control. Field crew leaders are responsible for planning and coordinating daily activities while in the field (e.g., ensuring all sites are sampled the required number of times). The data manager is responsible for coordinating data management throughout the lifespan of the project. He/she develops data management guidance for the project, develops the proper database application for data storage, entry, and retrieval, and advises the protocol lead to ensure that the field crew members are properly trained on using the application. The data manager is also responsible for data archiving and long-term data security and posting of products to NPS websites and data delivery systems.

Qualifications, Training, and Safety

Achieving the goal of accurate, reliable, and consistent data begins with the hiring process (SOP 1 – Before the Field Season) followed by a rigorous training program (SOP 2 – Field Crew Training and Safety).These topics and the related SOPs are among the most important parts of this protocol because they summarize the essential qualifications and skills field crew members must possess for this project, provide guidance on selecting and hiring these individuals, and outline the required training. The quality of the observer, combined with appropriate training, will determine the quality of the data. This cannot be overemphasized. Carefully screening of initial applicants, combined with rigorous training, can eliminate the more obvious visual, aural, psychological, and competency factors that affect observer variability (Kepler and Scott 1981, Ralph et al. 1993, McLaren and Cadman 1999).

The essential skills and experience necessary for field crew members include: identifying eastern forest birds by sight and sound (songs, calls, and drumming), using distance estimation techniques, good eyesight and good hearing ability, excellent physical condition, and backcountry experience. Crew members must already be proficient at identifying (by their vocalizations) the majority of bird species expected to be encountered. This is determined based on prior experience, reference checks, and a bird song quiz (SOP 1 – Before the Field Season)

Table 10. Roles and responsibilities for streamside bird monitoring.

Role	Responsibilities
Protocol Lead	• Implements program and provides oversight, administration, and budget tracking • May serve as NPS key official, agreement technical representative, or contracting officers technical representative on agreements or contracts, as qualified • Prepares for field season including hiring and training field crew members/leaders • Assumes primary responsibility for data analysis and reporting • Assists data manager with data certification. • Liaison to Washington Support Office (WASO) programs, offices, and other I&M networks • Handles and coordinates data requests • Coordinates review and changes to the protocol
Field Crew and Field Crew Leader	• Data collection • Data entry • Data review and quality control • Recommend changes to the protocol in terms of field operations • Crew leader plans and coordinates daily activities of the field crew
Data Manager	• Advises on data and information management activities • Develops and maintains compliant and functional database • Data archiving and long-term data security • Posts data, metadata, reports, and other products to NPS data storage and delivery systems and network Web sites

The physical and psychological demands of remote field work in the ERMN should not be underestimated and crew members need to be informed and mentally and physically prepared and qualified. Even the most skilled observer is of no use if they are unable to cope with adverse field conditions. Bird surveys in the ERMN demand a capacity for adjusting to waking well before dawn, safely navigating by car and foot to remote field sites using GPS, and carefully hiking through rugged, steep terrain with dense understory vegetation, deep creeks, and waterfalls.

Each crew member is required to participate in a training session prior to data collection (fully explained in SOP 2 – Field Crew Training and Safety). Training is designed to ensure that, upon completion, all crew members are able to identify (by sight and especially by sound) all of the bird species that are regularly encountered in the respective park unit(s) during point counts and >98% of bird species that have reasonable potential to be encountered. It is also important that observers are able to accurately and consistently estimate distances to unseen, singing birds. Emphasis will be placed on following standard operating procedures for data collection to assure accuracy and consistency among observers. Training will also ensure that field crew members know how to navigate to point count stations and enter data into the provided MS Access database application.

The ERMN considers the occupational health and safety of their employees, cooperators, contractors, and volunteers to be of utmost importance, and is committed to ensuring that all seasonal field crew members receive adequate training on safety procedures, accident reporting, and emergency response prior to field work. All field crew members are equally responsible for keeping safety topics covered during training at the forefront of daily activities throughout the field season. Safety procedures,

emergency contacts, accident reporting, and radio use are outlined in SOP 2 – Field Crew Training and Safety.

Encountering hazardous situations is inherent to all field monitoring activities; consequently, all personnel who participate in a field-based monitoring protocol are always, to some extent, exposed to the risk of accident, injury, or illness. In recognizing this, the ERMN is committed to conduct monitoring activities including driving, accessing and navigating to monitoring sites, making field measurements and observations, and processing samples in a manner where hazardous conditions are recognized and measures are taken to minimize these risks.

Consistent with NPS Directors Order 50 and Reference Manual 50B for Occupational Health and Safety (NPS 1999), the ERMN will:

- Promote and enforce safe work practices and integrate safety and health into every operation and activity.
- Evaluate occupational safety and health management programs annually, and revise as appropriate.
- Provide employees the supervision, knowledge, equipment, and skills necessary to safely perform their assigned tasks.
- Make safe behavior a condition of employment, and require that employees and supervisors work together to identify and mitigate unsafe and unhealthful conditions, activities, and behaviors.
- Promote and enforce the safe operation of motor vehicles and equipment.

The ERMN applied the GREEN-AMBER-RED (GAR) Risk Assessment Model as outlined in the NPS Operational Leadership Student Manual (Version 2; July 2011) to the ERMN Streamside Bird Monitoring Protocol and provides that assessment in Appendix G.

The primary tool used to promote safe conduct is the Job Hazard Analysis (JHA). This approach is consistent with NPS Directors Order 50 and Reference Manual 50B for Occupational Health and Safety. The JHA process is to (1) identify hazards associated with field and laboratory settings, as appropriate, and (2) develop approaches to mitigate those hazards. The JHA for this protocol is presented to and discussed with each field crew member during training (SOP 2 – Field Crew Training and Safety)

Annual Workload and Schedule

Implementation of the streamside bird protocol is a year-round responsibility for the protocol lead. Data collection, management, analyses, and reporting must be completed every year along with protocol revisions, website updates, budget and project management, and communications with parks and other interested parties. That said, the avian breeding season (May–July) of each year is the focal point for data collection and therefore dictates the annual schedule.

Beginning in January, the protocol lead should ensure that field equipment is organized and ready for use; ensure that housing, vehicles, and park radios are arranged and available; and begin the hiring process. Training typically begins during the second or third week of May, with data collection beginning as soon as the protocol lead determines that the crews are sufficiently trained and ready to begin. The field season, including training, is approximately eight weeks in length and is therefore typically completed by the first week of July.

The following timeline outlines the annual schedule for implementing the ERMN streamside bird protocol:

1. January–April (Protocol lead)
    a. Hire field crews
    b. Prepare for field season
2. May–July (Protocol lead and field crews)
    a. Training
    b. Conduct point counts
    c. Enter and proof data
3. August–December (Protocol lead)
    a. Analyze data
    b. Prepare and submit annual report
    c. Discuss results with park resource managers
    d. Present results at professional meetings/peer reviewed publications

Facility and Equipment Needs

This protocol requires no specialized equipment or facilities for ERMN personnel beyond normal office space, seasonal field housing, appropriate vehicles, and equipment storage needs.
SOP 1 – Before the Field Season contains a list of the equipment needed by survey crews.

Startup Costs and Budget Considerations

This protocol was developed through a cooperative agreement with The University of Georgia's Warnell School of Forestry and Natural Resources. The agreement covered protocol research and development, field personnel, and data collection at New River Gorge NR, Gauley River NRA, and Bluestone NSR for the first four years of the program (FY2007–2010). The total budget for this agreement and its modifications was approximately $375,000. An additional cooperative agreement with a budget of approximately $57,000 with East Stroudsburg University covered protocol development and data collection at Delaware Water Gap NRA from 2009 through 2010. Beginning

in 2010 (and the 2011 field season) the ERMN Program Manager became the protocol lead and these cooperative agreements came to an end. Routine data collection now requires a field crew of two (one of which is the crew leader). The protocol lead (who acts as a crew leader) and an additional crew member collect data at Bluestone NSR, Allegheny Portage Railroad NHS, Fort Necessity NB, and Friendship Hill NHS.

Costs associated with implementing the annual field sampling portion of the streamside bird monitoring protocol are approximately $19,900 with details provided in Table 11. This estimate includes personnel costs for field crew leaders and crew members, transportation, housing, travel costs, and supplies that are used every year. Costs not shown include approximately 40% of the ERMN program manager's time to be the protocol lead. Because of the revisit schedule ALPO, BLUE, FONE, and FRHI are sampled every other year.

Table 11. Estimated annual costs to implement the streamside bird monitoring protocol in six park units of the Eastern Rivers and Mountains Network.

Budget Category	NERI, DEWA	BLUE	ALPO	FONE, FRHI
Wages, contracts, fringe	$11,800	$750	$0	$400
Travel	$1,200	$1,400	$300	$850
Supplies	$500	$50	$50	$50
Indirect if Univ. (17.5%)	$2,200	$0	$0	$0
Park housing	$2,000	$0	$0	$0
Total	$17,700	$2,200	$350	$1,300

Revising the Protocol

Protocol review and revision is an on-going task resulting in a "living" document. Feedback, review, and suggested changes should involve input from all of those involved in the project and should occur at least annually at the completion of each field season. This level of revision may or may not require actual changes to the protocol. The protocol will also be thoroughly reviewed roughly every five years (potentially coincided with periodic variability and trends reporting). The protocol lead and data manager (at a minimum) and, preferably, qualified external reviewers will critically evaluate the narrative, SOPs, associated database, analyses and reports produced thus far, and other products.

The protocol narrative and each SOP contain a revision history log located at the beginning of each document that is completed for each change to explain reasons for changes, and to assign a new version number to the revised SOP or narrative. Careful documentation of changes to the protocol and a library of previous protocol versions are essential for maintaining consistency in data acquisition and for appropriate treatment of the data during data summary and analysis.

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Appendix A: Defining the Sampling Frame

Overview

This appendix describes the data layers and procedures used to define the sampling frame for the three ERMN monitoring protocols involving flowing surface waters (river water quality, stream benthic macroinvertebrates, and streamside birds). It was our intent to develop a sampling frame that could be used for multiple ERMN monitoring protocols and would allow sampling co-location among protocols.

All flowing surface waters were delineated using ArcGIS and then placed into size categories according to upstream contributing area (i.e., watershed area). All streams and rivers with a contributing area ≥ 100.0 km2 at their mouth (i.e., outpour point) or at the park boundary (if a stream/river flows out of the park) were categorized as "rivers" and are monitored as described in the River Water Quality Monitoring Protocol Implementation Plan (Tzilkowski et al. 2016a). All streams with a contributing area ≤ 2.0 km2 at most parks were defined as "ephemeral" or "intermittent" and not included in the sampling frame of any ERMN protocol. This criterion was relaxed to ≤ 1.0 km2 at Fort Necessity NB and Friendship Hill NHS so that the limited amount of surface water at those small parks was included and sampled.

All surface waters with contributing areas between 2 and 100 km2 were categorized as "wadeable streams" and were included in the common sampling frame for the benthic macroinvertebrate monitoring protocol (Tzilkowski et al. 2016b) and streamside bird monitoring protocol (this protocol). This appendix also describes how wadeable streams were partitioned into a finite number of discrete 100 m stream segments used for sample site selection at New River Gorge NR, Gauley River NRA, and Delaware Water Gap NRA.

All associated input files and products described in this appendix are archived and available upon request.

Step 1. Drainage Line Modeling and Delineation

We used the Terrain Preprocessing functions in Arc Hydro (version 2.0, October 2011) for ArcGIS 10.0 to generate a flow accumulation model and delineate drainage lines representing the network of perennially flowing surface waters (i.e., streams and rivers) for each park (Table A.1).

Flow Accumulation Models

Generating a flow accumulation model required two input files: a digital elevation model (DEM) and a hydrology layer to "precondition" DEMs for processing. The best available DEM data that covered the area of interest for all parks was the 10 m grid from the USGS National Elevation Dataset. We evaluated both LiDAR and 3 m DEMs but complete coverages were not available for all parks and areas of interest; consequently, we used the best available hydrology dataset with complete coverage – the USGS National Hydrography Dataset (NHD) high resolution (1:24,000) flowline feature class.

Drainage Line Delineation

We considered perennial streams as having at least a 2.0 km^2 drainage area and streams with contributing area as intermittent (Paybins 2003; M. Marshall, C. Tzilkowski, and A. Weber, pers.

obs.); therefore, we set a threshold (2.0 km^2) in the flow accumulation model to initiate a stream (and its downstream flow) as having a drainage area of 2.0 km^2. Each grid cell that had a drainage area of at least 2.0 km^2 was given a value of 1 in the resulting stream grid layer. This stream grid layer was then used to generate drainage lines that represented streams with at least a 2.0 km^2 drainage area. The 2.0 km^2 criterion resulted in very few delineated "streams" at Fort Necessity NB and Friendship Hill NHS; consequently, the criterion was relaxed to 1.0 km^2 at those parks to delineate (and sample) the limited amount of flowing surface water at these small parks (Table A.2).

Step 2. Drainage Line Refinement

Because all ERMN sampling is constrained to within the authorized boundary of each park, we first clipped the drainage lines generated in Step 1 at the park boundary using the most recent park boundary shapefiles. Next, we split drainage lines at their outpour points (i.e., confluence with another stream) which resulted in sections of lines (streams), separated by nodes (confluences; Table A.3). This "splitting" determined the number of stream sections that were classified among watershed size classes (Step 3).

Drainage lines, which were "line features", did not accurately represent the areal nature of larger streams and rivers; therefore, we overlaid the USGS NHD high resolution (1:24,000) area feature class and split drainage lines based on the "edge" of rivers (e.g., Delaware River) as defined by the NHD and then removed overlapping sections. Similarly, the NHD did not accurately represent stream area (particularly large streams and rivers) when compared to available aerial photography in some cases. In these cases, we used aerial photography (ESRI's Basemap services) to more accurately determine where to split drainage lines – this was a subjective procedure based on the best available data that, in our judgment, more accurately represented reality than relying solely on the NHD. Using this method, we defined 689.7 km of perennially flowing surface waters within the nine ERMN park unit boundaries (Table A.4).

Step 3. Drainage Line Categorization – Watershed Size

We defined a batch point at the downstream end of each drainage line section to generate watershed polygons and calculate the watershed area for each section using the Watershed Processing functions in Arc Hydro. We then categorized line sections into four size classes based upon watershed size (Table A.5). The intent was to clearly define the "wadeable stream" size class given the focus of several monitoring protocols on these streams but to also partition the range of stream and river sizes existing in the ERMN. This process resulted in three large river sections, eight medium rivers, 14 small rivers, and more than 220 km of wadeable streams throughout the ERMN (Table A.6; Figures A1 – A9).

Step 4. Defining the Wadeable Stream Sampling Frame

A random site selection approach was necessary at the three largest ERMN parks (Delaware Water Gap NRA, Gauley River NRA, and New River Gorge NR; Appendix B); therefore, we created a "wadeable stream" sampling frame comprised of discrete (100 m) sampling units from which co-located BMI and Streamside Bird sampling sites could be randomly drawn.

For several reasons, we had to first eliminate several wadeable stream sections prior to developing the sampling frame. All sections ≤ 400 m were eliminated because ERMN Streamside Bird sampling requires three point count stations, spaced 200 m apart and parallel to the stream (totaling 400 m; the largest sampling unit of the wadeable stream-based protocols). This ensured that all wadeable stream-based protocols could be implemented at selected sites. Second, we removed wadeable stream sections that were within large stream/river floodplains (Table A.7) to minimize variance associated with these hydrologically and biologically distinct transition zones. Third, we eliminated several sections of wadeable stream that "meandered" across park boundaries. Due to the uncertainty of determining if these sections fell on NPS property, we elected to eliminate them *a priori*. Finally, after partitioning the remaining sections of wadeable stream into 100 m segments (see below), any remaining segment < 100 m was eliminated. The total length of wadeable stream eliminated (and therefore not included in the sampling frame and area of statistical inference) for each of these criteria is summarized in Table A.8.

After finalizing the wadeable stream population to be included in the sampling frame, we used several Arc GIS 10.0 tools to create the 100 m segments that constitute the sampling frame (Figure A.10). The segments were discrete but continuous, such that Delaware Water Gap NRA had 607 uniquely identified 100 m stream segments that corresponded to the 60.7 km of wadeable stream in the park. Similarly, New River Gorge NR and Gauley River NRA had 1,008 and 109 uniquely identified 100 m stream segments, respectively. Each 100 m segment was defined by the UTM coordinates of the center point of the segment.

Table A.1. Input files used, and final products generated while delineating drainage lines that represent Eastern Rivers and Mountains Network intermittent and perennial streams.

File Type	File Name
Input files	USGS NHD high resolution (1:24,000) line feature class
	USGS NHD high resolution (1:24,000) area feature class
	ERMN_Park_Boundaries.shp
	USGS National Elevation Dataset 10 m Digital Elevation Model (DEM)
Final Products	USGS NHD high resolution (1:24,000) line feature class
	USGS NHD high resolution (1:24,000) area feature class
	ERMN_Park_Boundaries.shp
	USGS National Elevation Dataset 10 m Digital Elevation Model (DEM)
	USGS NHD high resolution (1:24,000) line feature class
	USGS NHD high resolution (1:24,000) area feature class
	ERMN_Park_Boundaries.shp
	USGS National Elevation Dataset 10 m Digital Elevation Model (DEM)

Table A.2. Eastern Rivers and Mountains Network perennial stream shapefiles.

Park	Shapefile
Allegheny Portage Railroad NHS	ALPO_ FlowingWaters _2sqkm.shp
Bluestone NSR	BLUE_ FlowingWaters _2sqkm.shp
Delaware Water Gap NRA	DEWA_ FlowingWaters _2sqkm.shp
Fort Necessity NB	FONE_ FlowingWaters _1sqkm.shp
Friendship Hill NHS	FRHI_ FlowingWaters _1sqkm.shp
Gauley River NRA	GARI_ FlowingWaters _2sqkm.shp
Johnstown Flood NMem	JOFL_FlowingWaters_2sqkm.shp
New River Gorge NR	NERI_ FlowingWaters _2sqkm.shp
Upper Delaware SRR	UPDE_FlowingWaters_2sqkm.shp

Table A.3. Number and cumulative length of perennial stream and river sections in Eastern Rivers and Mountains Network parks. Stream sections were defined as having ≥2.0 km^2 contributing area and were delimited by confluences or park boundaries.

Park	Sections	Length (km)
Upper Delaware SRR	68	182.9
Delaware Water Gap NRA	45	174.9
Allegheny Portage Railroad NHS	3	3.7
Johnstown Flood NMem	2	1.0
Fort Necessity NB[1]	3	2.3
Friendship Hill NHS[1]	2	1.2
Gauley River NRA	22	68.2
New River Gorge NR	86	230.7
Bluestone NSR	7	24.7
Total	238	689.7

[1] Stream segments (drainage lines) were defined at these parks by contributing areas ≥1.0 km^2 so that the limited number and length of streams present were included (and sampled).

Table A.4. Park, size category, name, length in park (Length), and contributing area (Area) for flowing surface waters in the Eastern Rivers and Mountains Network. UNT = Unnamed tributary.

Park	Category	Name	Length (km)	Area (km^2)
New River Gorge NR	Large River	New River	90.41	17815.13
New River Gorge NR	Small River	Dunloup Creek	6.45	125.36
New River Gorge NR	Small River	Glade Creek	9.94	163.64
New River Gorge NR	Small River	Lick Creek	1.25	101.25
New River Gorge NR	Small River	Manns-Glade Creek	9.11	151.01
New River Gorge NR	Small River	Piney Creek	1.28	351.65
New River Gorge NR	Wadeable Stream	Arbuckle Creek	2.79	23.82

Table A.4 (continued). Park, size category, name, length in park (Length), and contributing area (Area) for flowing surface waters in the Eastern Rivers and Mountains Network. UNT = Unnamed tributary.

Park	Category	Name	Length (km)	Area (km^2)
New River Gorge NR	Wadeable Stream	Batoff Creek	2.14	9.40
New River Gorge NR	Wadeable Stream	Big Branch	1.25	2.86
New River Gorge NR	Wadeable Stream	Bills Branch	1.49	3.66
New River Gorge NR	Wadeable Stream	Bucklick Branch	0.57	2.71
New River Gorge NR	Wadeable Stream	Buffalo Creek	2.69	14.11
New River Gorge NR	Wadeable Stream	Butcher Branch	1.20	3.16
New River Gorge NR	Wadeable Stream	Camp Branch	1.74	4.20
New River Gorge NR	Wadeable Stream	Camp Creek	1.50	5.23
New River Gorge NR	Wadeable Stream	Coal Run	1.70	9.68
New River Gorge NR	Wadeable Stream	Craig Branch	2.06	3.13
New River Gorge NR	Wadeable Stream	Davis Branch	1.22	3.00
New River Gorge NR	Wadeable Stream	Dowdy Creek	3.23	6.52
New River Gorge NR	Wadeable Stream	Ephraim Creek	2.89	14.06
New River Gorge NR	Wadeable Stream	Fall Branch	2.38	20.28
New River Gorge NR	Wadeable Stream	Farleys Creek	3.53	16.85
New River Gorge NR	Wadeable Stream	Fern Creek	1.73	9.44
New River Gorge NR	Wadeable Stream	Fire Creek	2.00	4.06
New River Gorge NR	Wadeable Stream	Kates Branch (Glade)	2.30	4.33
New River Gorge NR	Wadeable Stream	Kates Branch (New)	1.92	3.72
New River Gorge NR	Wadeable Stream	Keeney Creek	1.99	23.14
New River Gorge NR	Wadeable Stream	Laurel Creek	7.31	71.08
New River Gorge NR	Wadeable Stream	(UNT Meadow Creek 42)	0.95	13.18
New River Gorge NR	Wadeable Stream	Little Laurel Creek	1.81	4.20
New River Gorge NR	Wadeable Stream	Manns Creek	2.89	39.00
New River Gorge NR	Wadeable Stream	Marr Branch	1.14	8.59
New River Gorge NR	Wadeable Stream	Meadow Creek	9.41	74.44
New River Gorge NR	Wadeable Stream	Meadow Fork	0.83	10.41
New River Gorge NR	Wadeable Stream	Mill Branch	1.20	2.68
New River Gorge NR	Wadeable Stream	Panther Branch	1.53	4.43
New River Gorge NR	Wadeable Stream	Pinch Creek	1.89	40.47
New River Gorge NR	Wadeable Stream	Polls Branch	1.70	4.93
New River Gorge NR	Wadeable Stream	Richlick Branch	1.73	3.17
New River Gorge NR	Wadeable Stream	River Branch	1.92	4.76
New River Gorge NR	Wadeable Stream	Second Fork	1.96	5.19
New River Gorge NR	Wadeable Stream	Sewell Branch	2.98	4.73
New River Gorge NR	Wadeable Stream	Short Creek	1.27	6.18
New River Gorge NR	Wadeable Stream	Slate Fork - Mill Creek	2.55	16.24
New River Gorge NR	Wadeable Stream	Slater Creek	3.55	8.08
New River Gorge NR	Wadeable Stream	UNT Arbuckle Creek	0.01	3.75

Table A.4 (continued). Park, size category, name, length in park (Length), and contributing area (Area) for flowing surface waters in the Eastern Rivers and Mountains Network. UNT = Unnamed tributary.

Park	Category	Name	Length (km)	Area (km^2)
New River Gorge NR	Wadeable Stream	UNT Buffalo Creek	0.61	2.40
New River Gorge NR	Wadeable Stream	UNT Coal Run	0.06	3.21
New River Gorge NR	Wadeable Stream	UNT Dunloup Creek	0.23	17.10
New River Gorge NR	Wadeable Stream	UNT Ephraim Creek	0.84	3.94
New River Gorge NR	Wadeable Stream	UNT Fall Branch	0.47	3.75
New River Gorge NR	Wadeable Stream	UNT Fall Branch 2	0.30	2.90
New River Gorge NR	Wadeable Stream	UNT Farleys Creek	0.05	2.00
New River Gorge NR	Wadeable Stream	UNT Laurel Creek	1.40	3.76
New River Gorge NR	Wadeable Stream	UNT Laurel Creek 2	0.19	2.03
New River Gorge NR	Wadeable Stream	UNT Laurel Creek 3	0.39	2.47
New River Gorge NR	Wadeable Stream	UNT Laurel Creek x	0.00	2.69
New River Gorge NR	Wadeable Stream	UNT Lefthand Fork Meadow Cr	0.56	3.49
New River Gorge NR	Wadeable Stream	UNT Manns Creek 1	0.83	8.15
New River Gorge NR	Wadeable Stream	UNT Manns Creek 2	1.14	4.21
New River Gorge NR	Wadeable Stream	UNT Manns Creek 3	0.17	3.16
New River Gorge NR	Wadeable Stream	UNT Manns Creek x	0.02	6.63
New River Gorge NR	Wadeable Stream	UNT Marr Branch	0.31	2.70
New River Gorge NR	Wadeable Stream	UNT Meadow Creek 22	0.76	3.16
New River Gorge NR	Wadeable Stream	UNT Meadow Creek 67	0.46	6.68
New River Gorge NR	Wadeable Stream	UNT Meadow Creek 87	0.18	9.76
New River Gorge NR	Wadeable Stream	UNT New River 21	0.76	3.36
New River Gorge NR	Wadeable Stream	UNT New River 26	1.02	6.61
New River Gorge NR	Wadeable Stream	UNT New River 29	1.74	4.17
New River Gorge NR	Wadeable Stream	UNT New River 30	0.83	3.37
New River Gorge NR	Wadeable Stream	UNT New River 36	0.63	3.58
New River Gorge NR	Wadeable Stream	UNT New River 42	0.68	2.93
New River Gorge NR	Wadeable Stream	UNT New River 52	1.36	4.39
New River Gorge NR	Wadeable Stream	UNT New River 55	0.21	47.19
New River Gorge NR	Wadeable Stream	UNT New River 60	0.28	6.19
New River Gorge NR	Wadeable Stream	UNT New River 61	0.28	12.20
New River Gorge NR	Wadeable Stream	UNT New River 63	0.07	8.16
New River Gorge NR	Wadeable Stream	UNT New River 9	0.27	3.16
New River Gorge NR	Wadeable Stream	UNT Pinch Creek	0.31	2.77
New River Gorge NR	Wadeable Stream	UNT Piney Creek	0.65	2.21
New River Gorge NR	Wadeable Stream	UNT Slate Fork - Mill Creek	0.02	3.07
New River Gorge NR	Wadeable Stream	UNT UNT Manns Creek 1	0.65	2.28

Table A.4 (continued). Park, size category, name, length in park (Length), and contributing area (Area) for flowing surface waters in the Eastern Rivers and Mountains Network. UNT = Unnamed tributary.

Park	Category	Name	Length (km)	Area (km^2)
New River Gorge NR	Wadeable Stream	UNT UNT New River 26	0.03	2.43
New River Gorge NR	Wadeable Stream	UNT Wolf Creek	0.65	6.14
New River Gorge NR	Wadeable Stream	White Oak Creek	0.03	21.12
New River Gorge NR	Wadeable Stream	Wolf Creek	3.82	44.36
Delaware Water Gap NRA	Large River	Delaware River	69.95	10212.85
Delaware Water Gap NRA	Small River	Bushkill Creek	4.99	409.30
Delaware Water Gap NRA	Small River	Flat Brook	19.32	170.82
Delaware Water Gap NRA	Wadeable Stream	Adams Creek	4.10	19.52
Delaware Water Gap NRA	Wadeable Stream	Caledonia Creek	1.59	2.59
Delaware Water Gap NRA	Wadeable Stream	Conashaugh Creek	2.27	5.40
Delaware Water Gap NRA	Wadeable Stream	Deckers Creek	0.82	2.58
Delaware Water Gap NRA	Wadeable Stream	Dingmans Creek	6.61	44.02
Delaware Water Gap NRA	Wadeable Stream	Dry Brook	1.37	3.22
Delaware Water Gap NRA	Wadeable Stream	Dunnfield Creek	6.34	9.86
Delaware Water Gap NRA	Wadeable Stream	Hornbecks Creek	3.78	23.81
Delaware Water Gap NRA	Wadeable Stream	Jacksonburg Creek	0.20	2.32
Delaware Water Gap NRA	Wadeable Stream	Kittatinny Creek	2.80	4.21
Delaware Water Gap NRA	Wadeable Stream	Little Bushkill Creek	2.37	86.55
Delaware Water Gap NRA	Wadeable Stream	Mill Creek	3.71	12.46
Delaware Water Gap NRA	Wadeable Stream	Raymondskill Creek	4.96	62.13
Delaware Water Gap NRA	Wadeable Stream	Sand Hill Creek	1.69	8.64
Delaware Water Gap NRA	Wadeable Stream	Slateford Creek	1.54	7.26
Delaware Water Gap NRA	Wadeable Stream	Spackmans Creek	1.41	2.97
Delaware Water Gap NRA	Wadeable Stream	Toms Creek	4.13	24.28
Delaware Water Gap NRA	Wadeable Stream	UNT Adams Creek	0.24	2.04
Delaware Water Gap NRA	Wadeable Stream	UNT Bushkill Creek	0.40	3.65
Delaware Water Gap NRA	Wadeable Stream	UNT Delaware River 210	0.76	2.15
Delaware Water Gap NRA	Wadeable Stream	UNT Delaware River 214.5	0.03	12.44
Delaware Water Gap NRA	Wadeable Stream	UNT Delaware River 242	0.64	3.90
Delaware Water Gap NRA	Wadeable Stream	UNT Delaware River 246.5	1.15	19.39
Delaware Water Gap NRA	Wadeable Stream	UNT Delaware River 247	0.97	63.61
Delaware Water Gap NRA	Wadeable Stream	UNT Delaware River 247.5	0.03	13.51
Delaware Water Gap NRA	Wadeable Stream	UNT Delaware River 248	1.09	2.73
Delaware Water Gap NRA	Wadeable Stream	UNT Delaware River 249	1.32	5.53
Delaware Water Gap NRA	Wadeable Stream	UNT Dingmans Creek	0.84	2.43
Delaware Water Gap NRA	Wadeable Stream	UNT Flat Brook	1.00	2.94
Delaware Water Gap NRA	Wadeable Stream	UNT Flat Brook 1	0.01	2.36
Delaware Water Gap NRA	Wadeable Stream	UNT Flat Brook 2	0.02	41.27
Delaware Water Gap NRA	Wadeable Stream	UNT Flat Brook 3	0.41	3.10
Delaware Water Gap NRA	Wadeable Stream	UNT Flat Brook 4	0.65	5.31

Table A.4 (continued). Park, size category, name, length in park (Length), and contributing area (Area) for flowing surface waters in the Eastern Rivers and Mountains Network. UNT = Unnamed tributary.

Park	Category	Name	Length (km)	Area (km^2)
Delaware Water Gap NRA	Wadeable Stream	UNT Toms Creek	0.72	2.47
Delaware Water Gap NRA	Wadeable Stream	UNT Toms Creek 2	0.34	3.40
Delaware Water Gap NRA	Wadeable Stream	UNT UNT Delaware River 247	0.00	0.00
Delaware Water Gap NRA	Wadeable Stream	UNT Vancampens Brook	0.55	2.21
Delaware Water Gap NRA	Wadeable Stream	UNT Vancampens Brook 1	0.16	2.02
Delaware Water Gap NRA	Wadeable Stream	Van Campen Creek	3.17	5.89
Delaware Water Gap NRA	Wadeable Stream	Vancampens Brook	13.20	23.97
Delaware Water Gap NRA	Wadeable Stream	White Brook	2.38	5.48
Delaware Water Gap NRA	Wadeable Stream	Yards Creek	0.81	2.44
Gauley River NRA	Medium River	Gauley River	42.12	3347.71
Gauley River NRA	Medium River	Meadow River	9.52	945.18
Gauley River NRA	Small River	Peters Creek	2.76	135.62
Gauley River NRA	Wadeable Stream	Bucklick Branch	0.64	3.37
Gauley River NRA	Wadeable Stream	Dogwood Creek	0.75	15.88
Gauley River NRA	Wadeable Stream	Hedricks Creek	0.53	12.74
Gauley River NRA	Wadeable Stream	Horseshoe Creek	1.49	11.48
Gauley River NRA	Wadeable Stream	Laurel Creek	1.27	12.16
Gauley River NRA	Wadeable Stream	Meadow Creek	1.82	18.53
Gauley River NRA	Wadeable Stream	Ramsey Branch	0.96	9.00
Gauley River NRA	Wadeable Stream	Sugar Creek	1.12	6.86
Gauley River NRA	Wadeable Stream	UNT Gauley River 22	0.26	16.73
Gauley River NRA	Wadeable Stream	UNT Gauley River 26	0.64	3.18
Gauley River NRA	Wadeable Stream	UNT Gauley River 27	1.16	4.44
Gauley River NRA	Wadeable Stream	UNT Gauley River 30	0.54	6.07
Gauley River NRA	Wadeable Stream	UNT Gauley River 31	0.31	6.81
Gauley River NRA	Wadeable Stream	UNT Gauley River 34	0.37	24.86
Gauley River NRA	Wadeable Stream	UNT Laurel Creek	0.03	5.01
Gauley River NRA	Wadeable Stream	UNT Meadow River 2	0.52	4.11
Gauley River NRA	Wadeable Stream	UNT Meadow River 3	0.25	2.86
Gauley River NRA	Wadeable Stream	UNT Meadow River 4	0.59	10.33
Gauley River NRA	Wadeable Stream	UNT Meadow River 5	0.58	2.21
Upper Delaware SRR	Large River	Delaware River	123.43	7989.18
Upper Delaware SRR	Medium River	East Branch	0.05	2188.29
Upper Delaware SRR	Medium River	West Branch	0.10	1735.11
Upper Delaware SRR	Medium River	Lackawaxen River	0.93	1557.39
Upper Delaware SRR	Medium River	Mongaup River	1.65	542.98
Upper Delaware SRR	Small River	Callicoon Creek	2.29	291.83
Upper Delaware SRR	Small River	Shohola Creek	0.54	224.31
Upper Delaware SRR	Small River	Equinunk Creek	0.72	150.16
Upper Delaware SRR	Small River	Tenmile River	1.04	127.06

Table A.4 (continued). Park, size category, name, length in park (Length), and contributing area (Area) for flowing surface waters in the Eastern Rivers and Mountains Network. UNT = Unnamed tributary.

Park	Category	Name	Length (km)	Area (km^2)
Upper Delaware SRR	Small River	Calkins Creek	0.76	114.73
Upper Delaware SRR	Wadeable Stream	Masthope Creek	1.30	80.85
Upper Delaware SRR	Wadeable Stream	Halfway Brook	1.26	73.69
Upper Delaware SRR	Wadeable Stream	Little Equinunk Creek	0.86	65.45
Upper Delaware SRR	Wadeable Stream	Beaver Brook	1.35	61.25
Upper Delaware SRR	Wadeable Stream	Basket Creek	0.91	58.73
Upper Delaware SRR	Wadeable Stream	Mill Brook	1.08	51.09
Upper Delaware SRR	Wadeable Stream	Hankins Creek	1.68	40.87
Upper Delaware SRR	Wadeable Stream	Shingle Kill	0.25	33.62
Upper Delaware SRR	Wadeable Stream	Twin Lakes Creek	0.63	29.88
Upper Delaware SRR	Wadeable Stream	Beaverdam Creek	0.42	27.68
Upper Delaware SRR	Wadeable Stream	Hollister Creek	1.12	24.67
Upper Delaware SRR	Wadeable Stream	Mitchell Pond Brook	1.17	20.98
Upper Delaware SRR	Wadeable Stream	Pond Eddy Creek	0.47	18.18
Upper Delaware SRR	Wadeable Stream	Pea Brook	1.80	16.71
Upper Delaware SRR	Wadeable Stream	Bush Kill	0.21	16.45
Upper Delaware SRR	Wadeable Stream	Bouchoux Brook	0.74	13.70
Upper Delaware SRR	Wadeable Stream	Hoolihan Brook	1.91	12.34
Upper Delaware SRR	Wadeable Stream	Westcoolang Creek	1.47	11.92
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 289.5	1.15	11.61
Upper Delaware SRR	Wadeable Stream	Factory Creek	1.29	11.09
Upper Delaware SRR	Wadeable Stream	Abe Lord Creek	1.07	10.90
Upper Delaware SRR	Wadeable Stream	Panther Creek	1.90	10.69
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 268	0.32	10.37
Upper Delaware SRR	Wadeable Stream	Grassy Swamp Brook	0.77	10.21
Upper Delaware SRR	Wadeable Stream	Fish Cabin Creek	1.02	9.62
Upper Delaware SRR	Wadeable Stream	Narrow Falls Brook	0.39	8.80
Upper Delaware SRR	Wadeable Stream	Cooley Creek	1.22	8.73
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 290	0.90	7.74
Upper Delaware SRR	Wadeable Stream	Humphries Brook	0.97	7.45
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 291	0.82	7.34
Upper Delaware SRR	Wadeable Stream	Stockport Creek	0.88	7.26
Upper Delaware SRR	Wadeable Stream	Weston Brook	1.42	6.50
Upper Delaware SRR	Wadeable Stream	Schoolhouse Creek	0.50	6.12
Upper Delaware SRR	Wadeable Stream	Peggy Run	0.77	5.72
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 275	1.31	5.71
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 324.5	1.09	5.31
Upper Delaware SRR	Wadeable Stream	Blue Mill Stream	1.39	4.97
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 301.5	1.23	4.79
Upper Delaware SRR	Wadeable Stream	UNT UNT Del River 268	0.89	4.68

Table A.4 (continued). Park, size category, name, length in park (Length), and contributing area (Area) for flowing surface waters in the Eastern Rivers and Mountains Network. UNT = Unnamed tributary.

Park	Category	Name	Length (km)	Area (km^2)
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 293	0.96	4.21
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 277	0.87	4.05
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 328	1.14	3.75
Upper Delaware SRR	Wadeable Stream	UNT Halfway Brook	1.19	3.57
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 300	1.25	3.51
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 301	1.21	3.44
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 306	1.01	3.29
Upper Delaware SRR	Wadeable Stream	UNT Narrow Falls Brook	0.25	3.19
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 304	0.34	2.96
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 327.5	1.11	2.71
Upper Delaware SRR	Wadeable Stream	UNT Peggy Run	0.03	2.61
Upper Delaware SRR	Wadeable Stream	UNT Basket Creek	0.17	2.55
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 263	0.49	2.21
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 276	0.23	2.14
Upper Delaware SRR	Wadeable Stream	UNT Westcoolang Creek	0.46	2.12
Upper Delaware SRR	Wadeable Stream	UNT Grassy Swamp Brook	0.18	2.12
Upper Delaware SRR	Wadeable Stream	UNT Pea Brook	0.30	2.12
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 323	0.29	2.05
Upper Delaware SRR	Wadeable Stream	UNT Delaware River 318	0.03	2.03
Bluestone NSR	Medium River	Bluestone River	18.50	1139.45
Bluestone NSR	Wadeable Stream	Little Bluestone River	2.48	87.51
Bluestone NSR	Wadeable Stream	UNT Bluestone River 4	0.25	2.96
Bluestone NSR	Wadeable Stream	UNT Bluestone River 5	1.01	3.62
Bluestone NSR	Wadeable Stream	Jarrell Branch	0.27	2.08
Bluestone NSR	Wadeable Stream	Mountain Creek	0.87	58.30
Bluestone NSR	Wadeable Stream	Indian Branch	1.31	4.87
Allegheny Portage Railroad NHS	Wadeable Stream	Blair Gap Run	2.09	43.26
Allegheny Portage Railroad NHS	Wadeable Stream	Blair Run	0.22	17.04
Allegheny Portage Railroad NHS	Wadeable Stream	Millstone Run	1.37	4.91
Johnstown Flood NMem	Small River	SFLCR	0.92	136.41
Johnstown Flood NMem	Wadeable Stream	UNT SFLCR	0.08	6.72
Fort Necessity NB	Wadeable Stream	UNT Braddock Run	0.11	1.13
Fort Necessity NB	Wadeable Stream	Great Meadows Run	1.62	4.23
Fort Necessity NB	Wadeable Stream	UNT Great Meadows Run	0.60	1.54
Friendship Hill NHS	Wadeable Stream	Dublin Run	0.17	1.11
Friendship Hill NHS	Wadeable Stream	Ice Pond Run	1.07	1.30

Table A.5. Watershed sizes used to define our size categories of river and stream found within the nine parks of the Eastern Rivers and Mountains Network.

Size Category	Watershed Size (km2)
Large River	5,000 - 20,000
Medium River	500 - 5,000
Small River	100 - 500
Wadeable Stream	2 - 100

Table A.6. Size category, name, park, contributing area (Area; km^2), length in park (Length; km), and relevant monitoring protocol for flowing surface waters in the Eastern Rivers and Mountains Network.

Category	Name	Park	Area	Length	Protocol
Large River	New River	New River Gorge NR	17,815	90.4	River
	Delaware River	Delaware Water Gap NRA	10,213	69.9	
	Delaware River	Upper Delaware SRR	7,989	123.4	
Medium River	Gauley River	Gauley River NRA	3,347	42.1	River
	E.[1] Branch Delaware River	Upper Delaware SRR	2,188	<0.1	
	W.[2] Branch Delaware River	Upper Delaware SRR	1,735	0.1	
	Lackawaxen River	Upper Delaware SRR	1,557	0.9	
	Bluestone River	Bluestone NSR	1,139	18.5	
	Meadow River	Gauley River NRA	945	9.5	
	Brodhead Creek	Delaware Water Gap NRA	670	<0.1	
	Mongaup River	Upper Delaware SRR	543	1.7	
Small River	Bushkill Creek	Delaware Water Gap NRA	409	4.9	River
	Piney Creek	New River Gorge NR	352	1.3	
	Callicoon Creek	Upper Delaware SRR	292	2.3	
	Shohola Creek	Upper Delaware SRR	224	0.5	
	Flat Brook	Delaware Water Gap NRA	171	19.3	
	Glade Creek	New River Gorge NR	164	9.9	
	Manns Creek	New River Gorge NR	151	9.1	
	Equinunk Creek	Upper Delaware SRR	150	0.7	
	SFLCR[3]	Johnstown Flood NMem	136	0.9	
	Peters Creek	Gauley River NRA	136	2.7	
	Tenmile River	Upper Delaware SRR	127	1.0	
	Dunloup Creek	New River Gorge NR	125	6.5	
	Calkins Creek	Upper Delaware SRR	115	0.8	
	Lick Creek	New River Gorge NR	101	1.3	

[1] East
[2] West
[3] South Fork Little Conemaugh River
[4] Typically this criterion was 2 km^2 but it was relaxed to 1 km^2 at Fort Necessity NB and Friendship Hill NHS

Table A.6 (continued). Size category, name, park, contributing area (Area; km^2), length in park (Length; km), and relevant monitoring protocol for flowing surface waters in the Eastern Rivers and Mountains Network.

Category	Name	Park	Area	Length	Protocol
Wadeable Stream	see below	New River Gorge NR	≥ 2	112.3	Benthic Macro and Streamside Bird
	see below	Delaware Water Gap NRA	≥ 2	80.6	
	see below	Gauley River NRA	≥ 2	13.8	
	see below	Bluestone NSR	≥ 2	6.2	
	see below	Allegheny Portage Railroad NHS	≥ 2	3.7	
	see below	Johnstown Flood NMem	≥ 2	<0.1	
	see below	Fort Necessity NB	≥ 1	2.3	
	see below	Friendship Hill NHS	≥ 1	1.2	
Ephemeral Stream			<1 or[4] <2		Not sampled

[1] East
[2] West
[3] South Fork Little Conemaugh River
[4] Typically this criterion was 2 km^2 but it was relaxed to 1 km^2 at Fort Necessity NB and Friendship Hill NHS

Table A.7. Floodplain input files and products of the Eastern Rivers and Mountains Network wadeable stream sampling frame. Special Flood Hazard Areas contained in Digital Flood Insurance Rate Maps (DFIRM) from the Federal Emergency Management Agency were equivalent to the "100 year" floodplain – these areas were used eliminate wadeable stream sections from the sampling frame due to the transitional character of resident biological communities.

Park	File Type	Files
Delaware Water Gap NRA	Input Files	**S_Fld_Har_Ar.shp** - This inundation layer developed by DCS Hydraulics (2010) delineated the 100 yr (and 500 yr floodplains) using LiDAR collected in 2008. This layer (100 yr) was favored over the DFIRM layer for DEWA.
		DFIRM County Layers: Pennsylvania – Monroe Co. (5/2/2013); Northampton Co. (4/6/2001); Pike Co. (4/6/2001)
		New Jersey – Sussex (9/20/2011); Warren (9/20/2011)
	Final Product	**DEWA_DFIRM_FEMA_100YEAR.shp**
Gauley River NRA and New River Gorge NR	Input Files	**DFIRM County Layers**: Fayette (9/30/2010); Mercer (3/02/2005) Nicholas (7/04/2011); Raleigh (9/29/2006); Summers (2/03/2010)
	Final Product	**WVParks_DFIRM_FEMA_100YEAR.shp**

Table A.8. Initial wadeable stream length (Initial) and stream length removed for each of four criteria (< 400 m, Boundary Meanders, Remainders <100 m, and River floodplain) resulting in the total wadeable stream length included in the final sampling frame (Final). All lengths are kilometers (km).

Park	Initial	Segments <400m	Boundary Meanders	Remainders <100m	Floodplains	Final
Delaware Water Gap NRA	80.6	1.0	0.3	1.2	17.4	60.7
Gauley River NRA	13.8	1.6	0.0	0.5	0.8	10.9
New River Gorge NR	112.3	2.1	3.0	2.8	3.6	100.8

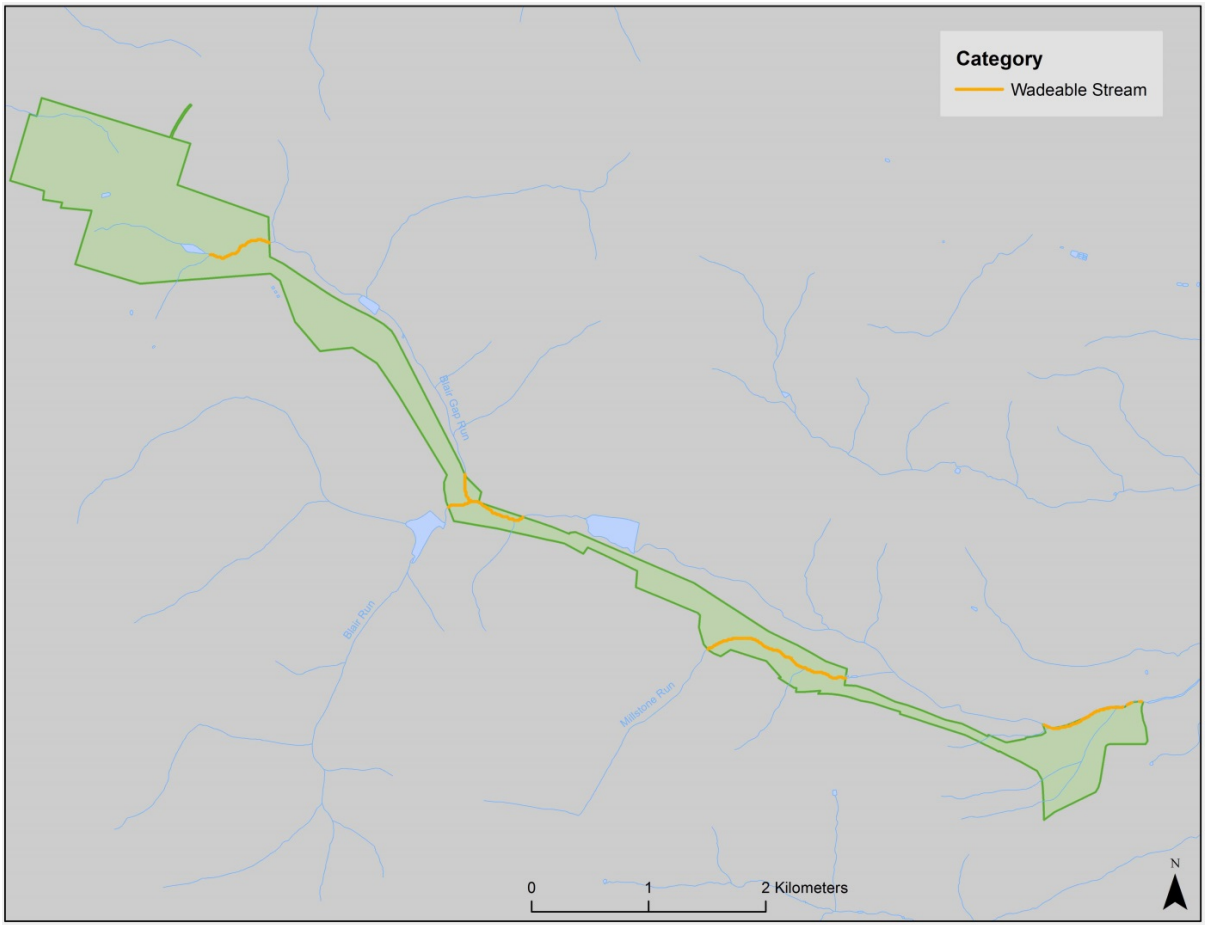

Figure A.1. Allegheny Portage Railroad NHS Wadeable Streams.

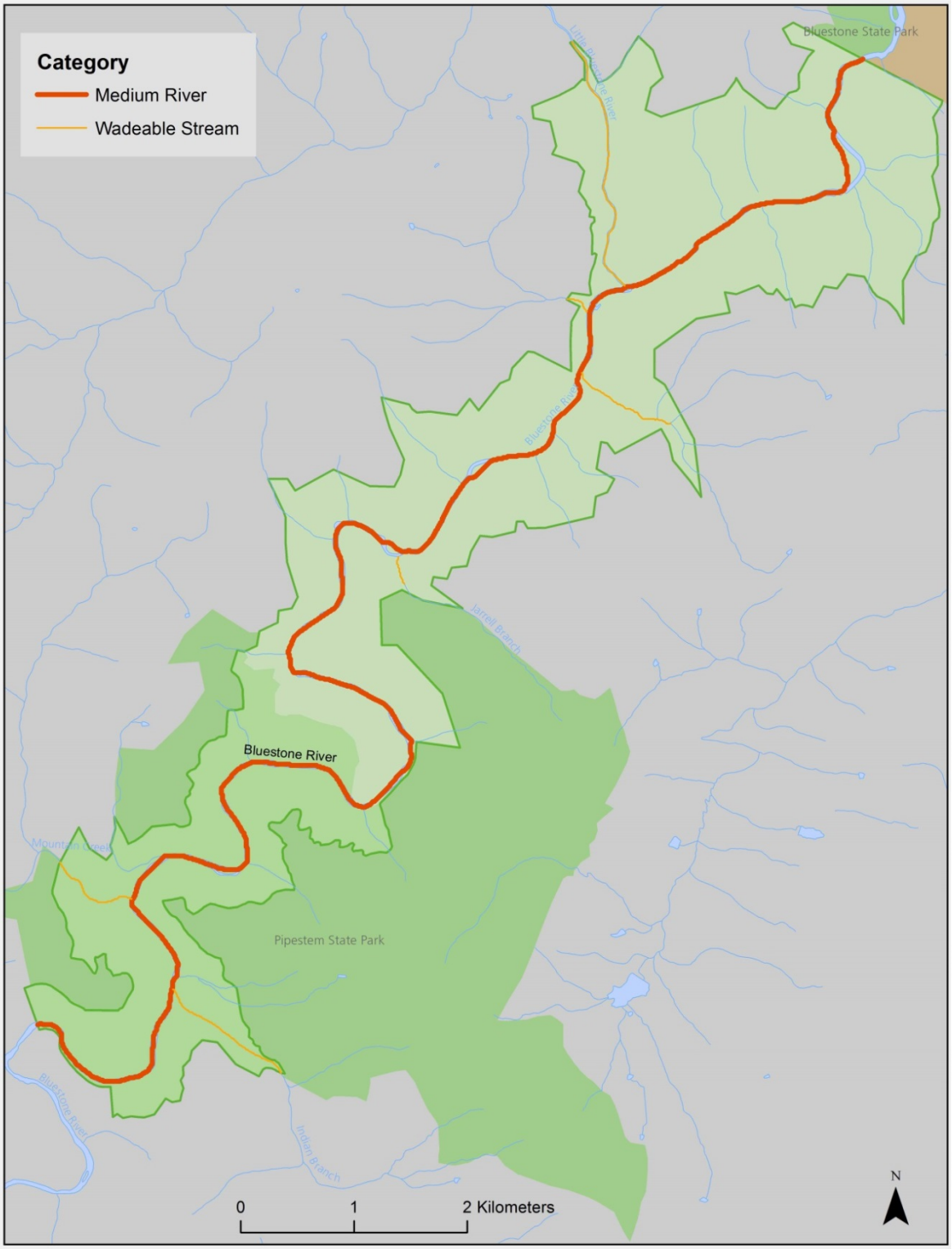

Figure A.2. Medium Rivers and Wadeable Streams at Bluestone NSR.

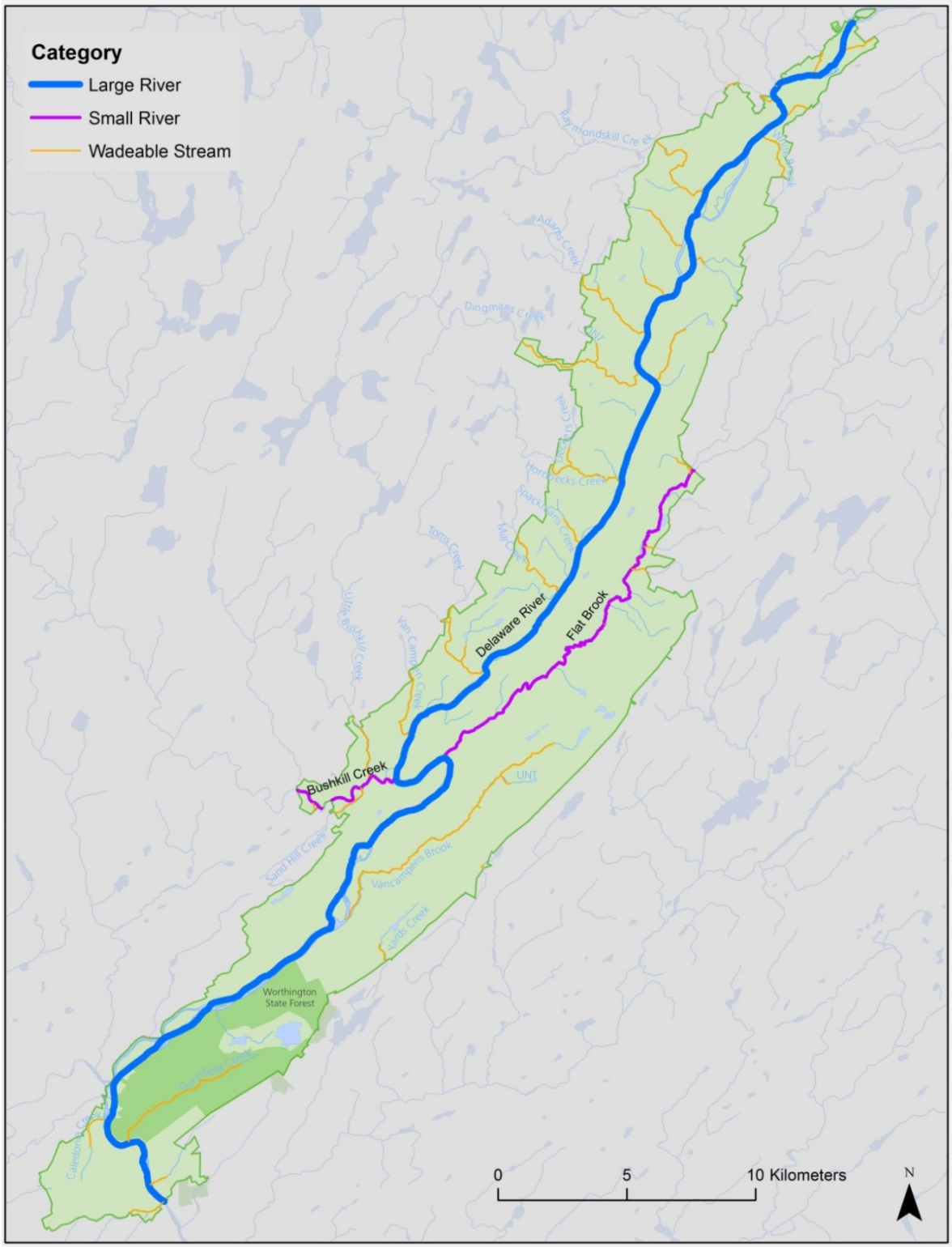

Figure A.3. Large Rivers, Small Rivers, and Wadeable Streams at Delaware Water Gap NRA.

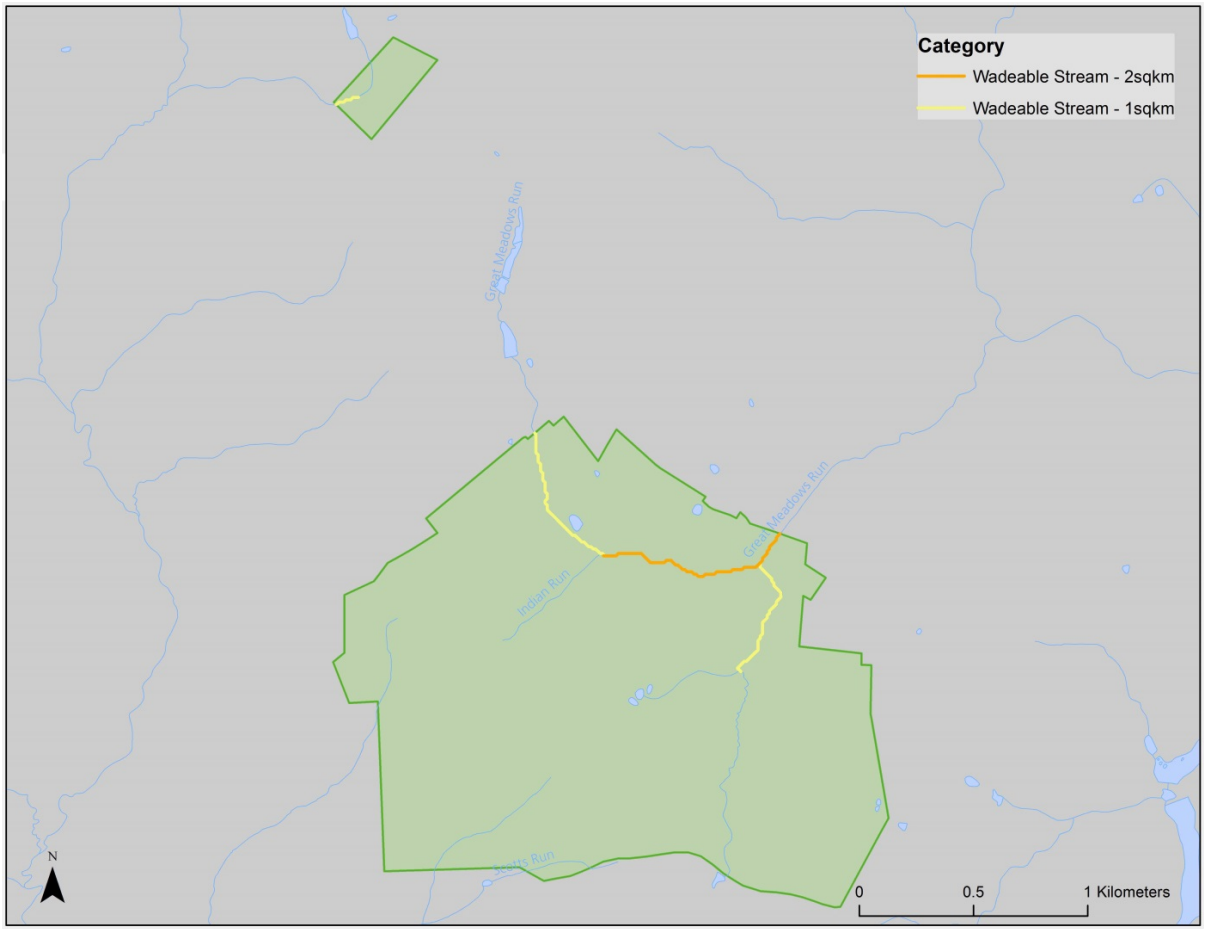

Figure A.4. All perennial, flowing surface waters of Fort Necessity NB were categorized as Wadeable Streams. The 2.0 km2 minimum watershed area criterion only delineated a “stream” along a short section of Great Meadows Run so it was instead set to 1.0 km2 so that the limited amount of surface water at the park could be delineated and sampled.

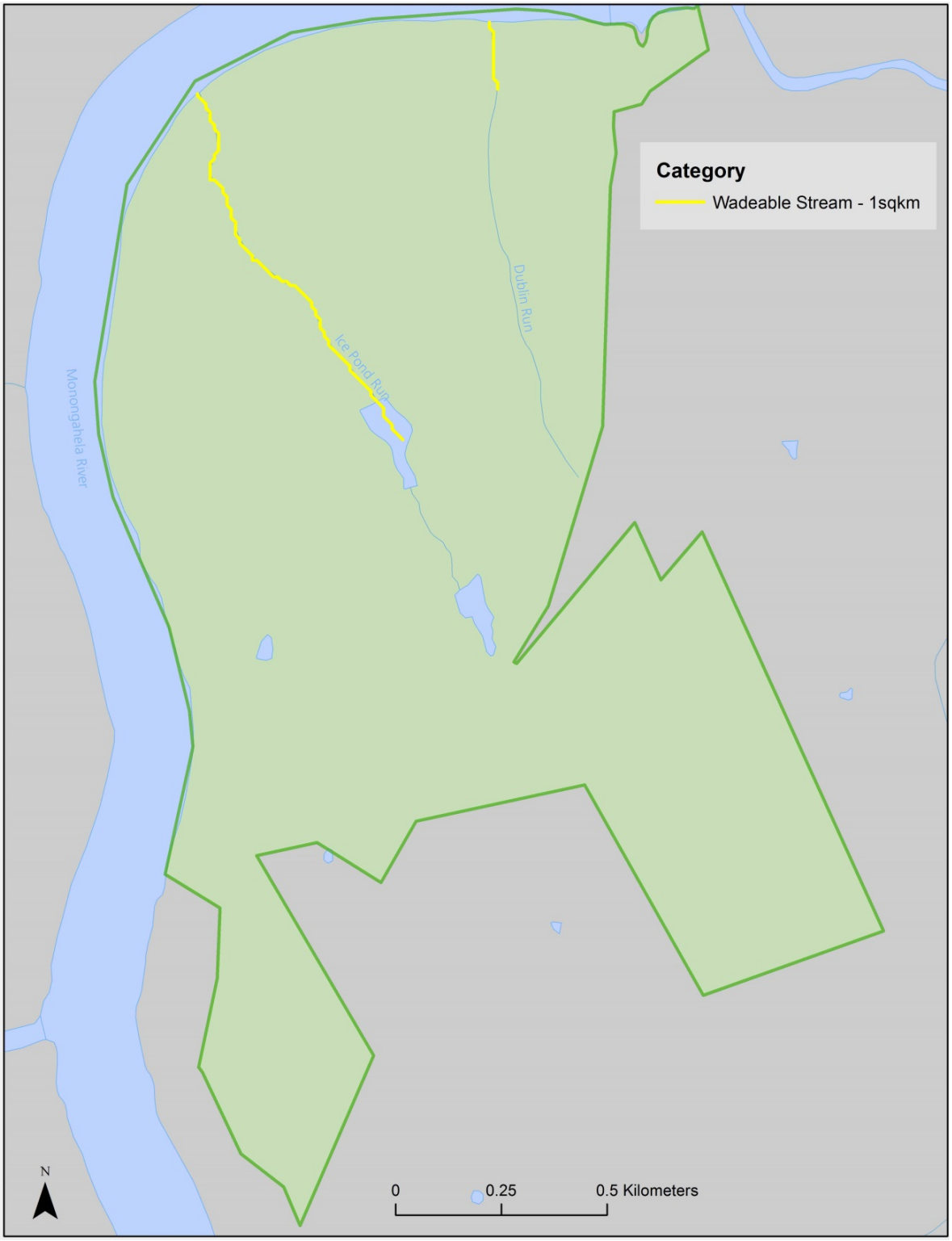

Figure A.5. All flowing surface waters of Friendship Hill NHS were categorized as Wadeable Streams. The 2.0 km^2 minimum watershed area criterion was relaxed to 1.0 km^2 in an effort to delineate (and sample) the limited amount of surface water at the park.

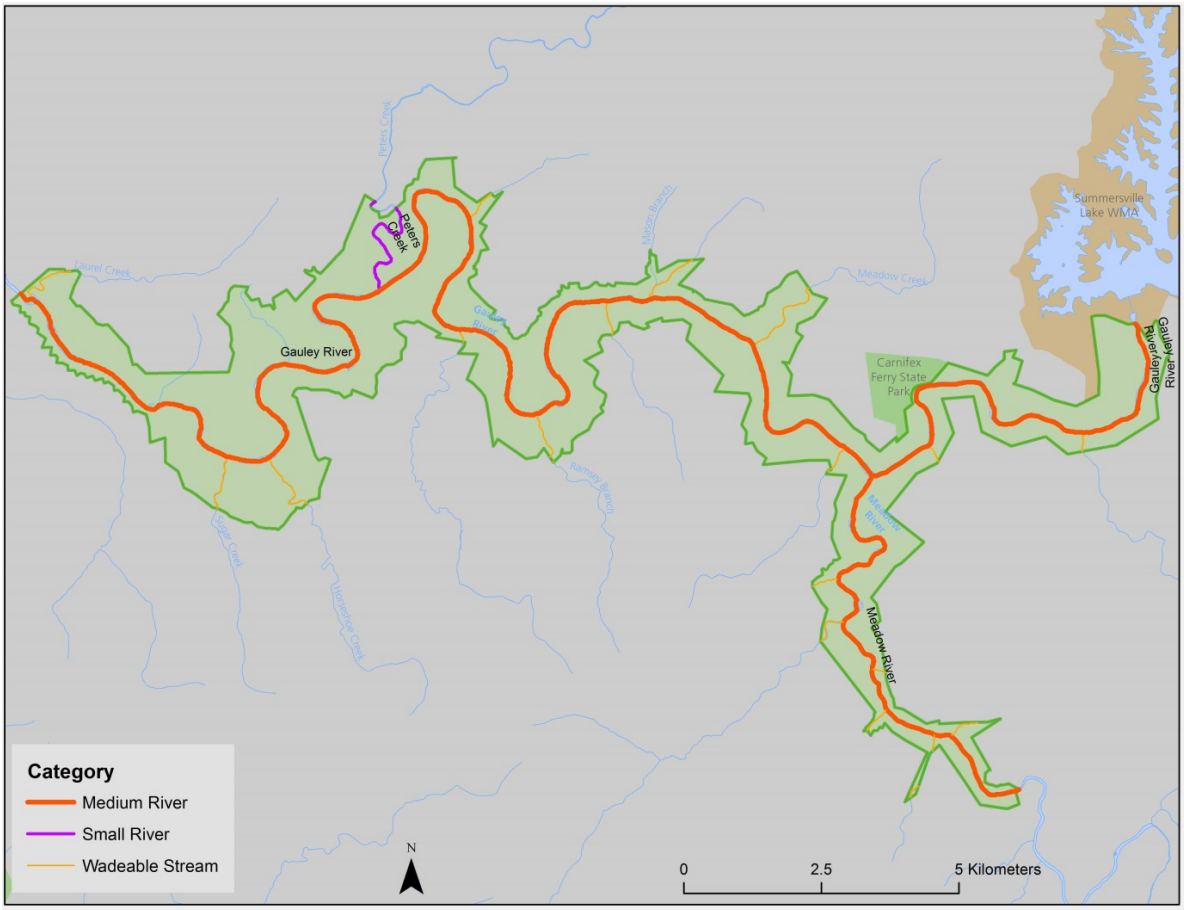

Figure A.6. Flowing surface waters at Gauley River NRA, categorized into Medium Rivers, Small Rivers, and Wadeable Streams.

Figure A.7. Flowing surface waters of Johnstown Flood NMem categorized into Small Rivers and Wadeable Streams.

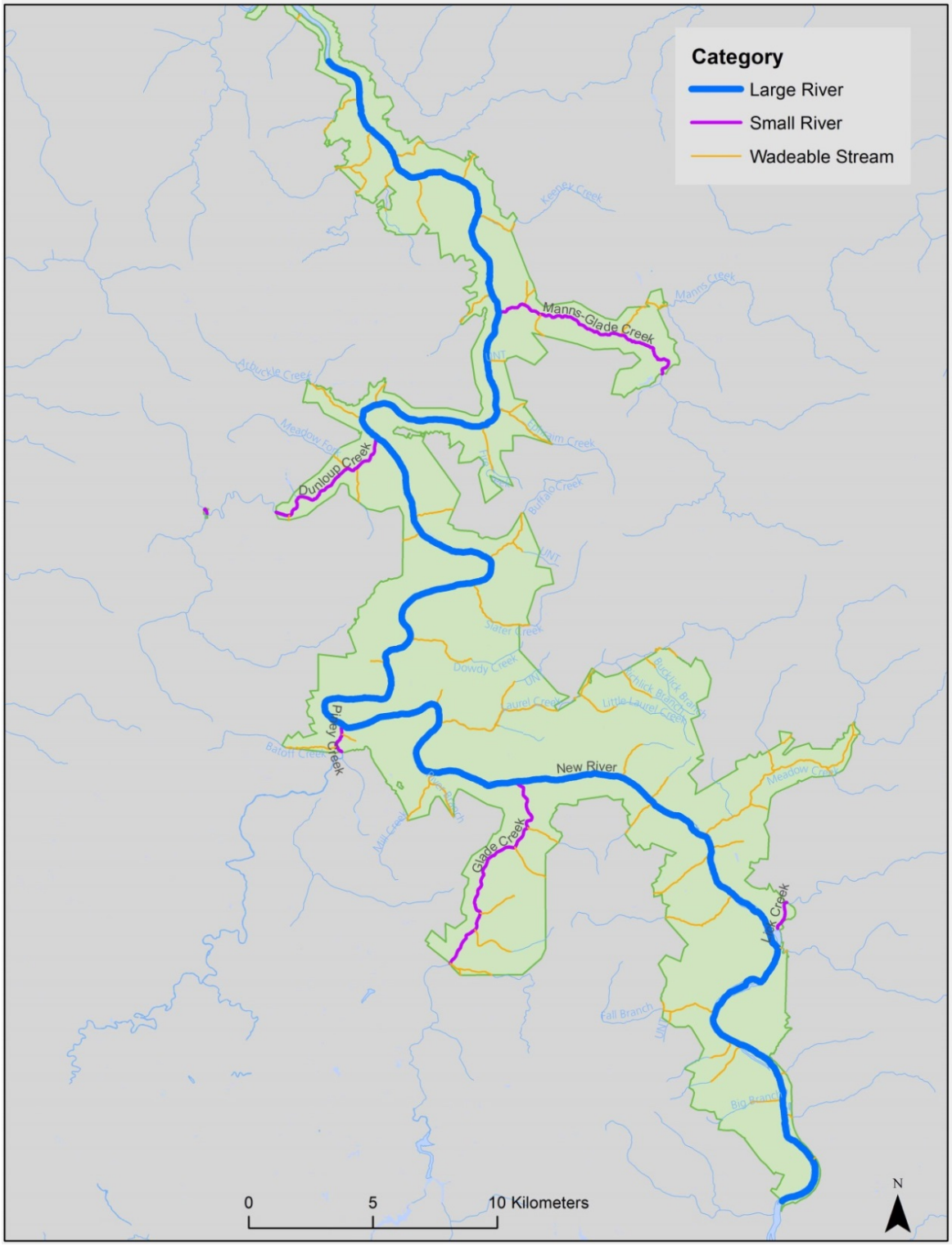

Figure A.8. Flowing surface waters at New River Gorge NR categorized into Large Rivers, Small Rivers, and Wadeable Streams.

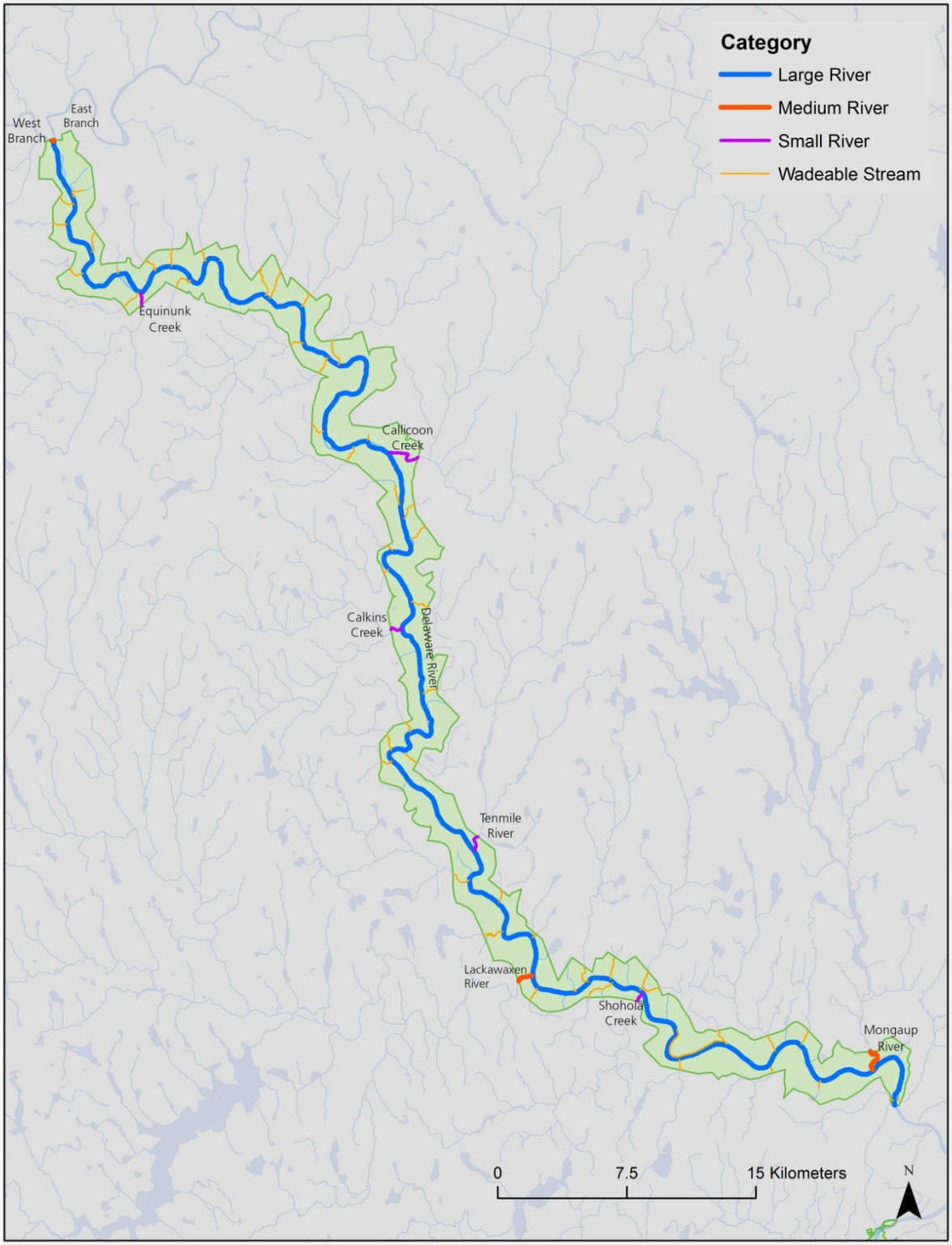

Figure A.9. Flowing surface waters of Upper Delaware SRR categorized into Large Rivers, Medium Rivers, Small Rivers, and Wadeable Streams.

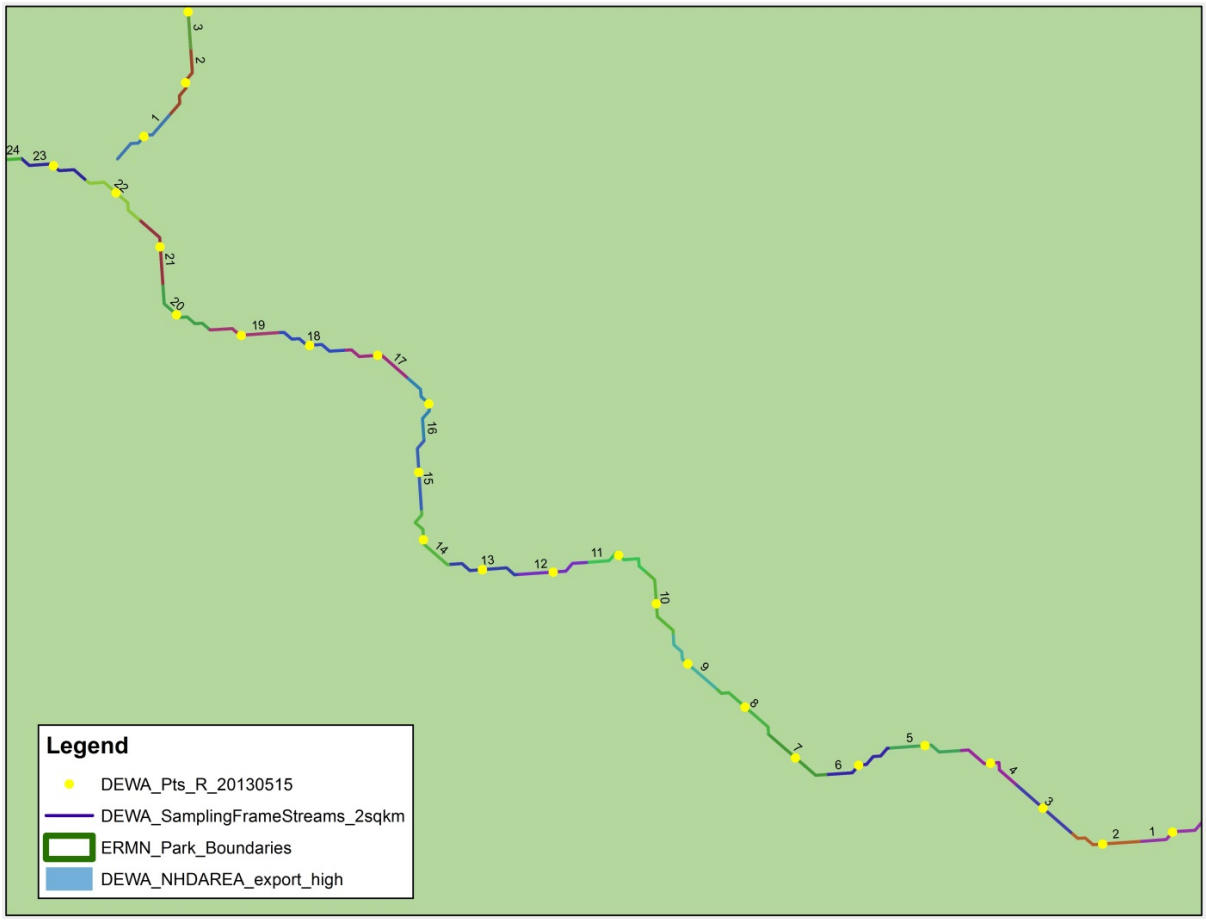

Figure A.10. Wadeable stream section at Delaware Water Gap NRA. The center points (yellow points) of 100 m stream segments (color coded) defined the sampling frame for the Benthic Macroinvertebrate Monitoring and Streamside Bird Monitoring protocols.

Appendix B: Site Selection at New River Gorge NR, Gauley River NRA, and Delaware Water Gap NRA

Overview

This appendix describes the site selection process used at New River Gorge NR, Gauley River NRA, and Delaware Water Gap NRA. Due to the relatively large size of those parks and the cumulative length of streams they contain, only a subset of the many 100 m stream reaches could be sampled. Consequently, a probability based design was used to ensure unbiased and statistically rigorous inferences regarding stream areas that were not sampled but were part of the wadeable stream sampling frame.

Spatially Balanced Sampling Background

Our approach to site selection was guided by the notion of parsimony – the design should be as straightforward as possible while meeting program objectives. A monitoring program should: (1) be easy to implement and maintain, (2) allow for a broad range of analyses (including those that are unforeseen at implementation), (3) remain understandable when program personnel change, and (4) engender support among stakeholders. Moreover, because the sampling design described here is for two wadeable stream-based protocols (benthic macroinvertebrates and streamside birds) and each protocol has multiple objectives with a corresponding array of response variables, the design could not focus on optimizing a single metric or objective because a design that is optimal for one metric is likely to be suboptimal for others. Simple random sampling is an approach that meets these considerations while providing an objective assessment of the sampled area (Thompson 2002, McDonald 2012). Simple random sampling is well-known and mathematically straight forward with established statistical properties. However, it suffers from the fact that it does not guarantee uniform spatial coverage of the area of interest. It is possible for significant "clumps", and corresponding "holes", to develop in the spatial coverage of simple random samples.

McDonald (2012) and Olsen et al. (2012) contrast several designs that ensure good ("balanced") spatial coverage and emphasize these designs work well for environmental monitoring because spatial variation is often one of the largest sources of variation in these types of efforts (the other large source is temporal variation). Moreover, these authors argue that when a spatially balanced sample is displayed graphically, viewers are more likely to accept the sample as being representative – and therefore more likely to accept the value of the estimates of status or trend resulting from the sample. The ERMN, along with many other networks (Fancy and Bennetts 2012), elected to use a spatially explicit sampling design (a generalized random tessellation stratified [GRTS] design; Stevens and Olsen [2004]) to select BMI and Streamside Bird sampling sites at Delaware Water Gap NRA, Gauley River NRA, and New River Gorge NR.

The GRTS approach is more complex than simple random sampling; however, we used the most basic GRTS algorithm (i.e., unstratified, equal inclusion probability) to ensure spatial balance while explicitly avoiding complexity that would need to be carried through to all subsequent analyses. While there are variance and other estimators specifically for GRTS designs (Stevens and Olsen 2004) this approach does not preclude other estimation and analysis approaches which assume simple

random sampling (Olsen et al. 2012; page 133) such as occupancy modeling (MacKenzie et al. 2006).

The GRTS technique uses reverse hierarchical ordering to map two-dimensional space (e.g., 100 m segments of the ERMN wadeable stream sampling frame [Appendix A]) into one-dimensional space, by giving each reach an ordered spatial address (e.g., coordinates of 100 m stream segment midpoints). Addresses are randomly ordered in a way that systematic sampling of the addresses results in a spatially balanced random sample (McDonald 2004; Stevens and Olsen 2004). That is, there is a generally uniform dispersion of selected sampling sites over the area of interest (sampling frame). In practice, the GRTS technique produces an ordered list of potential sample sites where any consecutive series of sites in the list is approximately spatially balanced. Sample sites are selected by proceeding down the ordered list until sufficient sites are included to meet program objectives.

This approach allows for a flexible sample size, such that sites at the "end" of the list can be added to, or excluded from, the sampling plan while maintaining spatial balance and without compromising overall design integrity (e.g., if sites are added or removed due to funding changes). Any subset of the ordered list has the same properties as the complete list so that consecutive subsets can also be used to define panels, for example. Note that if panels are used (as in this protocol), each panel is a spatially balanced sample for the population allowing status estimates for each time period as well as trend and change estimates across and between time periods (Olsen et al. 2012).

Random Site Selection Process

The software implementation of the GRTS algorithm [*function grts ()*] is available in the *spsurvey* package (Kincaid and Olsen 2012) developed for the R statistical software (R Development Core Team 2012). The *spsurvey* package is available on the R website (http://cran.r-project.org/web/packages/spsurvey/) including a relevant example application with R code of an unstratified, equal probability design for a finite, linear resource (i.e., http://cran.r-project.org/web/packages/spsurvey/vignettes/Finite_Design.pdf).

The implementation required the sample frame to be prepared and imported into R as an ESRI shapefile. The sampling frame in each park was divided into discrete 100 m sampling units (Appendix A) – there were 607, 109, and 1008 units for Delaware Water Gap NRA, Gauley River NRA, and New River Gorge NR, respectively. The R code for each park (Tables B.1 – B.3) draws 256 candidate sites from the total population (64 sites for GARI) and returns them as a new shapefile in the same projection (UTM) as the input shapefile. The output file contains a unique attribute (e.g., DEWA-001 through DEWA-256) for each site to identify its order in the spatially balanced list as well as the inclusion probability (i.e., weighting factor) for each site (specified to be equal for all sites) [1].

---

[1] Final shapefiles were named DEWA_Pts_R_20130515 (Delaware Water Gap NRA) and NERI_Pts_R_20130515

GARI_Pts_R_20150302 (New River Gorge NR)

Table B.1. R code used to select sites at Delaware Water Gap NRA using the GRTS function.

R-code Used

```
#Delaware Water Gap NRA GRTS Draw May 15, 2013. Unstratified, equal probability,
with spatial balance. Floodplain and small rivers excluded. Flow accumulation
equals 2 square kilometers.
#Load the spsurvey package
library(spsurvey)
#Read the attribute table from the shapefile
att<- read.dbf("DEWA_for_R_20130515")
#Display the initial six lines of the attribute data frame
head(att)
#Create the design list. One panel with 256 sites.
Equaldsgn <- list(None=list(panel=c(Panel1=256), seltype="Equal"))

#Generate random seed
zz <- round(runif(1)*1000000)
print(zz)
#Call the set.seed function so the draw is reproducible
#manually paste zz into set.seed below, then save $ run
set.seed(876467) # arbitrary digits

#Select the sample using GRTS.
DEWA.Sites<- grts(design=Equaldsgn,
       DesignID="DEWA",
       type.frame="finite",
       src.frame="shapefile",
       in.shape="DEWA_for_R_20130515",
       att.frame=att,
       shapefile=TRUE,
       out.shape="DEWA_from_R_20130515",
       prj="DEWA_for_R_20130515")
```

Table B.2. R code used to select sites at Gauley River NRA using the GRTS function.

R-code Used

```
#Gauley River NRA GRTS Draw March 16, 2015. Unstratified, equal probability, with
spatial balance. Floodplain and small rivers excluded. Flow accumulation equals 2
square kilometers.
#Load the spsurvey package
library(spsurvey)
#Read the attribute table from the shapefile
att<- read.dbf("GARI_for_R_20150302")
#Display the initial six lines of the attribute data frame
head(att)
#Create the design list. One panel with 64 sites.
Equaldsgn <- list(None=list(panel=c(Panel1=64), seltype="Equal"))

#Generate random seed
zz <- round(runif(1)*1000000)
print(zz)
#Call the set.seed function so the draw is reproducible
#manually paste zz into set.seed below, then save $ run
set.seed(263909) # arbitrary digits

#Select the sample using GRTS.
GARI.Sites<- grts(design=Equaldsgn,
       DesignID="GARI",
       type.frame="finite",
       src.frame="shapefile",
       in.shape="GARI_for_R_20150302",
       att.frame=att,
       shapefile=TRUE,
       out.shape="GARI_from_R_20150316",
       prj="GARI_for_R_20150302")
```

Table B.3. R code used to select sites at New River Gorge NR using the GRTS function.

R-code Used

```
#New River Gorge NR GRTS Draw May 15, 2013. Unstratified, equal probability, with
spatial balance.
#Floodplain and small rivers excluded.
#Flow accumulation equals 2 square kilometers.
#Load the spsurvey package
library(spsurvey)
#Read the attribute table from the shapefile
att<- read.dbf("NERI_for_R_20130515")
#Display the initial six lines of the attribute data frame
head(att)
#Create the design list. One panel with 256 sites.
Equaldsgn <- list(None=list(panel=c(Panel1=256), seltype="Equal"))


#Generate random seed
zz <- round(runif(1)*1000000)
print(zz)
#Call the set.seed function so the draw is reproducible
#manually paste zz into set.seed below, then save $ run
set.seed(807182) # arbitrary digits


#Select the sample using GRTS.
NERI.Sites<- grts(design=Equaldsgn,
       DesignID="NERI",
       type.frame="finite",
       src.frame="shapefile",
       in.shape="NERI_for_R_20130515",
       att.frame=att,
       shapefile=TRUE,
       out.shape="NERI_from_R_20130515",
       prj="NERI_for_R_20130515"
```

ERMN staff then evaluated each site (in order, beginning with DEWA-001 and NERI-001, respectively) for inclusion until 68 sites were included (32 sites at Delaware Water Gap NRA and 36 sites at New River Gorge NR; more at the latter due to greater total wadeable stream length). The number of sampling sites chosen was based on prior experience, available funding, and logistical constraints (as outlined in the protocol narrative), as well as statistical evaluation of the design's ability to meet program objectives (fully described in Appendix C).

Note that site selection for Gauley River NRA will occur when sufficient land has been acquired by NPS to initiate monitoring.

Site evaluation criteria included public (i.e., NPS) ownership, access, safety, and suitable habitat. Public ownership was evaluated with GIS using the most recent property ownership maps provided by park staff. Sites located on property not owned by the NPS were not permanently excluded but were instead held in a "dormant" state because it is conceivable that these sites might become sampleable if the NPS purchases the parcel. The protocol lead and data manager will contact park

staff every two years for updated parcel ownership maps. Sampling will be initiated at “dormant” sites that come under NPS ownership.

Despite the substantial familiarity of the parks and sites acquired by ERMN staff from 2007 through 2012, assessing “safety” and “suitable habitat” was difficult compared to determining land ownership and could not be done entirely using a GIS. Ideally, complete knowledge of the “habitat” or “safety” features of all sites would have been known, which would have allowed us to exclude inappropriate sites from the sampling frame a priori, but this was not possible. Instead, all potential sites on NPS land remained in the sampling frame and were available to be selected. After the draw of 256 sites, we first used available imagery, digital elevation models, terrain features, trail and road access, and personal experience to exclude many sites due to safety considerations. Field visits were then conducted to evaluate all remaining sites first hand in the spring of 2013 and 2014.

Two teams, each with two experienced ERMN employees, visited each site to assess safety considerations. Teams jointly made determinations as to whether sites should be included. Simultaneously, sites were assessed to ensure that the intended target stream habitat (riffles with abundant cobble) was present (Figure B.1) to align with the benthic macroinvertebrate sampling procedures. Although rare, habitat at some sites at both parks was atypical (e.g., boggy, sandy bottom, slow moving or solid bedrock “chutes”; Figure B.2); consequently, those sites were excluded from the sampling frame.

Figure B.1. Section of Toms Creek (Delaware Water Gap NRA) depicting typical riffle-cobble habitat included in Eastern Rivers and Mountains Network wadeable stream protocols.

Figure B.2. Section of Polls Branch (New River Gorge NR) depicting boggy, slow moving, sandy bottom habitat not included in Eastern Rivers and Mountains Network wadeable stream protocols.

We evaluated 39 sites (Table B.4) to reach the target of 32 sites at Delaware Water Gap NRA (Table B.5). Three of the evaluated sites are "dormant", including two on private inholdings and one that is "in" a small, man-made impoundment. This site will be sampled in the future if it is restored to a "stream" condition. Four sites were excluded due to inappropriate habitat and no sites were excluded due to safety. After the 32 sites were finalized, two sampling panels were created by assigning the first 16 sites in the list to "Panel 1" (even years, first sampled in 2014) and the second 16 sites to "Panel 2" (odd years, first sampled in 2015). Should all three currently dormant sites become active, two will be included in Panel 1 and one will be included in Panel 2.

We evaluated 85 sites at New River Gorge NR (Table B.6) to reach the target of 36 sites (Table B.7). Sixteen sites are "dormant" on private inholdings and 8 sites were excluded because they were inaccessible either due to unsafe conditions or private land that limited safe access. Due to steepness of the gorge and other areas of the park, an additional 20 sites had to be excluded based solely on unsafe conditions. Five sites were excluded due to inappropriate habitat (e.g., sandy-bottomed wetlands). After the 36 sites were finalized, two sampling panels were created by assigning the first 18 sites in the list to "Panel 1" (even years, first sampled in 2014) and the second 18 sites to "Panel 2" (odd years, first sampled in 2015). Should all 16 currently dormant sites become active, eight would be included in each sampling panel.

Table B.4. Unique generalized random tessellation stratified (GRTS) design identifier (ID), site name, sampling status, and Universal Transverse Mercator coordinates for 39 sampling sites evaluated at Delaware Water Gap NRA. Numbers in “Site Name” denote hectometers (100 m units) upstream from stream mouths (confluence with larger stream) or outpour point crossing park boundary.

GRTS_ID	Site Name	Status	UTM X	UTM Y
DEWA-001	Caledonia Creek 13	IN	487886.000002	4535590.715730
DEWA-002	Van Campen Creek 12	IN	501306.000002	4551390.789920
DEWA-003	Deckers Creek 03	IN	508126.000002	4560679.563480
DEWA-004	Dingmans Creek 05	IN	510507.309445	4563458.999990
DEWA-005	Dunnfield Creek 03	IN	489355.684708	4535878.684700
DEWA-006	Toms Creek 20	IN	503146.000002	4553997.834740
DEWA-007	Spackmans Creek 08	IN	507886.000002	4558254.710660
DEWA-008	Dingmans Creek 57	IN	506845.519353	4565149.480640
DEWA-009	Vancampens Brook 28	OUT - HABITAT	501733.915411	4546286.915400
DEWA-010	Vancampens Brook 95	IN	506406.190299	4549499.190290
DEWA-011	Adams Creek 14	IN	510296.000002	4566385.760360
DEWA-012	Adams Creek 33	IN	509178.892134	4567381.892120
DEWA-013	Little Bushkill Creek 01	IN	499552.414242	4549172.585750
DEWA-014	Vancampens Brook 43	IN	502936.169379	4546649.169370
DEWA-015	Dingmans Creek 39	IN	508093.128660	4564351.871330
DEWA-016	Raymondskill Creek 31	DORMANT - PRIVATE	512979.842182	4572158.999990
DEWA-017	Caledonia Creek 03	DORMANT - POND	488131.025261	4536378.999990
DEWA-018	Toms Creek 07	IN	503427.632062	4553128.999990
DEWA-019	Hornbecks Creek 23	OUT - HABITAT	507755.523034	4560158.523020
DEWA-020	Mill Creek 25	IN	506146.784780	4557508.215210
DEWA-021	Dunnfield Creek 61	OUT - HABITAT	493851.857865	4538114.857850
DEWA-022	Toms Creek 25	IN	503122.957793	4554465.957780
DEWA-023	UNT Dingmans Creek 07	IN	509576.000002	4564897.284270
DEWA-024	Raymondskill Creek 38	DORMANT - PRIVATE	512568.803053	4572516.196940
DEWA-025	Vancampens Brook 22	IN	501306.930563	4545939.930550
DEWA-026	UNT Vancampens Brook 05	IN	504990.142136	4548268.999990
DEWA-027	Adams Creek 03	IN	510913.976193	4565571.023800
DEWA-028	White Brook 15	IN	517122.357349	4571482.642640
DEWA-029	Sand Hill Creek 08	IN	498795.353860	4547899.000000
DEWA-030	Yards Creek 07	IN	499556.000002	4542285.568540
DEWA-031	Dingmans Creek 30	IN	508815.971372	4564368.971360
DEWA-032	Raymondskill Creek 13	IN	512939.680909	4571538.999990

Table B.4 (continued). Unique generalized random tessellation stratified (GRTS) design identifier (ID), site name, sampling status, and Universal Transverse Mercator coordinates for 39 sampling sites evaluated at Delaware Water Gap NRA. Numbers in “Site Name” denote hectometers (100 m units) upstream from stream mouths (confluence with larger stream) or outpour point crossing park boundary.

GRTS_ID	Site Name	Status	UTM X	UTM Y
DEWA-033	Dunnfield Creek 26	IN	491153.207794	4536916.207780
DEWA-034	Toms Creek 03	IN	503655.500029	4552868.999990
DEWA-035	Hornbecks Creek 15	IN	508396.208588	4560248.999990
DEWA-036	Mill Creek 12	IN	506350.713745	4556428.999990
DEWA-037	Dunnfield Creek 53	OUT - HABITAT	493197.801949	4537790.801940
DEWA-038	Vancampens Brook 76	IN	504936.000002	4548818.213560
DEWA-039	Adams Creek 21	IN	509913.229802	4566721.770190

Table B.5. Unique GRTS site identifier (ID), site name, and sampling panel for 32 sampling sites at Delaware Water Gap NRA. Numbers in “Site Name” denote hectometers (100 m units) upstream from stream mouths (confluence with larger stream) or outpour point crossing park boundary.

GRTS ID	Site Name	Panel
DEWA-011	Adams Creek 14	1
DEWA-012	Adams Creek 33	1
DEWA-001	Caledonia Creek 13	1
DEWA-003	Deckers Creek 03	1
DEWA-004	Dingmans Creek 05	1
DEWA-015	Dingmans Creek 39	1
DEWA-008	Dingmans Creek 57	1
DEWA-005	Dunnfield Creek 03	1
DEWA-013	Little Bushkill Creek 01	1
DEWA-020	Mill Creek 25	1
DEWA-007	Spackmans Creek 08	1
DEWA-018	Toms Creek 07	1
DEWA-006	Toms Creek 20	1
DEWA-002	Van Campen Creek 12	1
DEWA-014	Vancampens Brook 43	1
DEWA-010	Vancampens Brook 95	1
DEWA-027	Adams Creek 03	2
DEWA-039	Adams Creek 21	2

Table B.5 (continued). Unique GRTS site identifier (ID), site name, and sampling panel for 32 sampling sites at Delaware Water Gap NRA. Numbers in “Site Name” denote hectometers (100 m units) upstream from stream mouths (confluence with larger stream) or outpour point crossing park boundary.

GRTS ID	Site Name	Panel
DEWA-031	Dingmans Creek 30	2
DEWA-033	Dunnfield Creek 26	2
DEWA-035	Hornbecks Creek 15	2
DEWA-036	Mill Creek 12	2
DEWA-032	Raymondskill Creek 13	2
DEWA-029	Sand Hill Creek 08	2
DEWA-034	Toms Creek 03	2
DEWA-022	Toms Creek 25	2
DEWA-023	UNT Dingmans Creek 07	2
DEWA-026	UNT Vancampens Brook 05	2
DEWA-025	Vancampens Brook 22	2
DEWA-038	Vancampens Brook 76	2
DEWA-028	White Brook 15	2
DEWA-030	Yards Creek 07	2

Table B.6. Unique generalized random tessellation stratified (GRTS) design identifier (ID), site name, sampling status, and Universal Transverse Mercator coordinates for 85 sampling sites evaluated at New River Gorge NR. Numbers in “Site Name” denote hectometers (100 m units) upstream from stream mouths (confluence with larger stream) or outpour point crossing park boundary.

GRTS_ID	Site Name	Status	UTM X	UTM Y
NERI-001	Meadow Fork 1	IN	491945.77413	4199617.22587
NERI-002	UNT 1 Manns Creek 8	OUT - ACCESS	499542.38583	4206775.38583
NERI-003	Wolf Creek 14	OUT - SAFETY	492785.00000	4212004.37832
NERI-004	Farleys Creek 8	DORMANT - PRIVATE	507065.00000	4181719.03104
NERI-005	Buffalo Creek 16	IN	498877.05883	4196890.05883
NERI-006	Ephraim Creek 23	OUT - SAFETY	499954.91888	4200738.08112
NERI-007	Panther Branch 7	OUT - SAFETY	503743.12122	4185596.12122
NERI-008	Mill Branch 4	DORMANT - PRIVATE	507301.88077	4176094.88077
NERI-009	Slater Creek 20	IN	497972.83852	4193398.00000
NERI-010	Manns Creek 1	OUT - SAFETY	503049.07315	4204992.07315
NERI-011	Meadow Creek 17	IN	507853.26382	4185766.26382
NERI-012	Kates Branch (Glade) 5	OUT - SAFETY	497275.00000	4180501.33478
NERI-013	Dowdy Creek 16	OUT - HABITAT	495998.10137	4192494.89863

Table B.6 (continued). Unique generalized random tessellation stratified (GRTS) design identifier (ID), site name, sampling status, and Universal Transverse Mercator coordinates for 85 sampling sites evaluated at New River Gorge NR. Numbers in “Site Name” denote hectometers (100 m units) upstream from stream mouths (confluence with larger stream) or outpour point crossing park boundary.

GRTS_ID	Site Name	Status	UTM X	UTM Y
NERI-014	Short Creek 9	DORMANT - PRIVATE	496995.00000	4212007.02909
NERI-015	Meadow Creek 76	DORMANT - PRIVATE	511982.86844	4187875.86844
NERI-016	River Branch 4	IN	495672.53674	4186838.00000
NERI-017	Camp Creek 7	OUT - SAFETY	492435.04551	4198918.04551
NERI-018	Keeney Creek 10	IN	498155.53324	4209427.46677
NERI-019	Wolf Creek 3	OUT - SAFETY	492849.36286	4212913.63714
NERI-020	Farleys Creek 5	DORMANT - PRIVATE	507207.15041	4181960.15041
NERI-021	Fire Creek 17	IN	497845.00000	4199620.57359
NERI-022	UNT 2 Manns Creek 5	OUT - SAFETY	499605.00000	4205380.18898
NERI-023	UNT 52 New River 3	DORMANT - PRIVATE	507096.98485	4184358.00000
NERI-024	Big Branch 10	IN	508483.07612	4174088.00000
NERI-025	Dowdy Creek 30	OUT - HABITAT	496792.27922	4191838.00000
NERI-026	Little Laurel Creek 6	IN	501845.00000	4190130.89322
NERI-027	UNT Lefthand Fork Meadow Creek 4	OUT - ACCESS	509801.89252	4188734.89252
NERI-028	Pinch Creek 14	OUT - SAFETY	497443.84140	4179308.00000
NERI-029	Wolf Creek 30	OUT - HABITAT	492723.45449	4211259.54551
NERI-030	Marr Branch 7	OUT - SAFETY	491915.00000	4214238.12232
NERI-031	Meadow Creek 83	DORMANT - PRIVATE	512185.00000	4188475.57426
NERI-032	River Branch 6	IN	495820.53743	4186712.46257
NERI-033	UNT 29 New River 8	DORMANT - PRIVATE	495533.31988	4197808.00000
NERI-034	UNT 21 New River 1	IN	497799.54059	4203892.54058
NERI-035	Fern Creek 11	OUT - HABITAT	494726.15324	4212509.15324
NERI-036	UNT Fall Branch 2	IN	505025.00000	4177499.06015
NERI-037	Laurel Creek 47	IN	499568.84792	4190061.84792
NERI-038	Arbuckle Creek 2	IN	492325.76795	4201747.23205
NERI-039	Camp Branch 10	OUT - SAFETY	503372.05321	4188045.05321
NERI-040	Polls Branch 14	OUT - HABITAT	498543.49242	4182288.00000
NERI-041	UNT Laurel Creek 3	IN	498255.00000	4190093.89358
NERI-042	Bucklick Branch 3	IN	504260.64971	4191752.35029
NERI-043	Meadow Creek 39	IN	508985.93410	4187258.93410
NERI-044	Laurel Creek 8	IN	496547.26891	4189305.73109
NERI-045	Craig Branch 20	DORMANT - PRIVATE	495203.78680	4209589.21320
NERI-046	UNT Wolf Creek 3	DORMANT - PRIVATE	491909.80589	4211708.00000

Table B.6 (continued). Unique generalized random tessellation stratified (GRTS) design identifier (ID), site name, sampling status, and Universal Transverse Mercator coordinates for 85 sampling sites evaluated at New River Gorge NR. Numbers in “Site Name” denote hectometers (100 m units) upstream from stream mouths (confluence with larger stream) or outpour point crossing park boundary.

GRTS_ID	Site Name	Status	UTM X	UTM Y
NERI-047	Sewell Branch 2	OUT - SAFETY	506411.56166	4183844.56166
NERI-048	Mill Creek 12	IN	494975.00000	4186254.71920
NERI-049	UNT Buffalo Creek 6	IN	499050.85786	4196292.14214
NERI-050	Ephraim Creek 8	IN	498869.52783	4201563.47217
NERI-051	Butcher Branch 2	OUT - SAFETY	493822.32732	4211555.32732
NERI-052	Fall Branch 7	IN	506017.19755	4178045.80245
NERI-053	Slater Creek 13	IN	497495.00000	4193784.18168
NERI-054	Arbuckle Creek 5	IN	492067.50740	4201848.00000
NERI-055	UNT 52 New River 5	DORMANT - PRIVATE	507275.90097	4184408.90097
NERI-056	Second Fork 16	OUT - ACCESS	499697.81426	4183228.00000
NERI-057	UNT 42 New River 1	DORMANT - PRIVATE	495665.00000	4190185.48737
NERI-058	Richlick Branch 17	IN	504224.64466	4190418.35534
NERI-059	Meadow Creek 58	IN	510536.47234	4187846.52766
NERI-060	Bills Branch 6	OUT - ACCESS	499841.79087	4184921.20913
NERI-061	Coal Run 1	OUT - SAFETY	497694.84734	4206567.84734
NERI-062	Wolf Creek 9	OUT - SAFETY	492965.00000	4212386.38842
NERI-063	Sewell Branch 24	DORMANT - PRIVATE	504808.97761	4182571.97761
NERI-064	Batoff Creek 7	IN	490850.13771	4188358.00000
NERI-065	Meadow Fork 6	IN	491644.14462	4199968.85538
NERI-066	UNT UNT 1 Manns Creek 5	OUT - ACCESS	499259.64466	4207002.64466
NERI-067	Wolf Creek 17	OUT - SAFETY	492599.36822	4211828.00000
NERI-068	Farleys Creek 20	DORMANT - PRIVATE	506137.82538	4181200.82538
NERI-069	Buffalo Creek 4	IN	498070.87088	4196213.87088
NERI-070	Ephraim Creek 25	OUT - SAFETY	500111.74819	4200648.00000
NERI-071	Panther Branch 5	OUT - ACCESS	503842.11617	4185755.11617
NERI-072	Big Branch 9	IN	508578.93398	4174078.00000
NERI-073	Slater Creek 25	OUT - SAFETY	498418.99076	4193268.00000
NERI-074	Manns Creek 24	IN	504615.00000	4206077.14798
NERI-075	Meadow Creek 12	IN	507494.06072	4185517.06072
NERI-076	Kates Branch (Glade) 9	OUT - SAFETY	497515.77904	4180438.77904
NERI-077	Dowdy Creek 2	IN	494770.21861	4192728.00000
NERI-078	Short Creek 10	DORMANT - PRIVATE	497029.66880	4212092.66880
NERI-079	Meadow Creek 75	DORMANT - PRIVATE	511940.44203	4187793.44203

Table B.6 (continued). Unique generalized random tessellation stratified (GRTS) design identifier (ID), site name, sampling status, and Universal Transverse Mercator coordinates for 85 sampling sites evaluated at New River Gorge NR. Numbers in “Site Name” denote hectometers (100 m units) upstream from stream mouths (confluence with larger stream) or outpour point crossing park boundary.

GRTS_ID	Site Name	Status	UTM X	UTM Y
NERI-080	Mill Creek 1	IN	495322.09138	4187145.09138
NERI-081	UNT 29 New River 13	OUT - ACCESS	495983.61425	4197928.00000
NERI-082	Keeney Creek 15	IN	498514.62712	4209158.00000
NERI-083	Wolf Creek 5	OUT - SAFETY	492858.86034	4212734.13966
NERI-084	Kates Branch (New) 18	OUT - ACCESS	506712.57359	4174928.00000
NERI-085	Laurel Creek 61	IN	501567.37037	4190810.37037

Table B.7. Unique GRTS site identifier (ID), site name, and sampling panel for 36 sampling sites at New River Gorge NR. Numbers in “Site Name” denote hectometers (100 m units) upstream from stream mouths (confluence with larger stream) or outpour point crossing park boundary.

GRTS ID	Site Name	Panel
NERI-038	Arbuckle Creek 2	1
NERI-024	Big Branch 10	1
NERI-042	Bucklick Branch 3	1
NERI-005	Buffalo Creek 16	1
NERI-021	Fire Creek 17	1
NERI-018	Keeney Creek 10	1
NERI-037	Laurel Creek 47	1
NERI-044	Laurel Creek 8	1
NERI-026	Little Laurel Creek 6	1
NERI-011	Meadow Creek 17	1
NERI-043	Meadow Creek 39	1
NERI-001	Meadow Fork 1	1
NERI-016	River Branch 4	1
NERI-032	River Branch 6	1
NERI-009	Slater Creek 20	1
NERI-034	UNT 21 New River 1	1
NERI-041	UNT Laurel Creek 3	1
NERI-036	UNT to Fall Branch 2	1
NERI-054	Arbuckle Creek 5	2
NERI-064	Batoff Creek 7	2
NERI-072	Big Branch 9	2

Table B.7 (continued). Unique GRTS site identifier (ID), site name, and sampling panel for 36 sampling sites at New River Gorge NR. Numbers in "Site Name" denote hectometers (100 m units) upstream from stream mouths (confluence with larger stream) or outpour point crossing park boundary.

GRTS ID	Site Name	Panel
NERI-069	Buffalo Creek 4	2
NERI-077	Dowdy Creek 2	2
NERI-050	Ephraim Creek 8	2
NERI-052	Fall Branch 7	2
NERI-082	Keeney Creek 15	2
NERI-085	Laurel Creek 61	2
NERI-074	Manns Creek 24	2
NERI-075	Meadow Creek 12	2
NERI-059	Meadow Creek 58	2
NERI-065	Meadow Fork 6	2
NERI-080	Mill Creek 1	2
NERI-048	Mill Creek 12	2
NERI-058	Richlick Branch 17	2
NERI-053	Slater Creek 13	2
NERI-049	UNT to Buffalo Creek 6	2

The number of sampling sites per park is currently not proportional to total wadeable stream length per park (100.8 km or 62% for New River Gorge NR; 60.7 km or 38% for Delaware Water Gap NRA); however, if all 19 currently dormant sites are eventually included, the number of sampling sites per park will be proportional to the total wadeable stream length (52 sites or 60% at New River Gorge NR and 35 sites or 40% at Delaware Water Gap NRA). More importantly, the current number of sites in each park is likely to meet program objectives (Appendix C).

It should be noted that the input shapefile for the GRTS draw for New River Gorge NR erroneously contained duplicates for 73 sites; 7% of the total number of sites in the sampling frame (all sites along four streams at the north end of the park had duplicate records in the shapefile; a mistake discovered in October 2014, after the 2014 field season). While this error doubled the inclusion probability for these sites, all were excluded from the sampling plan due to safety, access, and habitat considerations. Therefore, there is not an immediate need to account for these different inclusion probabilities through differential weighting during analysis. Should that change, all original input files, code, products, weights, etc. associated with the sampling design are archived and available from the protocol lead and data manager.

Appendix C: Power to Detect Change in Resource Condition at New River Gorge NR and Delaware Water Gap NRA

This appendix describes the approach and simulation models used to evaluate trend detection capability of an indicator of resource condition at New River Gorge NR and Delaware Water Gap NRA.

Dr. Tyler Wagner (USGS PA Cooperative Research Unit) proved guidance and statistical code for these analyses.

Overview

A total of 68 sites were selected for sampling streamside birds (Appendix B) in Delaware Water Gap NRA (n = 32 sites) and New River Gorge NR (n = 36 sites) using a random, probability based design. Sampling occurs annually but all sites are divided into two equal sampling panels such that each site is sampled every other year (taking two years to sample all 68 sites). The initial number of sites and sampling panels were based on prior experience, available funding, and logistical constraints that were learned during 2007 – 2012.

This appendix describes the initial statistical simulations performed in 2014 (utilizing the data collected during 2007-2012) to evaluate if the level of sampling described above is sufficient to meet protocol objectives. The primary management objective of "no decline in the condition of park resources" was formalized as a statistical objective of having sufficient power (i.e., 80%) to detect a 1% annual decline in resource condition within ten years of sampling. The results (described below) suggest that this objective should be met at both Delaware Water Gap NRA and New River Gorge NR.

Trend Detection

To ensure maximal effectiveness a monitoring program must be able to detect changes or trends in the condition of park resources within a reasonable period of time and with a reasonable level of statistical confidence. Power analysis is a useful tool for evaluating the performance of ecological monitoring programs (Peterman 1990; Fairweather 1991; Hatch 2003), particularly for investigating how specific variance components affect the power to detect trends for a given sampling design (Urquhart et al. 1998).

Statistical power is the probability of rejecting the null hypothesis when it is, in fact, false (i.e., detecting a trend when a trend is present). Several factors influence the ability to detect change over time, including sample size (number of sites sampled), the probability of a type-I error (α), the probability of a type-II error (β), trend magnitude, and variance. Type-I error, or ''false change,'' refers to falsely detecting a trend when no trend is present. Type-II error, or ''missed change,'' refers to wrongly concluding that no trend is present when, in fact, there is a trend. Statistical power is defined as $1 - \beta$. Common values of α and β range from 0.01 to 0.2 (Gibbs et al. 1998).

One approach to evaluating the statistical power of different sampling designs to detect trends in resource condition is to use estimated variance components within a simulation framework (e.g.,

Wagner et al. 2007, Perles et al. 2014). A component of variance approach has been advocated to quantify variability in ecological data when evaluating temporal trends and monitoring ecological systems (Urquhart et al. 1998; Larsen et al. 2001; Kincaid et al. 2004), largely, because the structure of variance, not just total variance, can influence trend detection capabilities (Wagner et al. 2007). Under this framework, total variance is partitioned into five components, including:

1. spatial variation (site-to-site);
2. coherent temporal variation (year-to-year) affecting all sites in a similar manner;
3. ephemeral temporal variation (i.e., a site x year interaction) corresponding to independent yearly variation at each site;
4. trend variation corresponding to site-specific deviations from any long-term average trend; and
5. residual variation which includes observer error and other unexplained sources of variation.

Power analysis is not only a useful tool for investigating the effectiveness of different sampling designs and the relative power of different indicators, but it can also be used to elucidate how variance components affect the power to detect trends for a given sampling design. This is important because depending on the structure of the variance, power to detect trends may be increased by altering the sampling design.

Objectives

Preserving the condition of park resources unimpaired in perpetuity is the fundamental management objective of the NPS (NPS 2006). Indeed, this "anti-degradation" or "no decline in condition" management objective captures the essence of the NPS mission and forms the underpinnings of the NPS ecological monitoring program (Fancy et al. 2009). This primary management objective was formalized as a statistical objective of having sufficient power (0.80) to detect a 1% annual decline in resource condition within ten years of sampling ($\alpha = 0.05$) for the streamside bird monitoring protocol. This objective refers to the estimated average condition of the entire wadeable stream sampling area within each park.

This appendix describes a variance components approach utilizing pilot data collected from the streamside bird monitoring program to (1) assess an indicator of resource condition with respect to trend detection capabilities, and (2) investigate the extent to which the following factors affected the ability to detect temporal trends in the indicator: (a) using a sample-every-year design versus the current every-other-year panel design; (b) using a simple panel versus a connected panel design (where some plots are sampled every year); and (c) decreasing the trend magnitude effect size (from 1.0 to 0.5% change in an indicator·year-1).

Methods

As described above, data were collected in New River Gorge NR and Delaware Water Gap NRA from 2007 – 2012 prior to the 2013 decision to correct several mistakes in the initial sampling

design. These "pilot" data were assumed to be reasonable and representative data for the simulations described here to inform the likely performance of the current sampling design because the only substantive difference was the sampling locations (field and analysis methods were identical). Only the pilot sampling sites that fell within the sampling frame of the current design were included in these analyses (see Appendix A).

The monitoring protocol utilizes multi-metric indices of biotic integrity to describe resource condition. The bird community index (BCI) is an index of biotic integrity based on the breeding bird communities of the central Appalachians (O'Connell et al. 2000). The BCI is based on 16 response guilds that are each broadly classified as "specialist" or "generalist" depending on each guild's relationship to specific elements of biotic integrity (fully described in Appendix E). Higher BCI scores (indicating higher biotic integrity) describe a community in which specialists are well-represented relative to generalists.

The index was calculated for each park, site, and sampling year 2007 – 2012 data were available (Tables C.1 and C.2).

Table C.1. Bird community index values for pilot data collected at New River Gorge NR. Data were collected at 25 sites during May and June of 2007-2012 using methods described in Marshall et al. (2015). Data were considered "pilot" because they were collected from different sampling locations, not because the field methods differed from the current protocol (* = no data because site not sampled).

Site Name	2007	2008	2009	2010	2011	2012
Fall Branch	68.5	65.5	63.5	69.0	66.0	68.0
Slater Creek	64.5	64.5	67.0	69.0	63.0	68.0
UNT Laurel Creek (Highland Mtn.)	66.5	66.0	66.5	65.5	64.0	65.0
UNT Laurel Creek (Backus Mtn.)	62.5	68.0	65.5	67.0	67.0	63.5
Davis Branch	*	66.5	64.0	67.0	63.5	65.5
UNT Buffalo Creek	63.5	63.5	71.0	65.0	62.5	64.5
Bucklick Branch	65.0	62.5	64.5	64.5	65.0	65.5
Mill Creek	65.5	62.0	64.5	63.0	66.0	65.5
Dowdy Creek	61.5	56.0	63.5	67.5	66.5	65.0
UNT Meadow Creek	65.0	61.0	63.0	64.5	64.0	62.5
Buffalo Creek	64.0	57.5	66.0	64.5	58.5	67.5
Camp Branch	61.0	65.5	67.5	59.0	63.0	61.0
Big Branch	*	60.5	61.5	65.5	64.0	61.5
Richlick Branch	60.0	63.0	58.0	61.5	68.0	63.5
Bills Branch	63.5	65.0	59.0	60.0	61.5	64.5
Ephraim Creek	62.5	61.0	59.5	58.0	62.5	68.0
Arbuckle Creek	63.0	62.5	63.5	62.5	62.0	58.0
Fire Creek	58.0	62.5	59.5	62.0	61.0	66.0
Meadow Creek	53.0	55.5	65.0	64.5	64.5	61.0
Keeney Creek	*	62.5	57.5	65.0	57.0	57.5
Wolf Creek	62.5	60.5	62.0	56.5	53.0	54.5

Table C.1 (continued). Bird community index values for pilot data collected at New River Gorge NR. Data were collected at 25 sites during May and June of 2007-2012 using methods described in Marshall et al. (2015). Data were considered "pilot" because they were collected from different sampling locations, not because the field methods differed from the current protocol (* = no data because site not sampled).

Site Name	2007	2008	2009	2010	2011	2012
Battoff Creek	49.5	51.0	61.0	65.0	59.0	62.0
Little Laurel Creek	50.0	59.0	62.0	57.0	58.5	55.5
Laurel Creek	55.0	57.5	56.5	58.0	58.5	55.0
Kates Branch	60.5	55.0	57.5	53.5	*	*
Mean	61.1	61.4	62.8	63.0	62.4	62.9

Table C.2 Bird community index (BCI) values for pilot data collected at Delaware Water Gap NRA. Data were collected at 24 sites during May and June of 2007-2012 using methods described in Marshall et al. (2015). Data were considered "pilot" because they were collected from different sampling locations; not because the field methods differed from the current protocol (* = no data because site not sampled).

Site Name	2007	2008	2009	2010	2011	2012
Dunnfield Creek	57.0	65.0	62.0	63.0	66.5	63.5
Caledonia Creek	61.5	59.0	63.0	66.5	62.0	64.0
Raymondskill Creek	*	59.5	71.5	53.5	61.5	62.0
Conashaugh Creek	61.0	67.0	60.0	59.5	59.5	61.0
White Brook	64.0	54.5	60.5	59.0	63.0	64.0
Adams Creek	65.5	64.0	59.5	59.0	58.0	55.5
Slateford Creek	55.5	61.5	58.5	61.0	66.5	58.5
Vancampens Brook (Donkey Hollow)	54.5	62.0	65.0	61.0	61.0	56.5
UNT to Adams Creek	57.5	64.5	59.5	62.5	59.0	54.0
Fuller Brook	56.0	57.5	64.0	59.0	56.5	63.0
UNT to Delaware River (Arrow Island)	60.5	59.0	59.5	59.0	59.0	59.0
Dry Brook	59.5	54.5	60.0	57.5	60.0	57.0
Spackmans Creek	62.5	55.0	59.0	58.0	61.5	52.5
UNT to Toms Creek	60.0	57.0	59.5	56.0	57.5	58.5
Mill Creek	54.5	57.5	58.0	63.5	54.0	58.5
UNT to Dingmans Creek	*	57.0	53.0	57.5	59.0	61.0
Sandyston Creek	58.5	53.0	57.0	58.5	58.5	58.5
UNT to Delaware River (Sunfish Pond)	55.0	57.0	56.0	58.0	59.5	54.0
Dingmans Creek	50.0	57.0	58.5	58.5	60.5	54.0
Little Bushkill Creek	47.5	61.5	53.5	58.0	60.5	57.5
Toms Creek	*	54.5	61.0	55.0	55.5	54.0
Hornbecks Creek	53.0	55.0	58.5	57.0	52.5	57.0
Vancampens Brook (Millbrook Village)	54.0	56.5	51.0	55.5	53.0	53.0
Van Campen Creek	53.5	50.0	49.5	53.0	49.5	49.0
Mean	57.2	58.3	59.1	58.7	58.9	57.7

A linear mixed model that assumed Gaussian errors was used to estimate variance components in the index. Estimation was done with the R statistical software (R Development Core Team 2012). Example R code is in Table C.3. The mixed model used for the analyses was:

$$(1) \qquad y_{ijk} = \mu + a_i + year_j(\lambda + t_i) + b_j + c_{ij} + e_{ijk}$$

where y_{ijk} is the $\log_e$-transformed indicator from the kth sample for site i in year j, and μ and **λ** are the intercept and slope fixed effects (i.e., the population-average intercept and trend), respectively. The a_i is a random effect for site i, representing site-to-site (spatial) variability, independent and identically distributed (iid) as $N(\sigma_a^2)$; b_j is a random effect for the jth year (coherent temporal variability), iid as $N(0, \sigma_b^2)$; t_i is a random effect for the trend for site i, iid as $N(0, \sigma_t^2)$; c_{ij} is the site × year interaction (ephemeral temporal variability), iid as $N(0, \sigma_c^2)$; e_{ijk} is the unexplained error (residual error), independent as $N(0, \sigma_e^2)$. The year covariate (*year*) is the jth year minus the mean year (i.e., grand-mean centered). This standardization of year was performed to provide numerical stability. The variance components were estimated using restricted maximum likelihood and all analyses were considered significant at $P < 0.05$.

Next, a simulation approach was used to examine the statistical power to detect temporal trends in both indicators. Simulations followed the approach outlined in Perles et al. (2014). Briefly, 500 simulations were performed for each indicator and sampling scenario. During each simulation, a 30-year time series of an indicator was simulated for the number of potential sampling sites available in each park under the sampling plan developed in 2013 (n = 600 Delaware Water Gap NRA; n = 1,000 New River Gorge NR; see Appendix A) using the estimated spatial and temporal components of variation. A population-average temporal trend (**λ**) was then specified (e.g., a decrease of 1% of the indicator·year^{-1}); however, each individual site could deviate from this population-average trend, with the deviation dependent on the magnitude of the trend variance component (t_i).

Simulated data were sampled from the population of sites using one of the designs of interest: (a) sample every year, (b) sample with a two panel design (half the sites sampled each year), or (c) sample with a connected two panel design (half the sites sampled each year with a common panel where three to six sites are sampled every year). The number of sites sampled was 32 for Delaware Water Gap NRA and 36 for New River Gorge NR (i.e., the same number of sites in the current design).

During each simulation (i.e., every year of the sampling process), the model outlined in Equation 1 was used to test the null hypothesis that $\hat{\lambda} = 0$, and the test statistic was calculated and compared to a critical value (with $\alpha = 0.05$). Because the data generated depicted a situation in which the null hypothesis was known to be false (i.e., a trend of pre-specified magnitude was incorporated into the data), power was estimated as the percentage of trials (i.e., of 500 simulations) that rejected the null hypothesis.

All parameter estimation and simulation were conducted using the Random Effects module of AD Model Builder (ADMB) statistical programming software for fitting nonlinear models (http://admb-project.org; Fournier et al. 2012).

Table C.3. Example R code for linear mixed model used to estimate variance components of the benthic macroinvertebrate multi-metric index of biotic integrity (MIBI) from 18 sites at Delaware Water Gap NRA, 2008-2013. Code provided by Dr. Tyler Wagner (USGS PA Cooperative Fish and Wildlife Research Unit).

R-code Used

```
# rm(list=ls())
library(reshape2)
library(arm)

dat <- read.table('DEWA MIBI_forR.txt', header=T, na.strings='NA')
dim(dat)
head(dat)

# Reshape data from wide to long
       dat2 <- reshape(dat, direction="long", varying=list(names(dat)[2:6]),
       v.names="MIBI",
       idvar=c("Site_Name"), timevar="Year", times=2008:2012)

dim(dat2)
head(dat2)

# Sort by site
dat2 <- dat2[order(dat2$Site_Name) , ]
head(dat2,12)

# Quick plot of MIBI over time
plot(log(MIBI)~Year, data=dat2, col=Site_Name, pch=16)

# standardize year
dat2$yearZ <- (dat2$Year - mean(dat2$Year))/sd(dat2$Year)

# Create year as a categorical variable
dat2$yearC <- as.factor(dat2$Year)
summary(dat2)

#--------- Variance components model
# (1|yearC) = coherent temporal variance
# (0 + yearZ|Site_Name) = allow each site to have own linear trend [trend variance]
# (1|Site_Name) = site variance

m1 <- lmer(log(MIBI) ~ 1 + yearZ + (1|yearC) + (0 + yearZ|Site_Name) +
       (1|Site_Name) , data=dat2)
summary(m1)

# coef(m1)$Site_Name[,1]
# coef(m1)$Site_Name[,2]
```

Results

Partitioning of Variance Using Mixed Models

The fixed slope, total variance, and percent of total variance in different variance components are shown in Table C.4 for each park. Note that ephemeral temporal variation could not be estimated (and is likely > 0) because repeat samples were not collected within an annual sampling window for either protocol. The slope provides an estimate of the yearly change occurring for each indicator over the 6-year sampling period. The total variance was minimal compared to other plant and animal populations (Gibbs et al. 1998, Wagner et al. 2007, Perles et al. 2014).

Total variance was split between spatial and residual variance. Minimal coherent temporal variation (i.e., annual variation affecting all sites in a similar manner) was evident at both parks (less so at New River Gorge NR). This component can limit trend detection capability because it cannot be controlled by adding more sites or revisiting sites within a year (Larsen et al. 2001). The high percentage of the total variance contained in residual variance term in all cases does not necessarily refer solely to observer error while collecting field measurement. It refers to all of the remaining unexplained variation, which includes temporal variation and ephemeral temporal variation that could not be estimated separately by the model.

Power to Detect Trends in Resource Condition

Overall, the simulations indicated that the current sampling plan in both parks will likely yield 80% power to detect a 1% annual decline in resource condition within ten years of sampling (Table C.5) and therefore meet the protocol's sampling objectives. It also appears that there will be sufficient power to detect a more conservative decline of 0.5% annually within five years of sampling at both parks (Table C.5). Not surprisingly, sampling all sites every year yielded higher estimated power compared to the two panel design (sample half the sites each year; Table C.5); however, the expected gain in trend detection capability was minimal and therefore determined to not outweigh the substantial cost savings and logistical efficiency of paneling.

The sample every year, panel, and connected panel designs had similar power estimates for detecting temporal trends (Figures C.1 and C.2). Note that the more conservative trend of 0.5% decline of the indicator·year^{-1} is depicted. Within the first 5 years, some of the connected panel designs initially exhibited slightly higher power than the simple panel design, but this advantage was not retained in subsequent years. This pattern was similar regardless of the number of sites in the common panel (ranging from 3 to 6). Similarly, Urquhart et al. (1993) and Perles et al. (2014) found that a connected panel design had the greatest benefit to trend detection within the first four to eight years of sampling with negligible benefit thereafter.

In terms of management significance, for example, the average BCI score for New River Gorge NR from 2007 – 2012 was 62.3 placing it in the "highest ecological integrity" class (O'Connell et al. 2000; Appendix E). The NPS management objective would be to maintain streamside bird communities in this high integrity condition. Should the average BCI score decline 0.5% per year, the threshold to a lower ecological condition class (BCI = 60.0) would be crossed in roughly nine

years. It appears, then, that the monitoring plan as designed should have sufficient power to detect and inform management that these trends are occurring.

Limitations of this Approach

Several important caveats and assumptions should be considered when interpreting these results. First, the pilot data used in these analyses came from sampling locations that are not part of the current sampling plan so it must be assumed that these data are representative of what will be encountered at the current sampling locations. Second, sampling did not occur in ways that allowed ephemeral temporal variation to be estimated separately. It is likely that this component of variation is >0 by some unknown amount; consequently, these power estimates are likely to be a "best case" scenario. Third, despite the obvious advantages of having multiple years of data from multiple sites collected in the same manner in the same streams (if not exactly the same sites), the time series available was relatively short compared to the anticipated multi-decade duration of the monitoring program. Longer (or different) time series may produce different estimates of variance and its components. Finally, all simulations evaluated the power to detect linear trends which aligned with the current management objectives as stated. If, however, the objective were to detect abrupt shifts in system state or other non-linear dynamics, these simulations may not be particularly informative.

Regardless, these results provided meaningful guidance by allowing the evaluation of several sampling designs with regard to temporal trend detection in an important resource indicator. Similar analyses will be conducted periodically as new data are collected in an ongoing effort to ensure the sampling plan meets protocol objectives.

Table C.4 Percent of total variance in each of five variance components, total variance and slope estimated by mixed models for an index of resource condition (BCI = bird community index) from pilot date collected at New River Gorge NR and Delaware Water Gap NRA, 2007-2012.

Park	Index	Percent Spatial	Percent Coherent Temporal	Percent Ephemeral Temporal*	Percent Trend	Percent Residual	Total Variance	Slope	Slope Standard Error
New River Gorge NR	BCI	44	0	0	8	48	0.0047	0.0080	0.0057
Delaware Water Gap NRA	BCI	37	1	0	1	61	0.0051	0.0035	0.0058

* Ephemeral temporal variation could not be estimated because there were no repeat samples collected within an annual sampling window for either protocol.

Table C.5 Power to detect linear temporal trends an index of resource condition (BCI = bird community index) from pilot data collected at New River Gorge NR and Delaware Water Gap NRA, 2007-2012.

Park	Index	Power to detect -1%·year^{-1} after 10 years for Two Panels	Power to detect -1%·year^{-1} after 10 years Every Year	Power to detect - 0.5%·year^{-1} after 5 years Two Panels	Power to detect - 0.5%·year^{-1} after 5 years Every Year
New River Gorge NR	BCI	0.99	1.00	0.91	0.93
Delaware Water Gap NRA	BCI	1.00	1.00	0.92	0.96

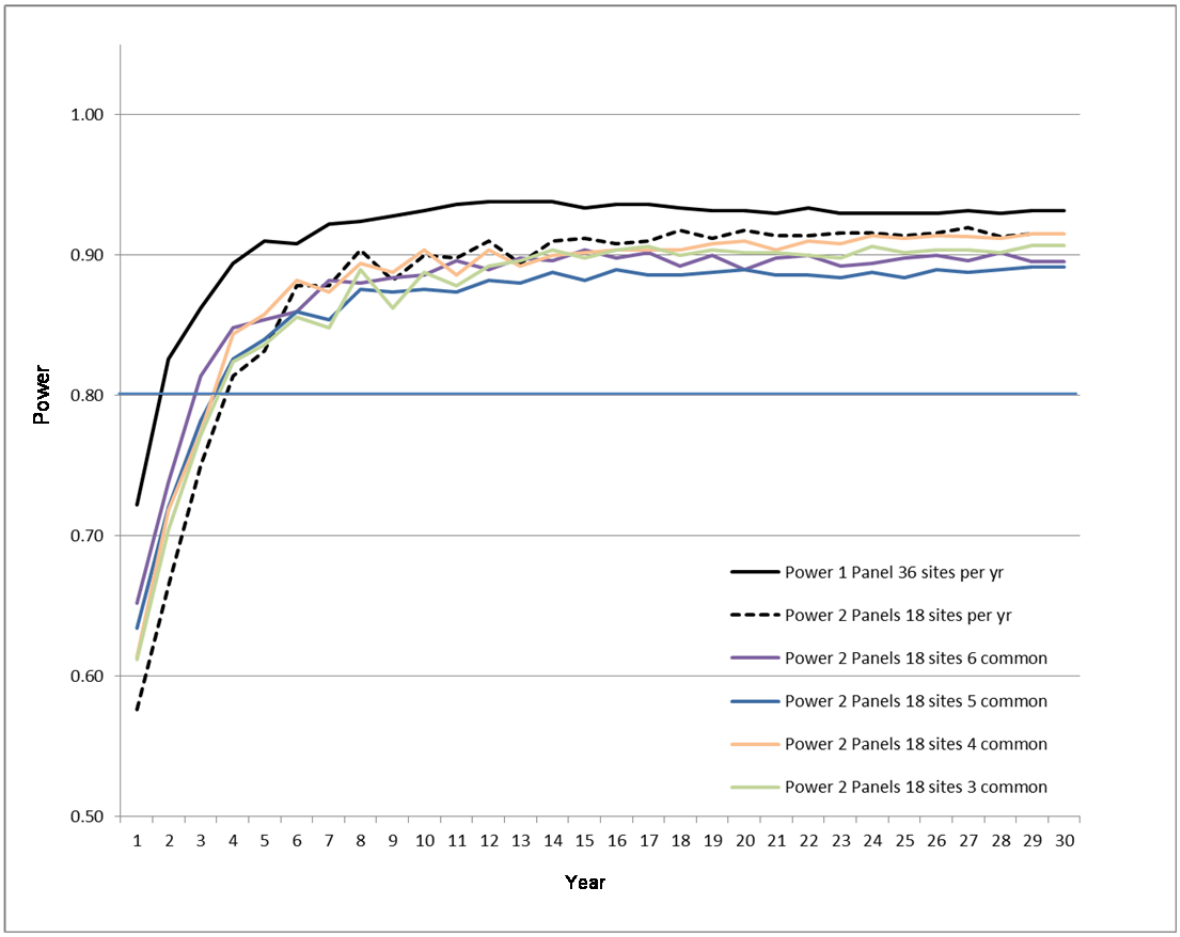

Figure C.1. Power to detect a linear –0.5% annual decline in the bird community index (BCI) at New River Gorge NR based on pilot data collected 2007 – 2012 using six different sampling designs.

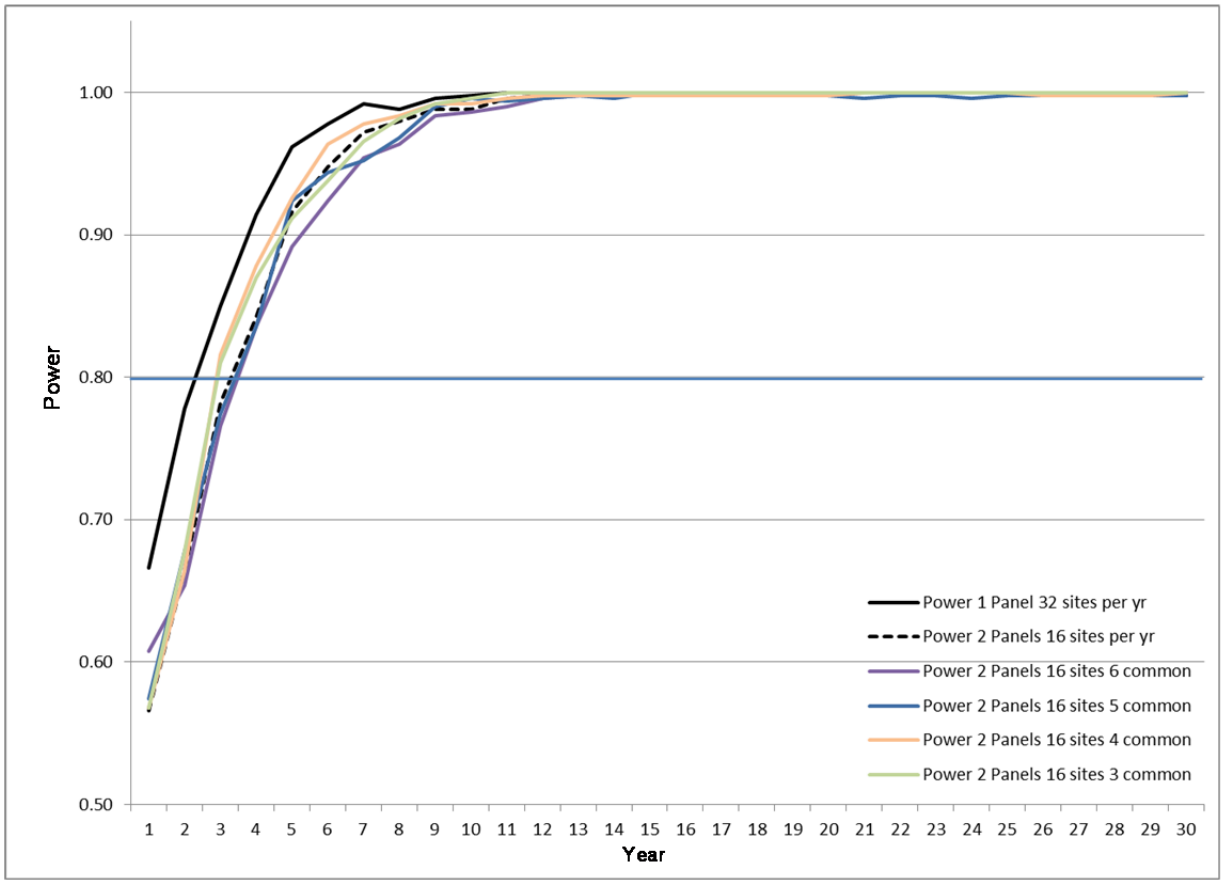

Figure C.2. Power to detect a linear –0.5% annual decline in the bird community index (BCI) at Delaware Water Gap NRA based on pilot data collected 2007 – 2012 using six different sampling designs.

Appendix D: Power to Detect Change in Resource Condition at Allegheny Portage Railroad NHS, Bluestone NSR, Fort Necessity NB, and Friendship Hill NHS

Overview

This appendix describes the approach and simulation models used to evaluate trend detection capability in resource condition at Allegheny Portage Railroad NHS, Bluestone NSR, Fort Necessity NB, and Friendship Hill NHS. The primary intent of this analysis was to determine the ability of the non-random (index site) sampling design to detect meaningful trends in resource condition at four small and/or linear parks (Allegheny Portage Railroad NHS, Bluestone NSR, Fort Necessity NB, and Friendship Hill NHS). Ten non-random "index sites" were established near the downstream end of each wadeable stream in these parks – four sites were selected at Bluestone NSR whereas two sites were selected at each of the other parks (Allegheny Portage Railroad NHS, Fort Necessity NB, and Friendship Hill NHS).

Streamside bird communities are sampled at each site, every other year. The monitoring protocol utilizes multi-metric indices of biotic integrity to describe resource condition. The bird community index (BCI) is an index of biotic integrity based on the breeding bird communities of the central Appalachians (O'Connell et al. 2000). The BCI is based on 16 response guilds that are each broadly classified as "specialist" or "generalist" depending on each guild's relationship to specific elements of biotic integrity (fully described in Appendix E). Higher BCI scores (indicating higher biotic integrity) describe a community in which specialists are well-represented relative to generalists.

Trends were evaluated independently at each site based on the first four years of monitoring (2011-2015) with a sampling objective of having sufficient power (i.e., 80%) to detect a 1% annual decline in resource condition within ten years. [Two sites at Bluestone NSR were not included because they were only sampled once during this period.] This objective, which is in the context of preserving park resource condition (i.e., anti-degradation), was somewhat arbitrary and ambitious given the potential for high variability among years. Nonetheless, this power analysis was conducted to evaluate the likelihood of meeting this sampling objective and to investigate the extent to which the following scenarios affect the ability to detect temporal trends at index sites: (a) using a sample-every-year design versus (b) a sample every-other-year design; and (c) removing the proportion of variance associated with existing linear trends in the data.

Methods

Program MONITOR (Gibbs and Ene 2010) was used to estimate the power to detect trends in the BCI under the three scenarios described above for each site (with the exception of Great Meadows Run at Fort Necessity NB and Blair Gap Run at Allegheny Portage Railroad NHS because each was only sampled twice). Each simulation is based on the 2011-2015 average BCI value and standard deviation for each site unless otherwise stated.

All simulations were designed to detect a *decreasing* trend based on the anti-degradation context of this monitoring program; however, similar results were expected for an *increasing* trend of the same magnitude. The first scenario ("sample every year") was parameterized in the "Survey design" section of MONITOR to sample one site annually for a period of 30 years. The "Design type" used was Simple Regression and "Measure type" was set to Normal. The "Variance type" was set to Total. In the "Trends" section, "Deterministic/Regression-type" was chosen to estimate power values for a -1% trend. The "Variance to mean relationship" was set to "Constant SD". In the "Simulation" section, the model was set to run 1,000 iterations using a one-tailed distribution, with no rounding of values or truncation and the significance value (alpha-level) was set to 0.05. The simulation model was run for each year, stepping through a 30 year period, and each model out (power estimate) was transferred to tabular form.

To simulate the "sample every other year" scenario, the "Survey design" section of MONITOR was changed to sample one site every *other* year for a period of 30 years. All other parameters remained unchanged.

The final scenario was based on the observation that a substantial amount of the total variance in BCI values at some sites was due to an existing linear trend in the existing data (i.e., a linear increase or decrease in BCI values over the four years of sampling). It did not seem appropriate or particularly informative to evaluate the ability to detect a "decline" in resource condition when the existing data were already showing a significant "increase" in condition. The linear regression coefficient of determination (R^2) which estimates the percentage of the total variance in the BCI that can be explained by a linear relationship between BCI and time (sampling year) was used to partition out this source of variation. This scenario was parameterized the same as the "sample every other year" with a -1% trend scenario; however, the total variance was reduced by the percentage indicated by the R^2 value, leaving only the residual variance (expressed as the SD for input to program MONITOR).

Results

The BCI value for each site and year it was sampled during the period 2011 through 2015 along with the average and standard deviation is shown in Table D.1. BCI values for each park and site plotted over time and fit with a simple linear regression model are shown in Figures D.1 through D.4. The regression coefficient of determination (R^2), slope of the regression line, p-value (testing the null hypothesis that the slope of the fitted line = 0), and residual variance (expressed as the standard deviation) are shown in Table D.1.

The average BCI value ranged from 43.3 (Blair Gap Run) to 63.3 (Mountain Creek; Table D.1). Among the sites sampled more than twice, the standard deviations ranged from 1.2 to 6.8 greatly influencing trend detection capability (see below).

Three of six sites (sampled on more than two occasions) showed positive slopes and three showed negative slopes (Table D.1 and Figures D.1 – D.4). Two of the positive slopes were significantly different from zero (Table D.1 and Figures D.1 – D.4). The BCI values at UNT (unnamed tributary) to Great Meadows Run and Ice Pond Run showed significant positive linear trend (4.5% and

8%·year^{-1}, respectively) over the four years of sampling. These linear trends contributed to a substantial proportion of the total variance in some cases – for example, 97% of the variance associated with BCI values at UNT to Great Meadows Run is explained by the linear trend.

Table D.1 Bird Community Index (BCI) values for streamside bird communities from eight sites at four National Park Service units sampled between 2011 and 2015. The 2011-2015 site average and standard deviation (SD) are also shown. BCI values plotted over time and fit with a simple linear regression model are shown in Figures X.1 through X.4 The regression coefficient of determination (R^2), slope of the regression line, p-value (testing the null hypothesis that the slope of the fitted line = 0), and residual variance (SD Residual) are shown.

Park	Site Name	2011	2012	2013	2014	2015	Average	SD	Slope	R^2	p-value	SD Residual
ALPO	Millstone Run	56.0	53.0	54.0	.	53.5	54.1	1.3	-0.44	0.33	0.425	0.9
ALPO	Blair Gap Run	.	.	42.5	.	44.0	43.3	1.1	0.75	.	.	.
BLUE	Mountain Creek	65.0	61.0	63.5	63.5	.	63.3	1.7	-0.20	0.02	0.844	1.6
BLUE	Little Bluestone River	63.0	66.0	59.0	59.5	.	61.9	3.3	-1.75	0.48	0.310	1.7
FONE	Great Meadows Run	.	.	41.5	.	45.5	43.5	2.8	2.00	.	.	.
FONE	UNT Great Meadows Run	43.5	46.5	50.5	.	54.0	48.6	4.6	2.64	0.97	0.017	0.2
FRHI	Dublin Run	57.0	58.0	55.5	.	58.0	57.1	1.2	0.13	0.03	0.814	1.1
FRHI	Ice Pond Run	43.0	47.5	51.0	.	59.0	50.1	6.8	3.96	1.00	0.001	0.0

. = no data collected or not applicable

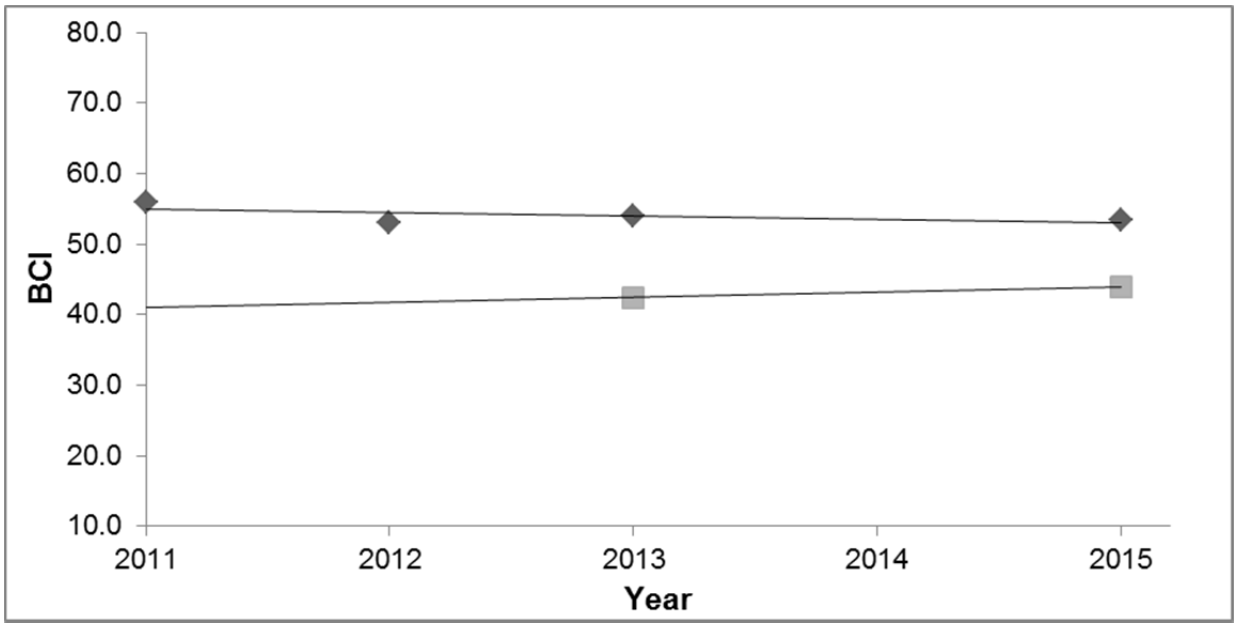

Figure D.1. *Simple linear regression of Bird Community Index (BCI) scores (from 2011-2015) at two Allegheny Portage Railroad NHS sites (diamonds = Millstone Run; squares = Blair Gap Run).*

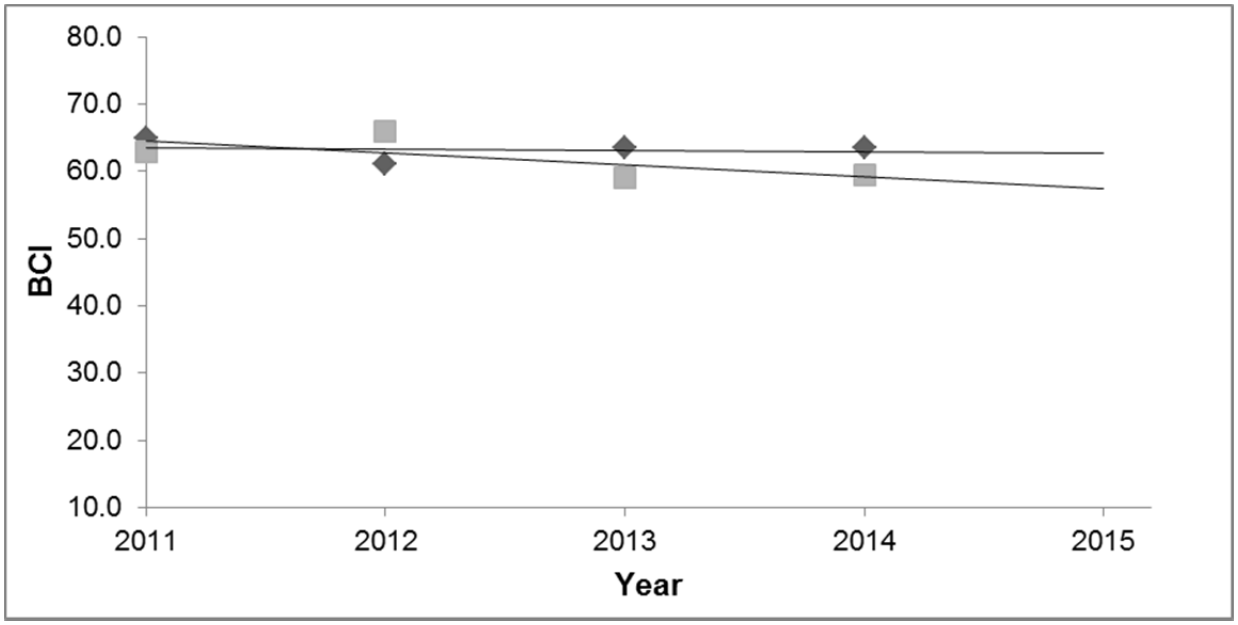

Figure D.2. Simple linear regression of Bird Community Index (BCI) scores (from 2011-2015) at two Bluestone NSR sites (diamonds = Mountain Creek; squares = Little Bluestone River).

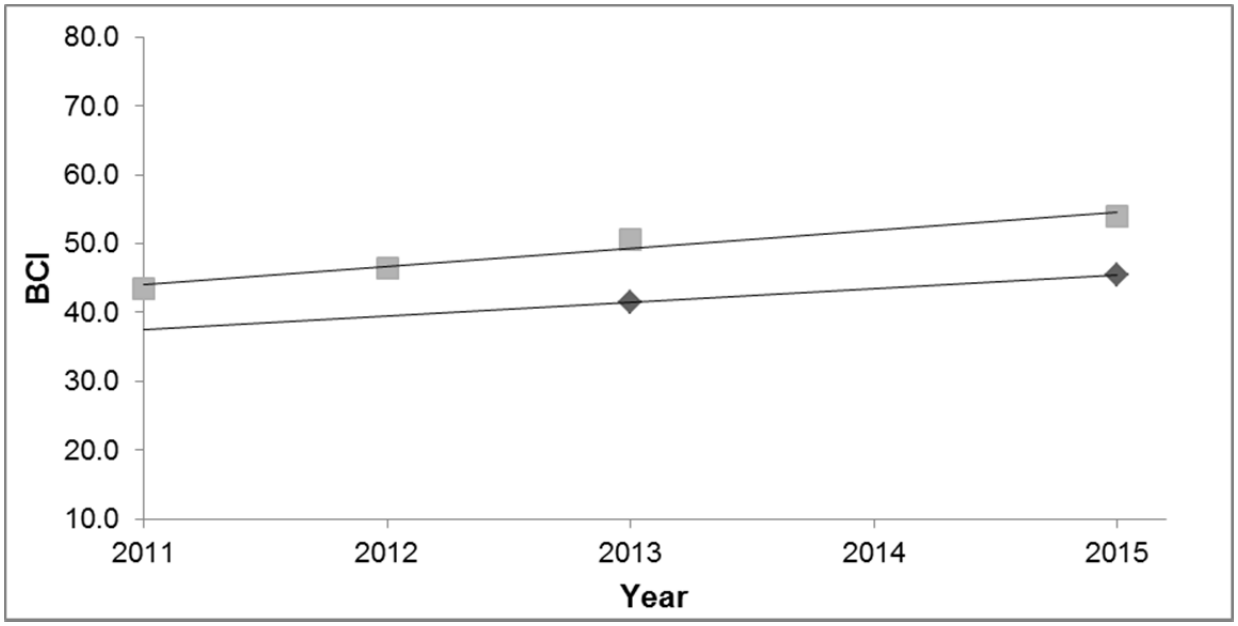

Figure D.3. Simple linear regression of Bird Community Index (BCI) scores (from 2011-2015) at two Fort Necessity NB sites (diamonds = Great Meadow Run; squares = Unnamed tributary to Great Meadows Run).

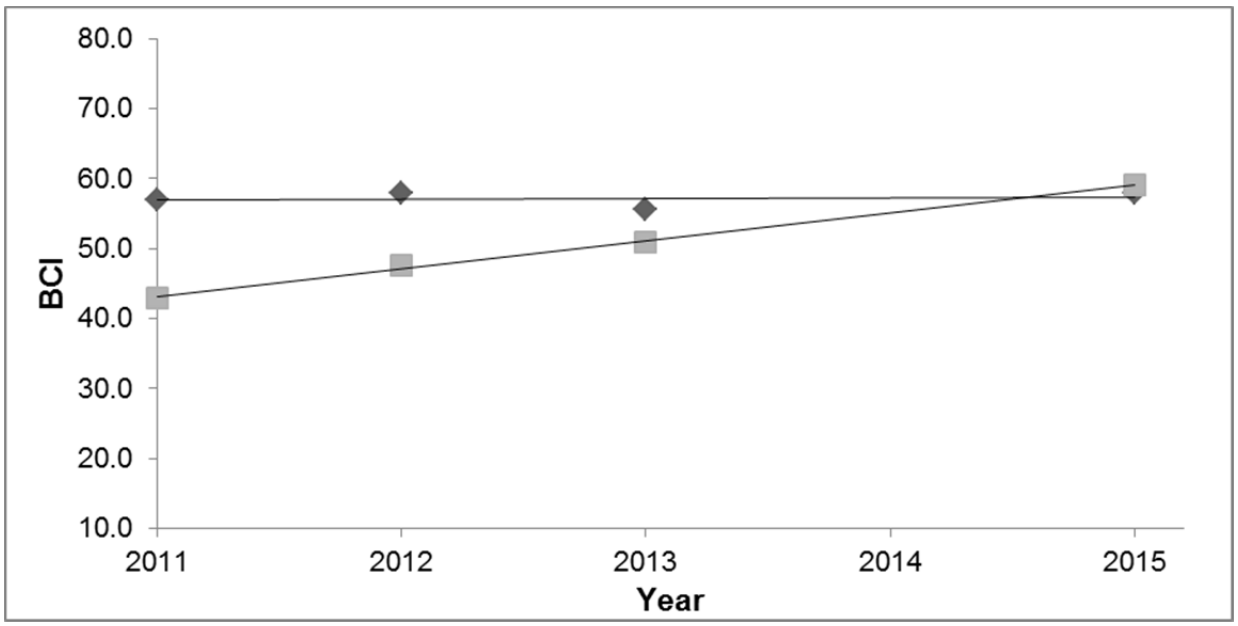

Figure D.4. Simple linear regression of Bird Community Index (BCI) scores (from 2011-2015) at two Friendship Hill NHS sites (diamonds = Dublin Run; squares = Ice Pond Run).

Power to Detect Trends in Resource Condition

Based on this analysis, the "sample every other year" design used for streamside bird monitoring at ERMN index sites will have sufficient power (i.e., 80%) to detect a 1% annual decline in resource condition within ten years of sampling at three of the six sites for which power simulations were conducted (Figures D.5 – D.8). Detecting a 1% annual decline (with 80% power) would only be statistically significant after: (1) 16 years of sampling at Little Bluestone River and (2) at least 25 years at UNT to Great Meadows Run and Ice Pond Run. The lower power, by definition, is due to higher total variance (Table D.1).

It was these latter three sites which were already exhibiting linear trends (two of which were statistically significant increases; Table D.1). Intuitively, then, it was these three sites for which removing the portion of total variance due to these existing linear trends (SD residual in Table D.1) most dramatically improved the ability to detect declining trends through simulation (Figures D.6 – D.8). Little Bluestone River, UNT to Great Meadows Run, and Ice Pond Run all met the original sampling objective based on the simulations where the SD was reduced proportional to the R2 value.

As expected, the simulations suggested that power would increase at all sites with increased sampling (i.e., every year); however, the ERMN made the decision that the modest increase in power does not justify the doubled (and potentially unsustainable) sampling effort.

While it is somewhat disconcerting that only half the sites investigated could meet the primary sampling objective as stated, these simulations demonstrated the fact that large changes can (and have been) detected in short time periods. If the program lasts beyond 25 years, it appears that very subtle changes in condition will be detectable with high power at all index sites.

Limitations of this Approach

Several important caveats and assumptions should be considered when interpreting these results. First, despite the obvious advantages of having multiple years of data, the time series available was relatively short compared to the anticipated multi-decade duration of the monitoring program. Longer (or different) time series may produce different mean estimates and variance, and therefore, power estimates. Second, all simulations evaluated the power to detect linear trends which aligned with the current objectives as stated. If, however, the objective were to detect abrupt shifts in system state or other non-linear dynamics, these simulations may not be particularly informative. Regardless, these results provided meaningful guidance by allowing the evaluation of several sampling designs with regard to temporal trend detection in an important resource indicator.

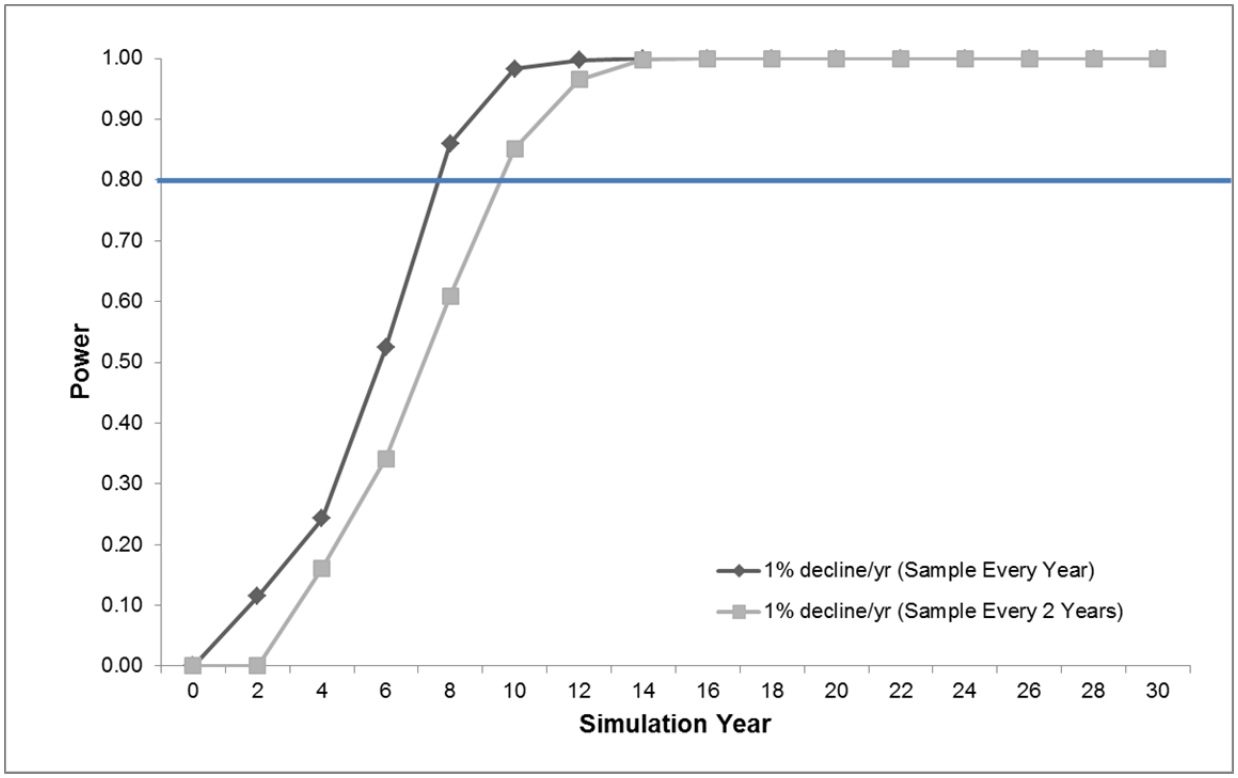

Figure D.5. Power to detect linear declines in resource condition at Millstone Run (Allegheny Portage Railroad NHS) based on 20011-2015 data and simulated under two scenarios. Horizontal blue line at 80% power added for reference.

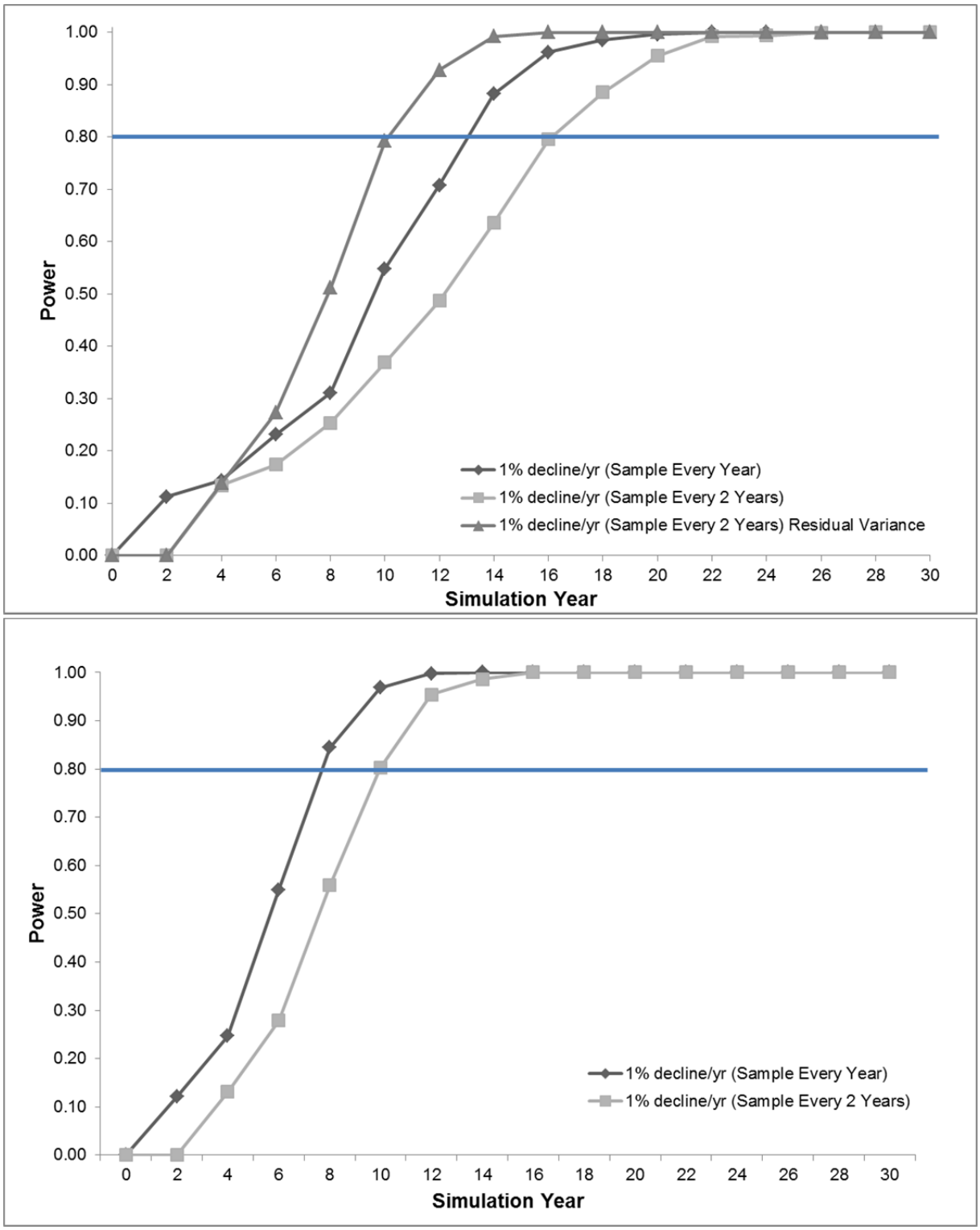

Figure D.6. Power to detect linear declines in resource condition at two sampling sites at Bluestone NSR [Little Bluestone River (top) and Mountain Creek (bottom)] based on 2011-2015 data and simulated under several scenarios. Horizontal blue line at 80% power added for reference.

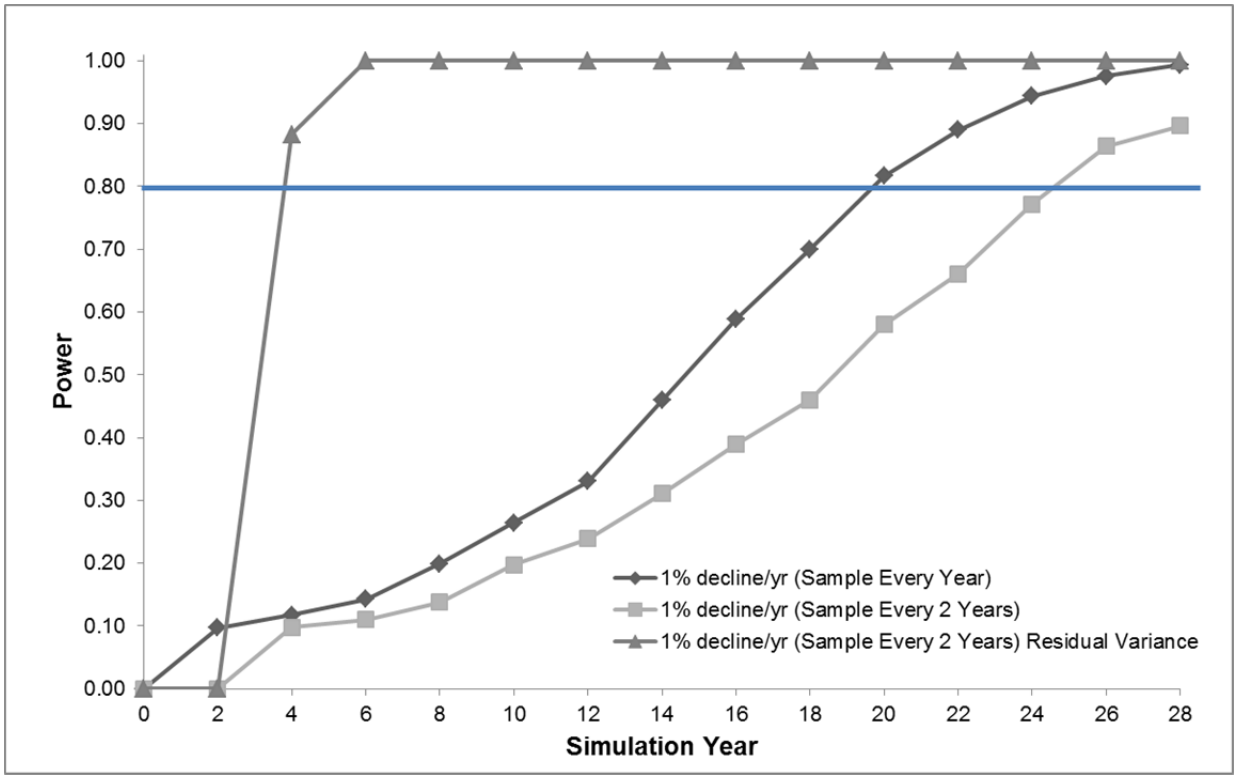

Figure D.7. Power to detect linear declines in resource condition at the Unnamed Tributary to Great Meadows Run sampling site in Fort Necessity NB based on 2011-2015 data and simulated under three scenarios. Horizontal blue line at 80% power added for reference.

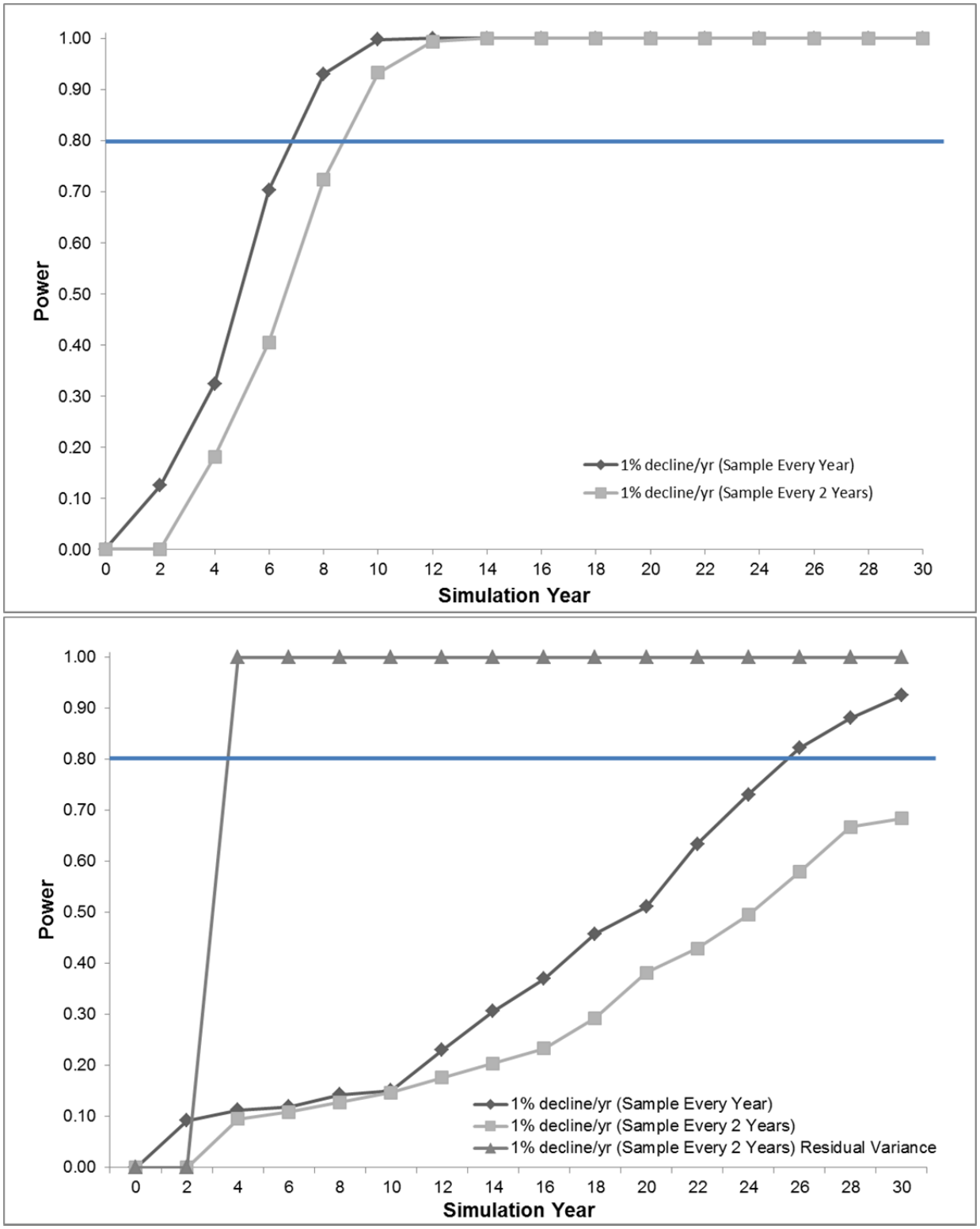

Figure D.8. Power to detect linear declines in resource condition at two sampling sites at Friendship Hill NHS [Dublin Run (top) and Ice Pond Run (bottom)] based on 20011-2015 data and simulated under several scenarios. Horizontal blue line at 80% power added for reference.

Appendix E: Overview of the Bird Community Index

This appendix provides detailed explanation and instructions for calculating and interpreting the bird community index (BCI) of biotic integrity developed by O'Connell et al. (1998a, 1998b, 2000). The following is only a summary and readers are encouraged to read the foundational papers in their entirety for a complete understanding of the BCI, its development, appropriate use, and application (O'Connell et al. 1998a, 1998b, and 2000).

O'Connell, T. J., L. E. Jackson, and R. P. Brooks. 2000. Bird guilds as indicators of ecological condition in the central Appalachians. Ecological Applications 10:1706-1721.

O'Connell, T. J., L. E. Jackson, and R. P. Brooks. 1998a. A bird community index of biotic integrity for the Mid-Atlantic Highlands. Environmental Monitoring and Assessment 51:145–156.

O'Connell, T. J., L. E. Jackson, and R. P. Brooks. 1998b. The bird community index: A tool for assessing biotic integrity in the Mid-Atlantic Highlands. Report 98-4 of the Penn State Cooperative Wetlands Center, Pennsylvania State University, University Park, Pennsylvania.

Overview

The bird community index (BCI) is an index of biotic integrity (Karr and Dudley 1981) based on the breeding bird communities of the central Appalachians (O'Connell et al. 1998a, 1998b, 2000). The BCI is based on 16 response guilds with each guild broadly classified as "specialist" or "generalist" based on each guild's relationship to specific elements of biotic integrity (Table E.1). Each bird species is assigned to a response guild and the BCI ranks the overall bird community detected at a site according to the proportional representation of the species' in the response guilds. Higher BCI scores (indicating higher biotic integrity) describe a community in which specialists are well-represented relative to generalists.

It is important to recognize that the BCI in its current formulation reflects the land-use and land-cover types of the central Appalachians (e.g., mature and regenerating forest, pasture and row crop, urban and suburban area, and mined lands) each of which, in the absence of irreversible anthropogenic disturbance, would succeed to forest. Moreover, specialist guilds tend to be associated with extensive forest cover and a taller more closed-canopy forest. Therefore, the sites with the highest BCI scores reflect bird communities associated with aspects mature forest structure, function, and composition. For example, sites with higher BCI scores consist of a bird community with fewer omnivores, nest predators/brood parasites, and residents (i.e., generalists); but more bark probers, single-brooded species, and interior-forest obligates (i.e., specialists). Therefore, the biotic or ecological "condition" described by the BCI moves along a disturbance gradient from relatively intact, extensive, mature forest (high biotic integrity and high BCI scores) to highly developed or urban (low biotic integrity and low BCI scores).

Table E.1. Biotic integrity elements, guild categories, sixteen response guilds, and guild interpretations used in an index of ecological integrity called the Bird Community Index (BCI; O'Connell et al. 1998a, 1998b, and 2000).

Biotic Integrity Element	Guild Category	Response Guild	Specialist	Generalist
Functional	trophic	omnivore		X
Functional	insectivore foraging behavior	bark prober	X	
Functional	insectivore foraging behavior	ground gleaner	X	
Functional	insectivore foraging behavior	upper-canopy forager	X	
Functional	insectivore foraging behavior	lower-canopy forager	X	
Compositional	origin	exotic/non-native		X
Compositional	migratory	resident		X
Compositional	migratory	temperate migrant		X
Compositional	number of broods	single-brooded	X	
Compositional	population limiting	nest predator/brood parasite		X
Structural	nest placement	canopy nester	X	
Structural	nest placement	shrub nester		X
Structural	nest placement	forest-ground nester	X	
Structural	nest placement	open-ground nester	X	
Structural	primary habitat	forest generalist		X
Structural	primary habitat	interior forest obligate	X	

The BCI was developed by O'Connell et al. (1998a, 1998b, 2000) as one component of the U.S. Environmental Protection Agency, Environmental Monitoring and Assessment Program's (EPA-EMAP) Mid-Atlantic Highlands Assessment (MAHA). The BCI is particularly amenable to application by the ERMN Streamside Bird Monitoring program for several reasons. First, the geographic extent of the MAHA (Figure E.1) aligns well with that of the ERMN and, as a result, so do the bird species included (Supplement E.1). This also means that the assessment of biotic integrity based on the bird community for the entire MAHA (O'Connell et al. 2000) provides an unparalleled regional context for comparisons to results within the ERMN. Finally, the sampling approaches employed by both efforts (five, 10 min point counts along a 1km transect) are virtually identical.

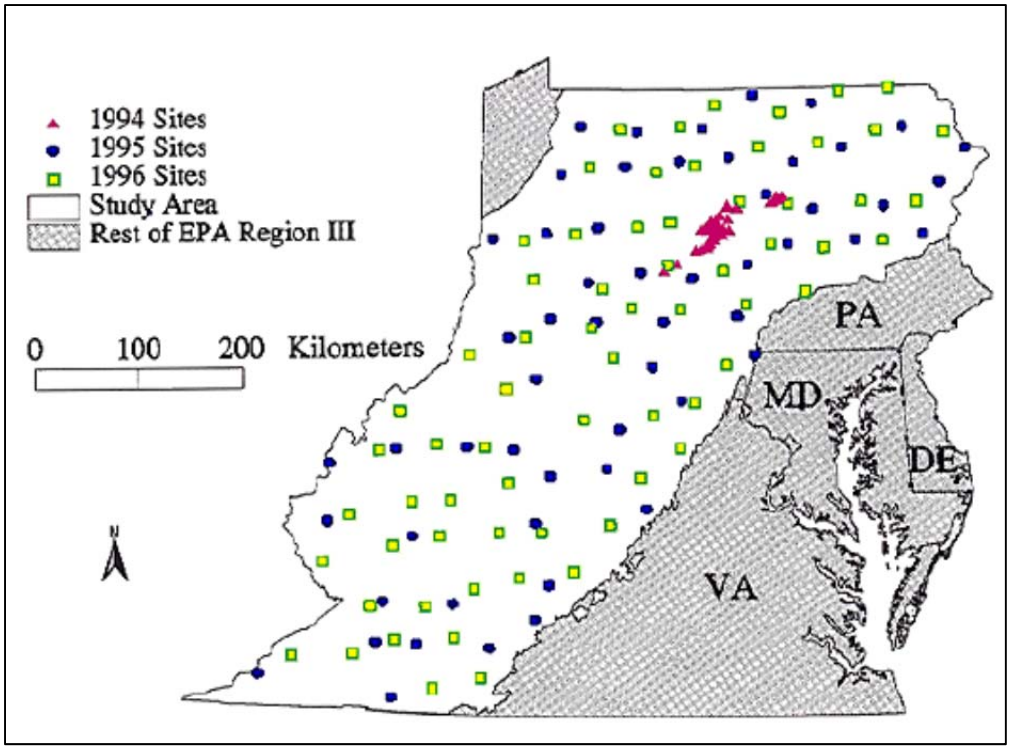

Figure E.1. Map of EPA Region III, MAHA study, area and specific sampling sites used by O'Connell et al. (2000) to develop the Bird Community Index (BCI).

Species and guilds

The BCI is based on (and limited to) detections of "songbirds" defined by O'Connell et al. (1998) as species in the orders Columbiformes (doves and pigeons), Cuculiformes (cuckoos), Apodiformes (swifts and hummingbirds), Piciformes (woodpeckers), and Passeriformes (perching birds). In the central Appalachians this includes 112 species (Supplement E.1). More than 98% of the bird detections in the ERMN Streamside Bird Monitoring Protocol from 2007-2011 were of species in these five orders. The only species periodically detected during monitoring that is not included in the BCI is the Swainson's warbler.

Each species was assigned to a response guild by O'Connell et al (1998a, 1998b, 2000) based on a thorough literature review of species' life-history traits (Supplement E.2). Response guilds can be defined as groups of species which require similar habitat, prey, and other conditions for survival and respond in predictable ways to habitat disturbance. For example, the loss of snags in a forest can result in a decrease in the guild of bark-probing insectivores. Also, the nest placement guilds relate directly to the availability of appropriate nesting substrate (a structural element). Therefore, birds that only nest in the forest canopy (specialists) indicate high integrity condition because they are largely restricted to mature forests native to the region, while shrub nesters (generalists) also encounter appropriate nesting substrate in regenerating forests, agricultural hedgerows, and suburban areas.

It is important to keep in mind that because guilds reflect different aspects of each species' life history traits, a species may belong to several guilds simultaneously, including both specialist and generalist guilds. For example, the downy woodpecker is a generalist according to Primary Habitat

and Migratory status, but a specialist according to its membership in four other guild categories (e.g., bark prober). That said, guild assignments within each guild category (Table E.1) are mutually exclusive so species belong to no more than eight guilds. A complete list of guilds (including guilds not included in the final BCI; see O'Connell et al. 2000 for details) with rationale for "specialist" and "generalist" interpretation is in Supplement E.3.

The next step in BCI development was to identify which bird community profiles indicate a low biotic integrity condition, and which are indicative of high biotic integrity. O'Connell et al. (1998a, 1998b, 2000) ranked each category of occurrence for each guild on a scale of high integrity to low integrity (Table E.2). For specialist guilds, they ranked the highest- occurrence category a "5," the next highest a "4," etc. For generalist guilds, they reversed the ranking, assigning "5" to the lowest-occurrence category. Therefore, a site can receive a rank of "5" for a guild if the site supports the highest category of proportional species richness for a specialist guild or the lowest category of proportional species richness for a generalist guild. Note that not all guilds have the same range and associated ranks.

Table E.2. Guilds and ranking system for calculating bird community based on O'Connell et al. (1998a, 1998b, 2000)[a].

Guild	Proportion of species detected	Rank	Guild	Proportion of species detected	Rank	Guild	Proportion of species detected	Rank
omnivore	0.000 - 0.290	5.0	exotic/non-native	0	5.0	canopy nester[b]	0.000 - 0.280	1.5
	0.291 - 0.410	4.0		0.001 - 0.020	4.5		0.281 - 0.320	2.0
	0.411 - 0.480	3.0		0.021 - 0.050	3.0		0.321 - 1.000	4.5
	0.481 - 0.580	2.0		0.051 - 0.110	2.0	shrub nester	0.000 - 0.210	4.0
	0.581 - 1.000	1.0		0.111 - 1.000	1.0		0.331 - 1.000	1.0
bark prober[b]	0.000 - 0.060	1.5	resident	0.000 - 0.260	5.0	open-ground nester[b]	0.000 - 0.020	1.0
	0.061 - 0.110	3.0		0.261 - 0.390	3.5		0.021 - 0.110	2.5
	0.111 - 0.170	4.0		0.391 - 0.570	2.0	forest-ground nester[b]	0	1.0
	0.171 - 1.000	5.0		0.571 - 1.000	1.0		0.001 - 0.020	1.5
ground gleaner[b]	0.000 - 0.050	1.5	temperate migrant	0.000 - 0.210	4.0		0.021 - 0.160	3.0
	0.051 - 0.070	2.0		0.211 - 0.300	2.0		0.161 - 0.240	4.5
	0.071 - 0.140	4.5		0.301 - 1.000	1.0		0.241 - 1.000	5.0
	0.141 - 1.000	5.0	single-brooded[b]	0.000 - 0.410	1.5	forest generalist	0.000 - 0.280	4.5
upper-canopy forager[b]	0.000 - 0.030	1.5		0.411 - 0.450	2.0		0.281 - 1.000	2.5
	0.031 - 0.050	2.0		0.451 - 0.610	3.0	interior forest obligate[b]	0.000 - 0.010	1.0
	0.051 - 0.120	3.0		0.611 - 0.730	4.0		0.011 - 0.080	1.5
	0.121 - 0.200	4.5		0.731 - 1.000	5.0		0.081 - 0.260	3.0
	0.201 - 1.000	5.0	nest predator/brood parasite	0.000 - 0.100	5.0		0.261 - 0.430	4.0
lower-canopy forager[b]	0.000 - 0.140	1.5		0.101 - 0.150	3.5		0.431 - 1.000	5.0
	0.141 - 0.230	2.5		0.151 - 0.180	2.0			
	0.231 - 1.000	5.0		0.181 - 1.000	1.0			

[a] Unmarked are generalist guilds.

[b] Specialist guilds.

BCI calculations

With species assigned to guilds (Supplement E.3) and guilds ranked (Table E.2), the proportional species richness of each guild is calculated. Proportional species richness is the number of guild members detected, divided by the total number of species detected. For example, if the bird community at a given site contains a total of 10 species, two of which are omnivores, then 20% of the species at that site are in the omnivore guild, and the site receives a score of 5.0 for that guild (Table E.2).

The ranks determined for the 16 separate guilds are summed to produce an overall BCI score for the sampling unit (e.g., a sample site). A theoretical "minimum integrity" community would receive a BCI score of 20.5; the theoretical "maximum integrity" score is 77 (Table E.2). O'Connell et al. (1998a, 1998b, and 2000) also established thresholds such that the overall BCI score places the sampling unit into one of four categories of ecological condition: "excellent" (highest-integrity), "good" (high-integrity), "fair" (medium integrity), and "poor" (low-integrity rural and low-integrity urban) ecological. The thresholds for these condition classes are as follows:

highest integrity:	60.1-77.0
high integrity:	52.1-60.0
medium integrity:	40.1-52.0
low integrity:	20.5-40.0

An example of these calculations resulting in a BCI of 58 ("high integrity") for Millstone Run at Allegheny Portage Railroad NHS from 2009 is shown in Table E.3.

Table E.3. Bird community composition and scores used for calculating bird community index of 58 (i.e., "high integrity") for Millstone Run (Allegheny Portage Railroad NHS) 2009. Specialist guilds indicated with astrices (*) and the remaining are generalist guilds.

Response Guild	Proportion of Species	Score
omnivore	0.346	4.0
bark prober*	0.154	4.0
ground gleaner*	0.077	4.5
upper-canopy forager*	0.115	3.0
lower-canopy forager*	0.154	2.5
exotic / nonnative	0.000	5.0
resident	0.385	3.5
temperate migrant	0.115	4.0
single-brooded*	0.500	3.0
nest predator / brood parasite	0.077	5.0

Table E.3 (continued). Bird community composition and scores used for calculating bird community index of 58 (i.e., "high integrity") for Millstone Run (Allegheny Portage Railroad NHS) 2009. Specialist guilds indicated with astrices (*) and the remaining are generalist guilds.

Response Guild	Proportion of Species	Score
canopy nester*	0.423	4.5
shrub nester	0.192	4.0
open-ground nester*	0.038	2.5
forest-ground nester*	0.115	3.0
forest-generalist	0.462	2.5
interior forest obligate*	0.385	3.0
	Total	**58.0**

Supplement E.1. Bird species included in the bird community index (BCI)

Common Name	Scientific Name	Code
Mourning Dove	*Zenaida macroura*	MODO
Rock Pigeon	*Columbia livia*	ROPI
Yellow-billed Cuckoo	*Coccyzus americanus*	YBCU
Black-billed Cuckoo	*Coccyzus erythropthalmus*	BBCU
Chimney Swift	*Chaetura pelagica*	CHSW
Ruby-throated Hummingbird	*Archilochus colubris*	RTHU
Red-bellied Woodpecker	*Melanerpes carolinus*	RBWO
Downy Woodpecker	*Picoides pubescens*	DOWO
Hairy Woodpecker	*Picoides villosus*	HAWO
Northern Flicker	*Colaptes auratus*	NOFL
Pileated Woodpecker	*Dryocopus pileatus*	PIWO
Red-headed Woodpecker	*Melanerpes erythrocephalus*	RHWO
Yellow-bellied Sapsucker	*Sphyrapicus varius*	YBSA
Eastern Wood-Pewee	*Contopus virens*	EAWP
Acadian Flycatcher	*Empidonax virescens*	ACFL
Alder Flycatcher	*Empidonax alnorum*	ALFL
Willow Flycatcher	*Empidonax traillii*	WIFL
Least Flycatcher	*Empidonax minimus*	LEFL

Supplement E.1 (continued). Bird species included in the bird community index (BCI)

Common Name	Scientific Name	Code
Eastern Phoebe	*Sayornis phoebe*	EAPH
Great Crested Flycatcher	*Myiarchus crinitus*	GCFL
Eastern Kingbird	*Tyrannus tyrannus*	EAKI
Horned Lark	*Eremophila alpestris*	HOLA
Yellow-throated Vireo	*Vireo flavifrons*	YTVI
Blue-headed Vireo	*Vireo solitarius*	BHVI
Warbling Vireo	*Vireo gilvus*	WAVI
Red-eyed Vireo	*Vireo olivaceus*	REVI
White-eyed Vireo	*Vireo griseus*	WEVI
Blue Jay	*Cyanocitta cristata*	BLJA
American Crow	*Corvus brachyrhynchos*	AMCR
Fish Crow	*Corvus ossifragus*	FICR
Common Raven	*Corvus corax*	CORA
Purple Martin	*Progne subis*	PUMA
Tree Swallow	*Tachycineta bicolor*	TRES
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	NRWS
Cliff Swallow	*Petrochelidon pyrrhonota*	CLSW
Barn Swallow	*Hirundo rustica*	BARS
Carolina Chickadee	*Poecile carolinensis*	CACH
Black-capped Chickadee	*Poecile atricapillus*	BCCH
Tufted Titmouse	*Baeolophus bicolor*	TUTI
Red-breasted Nuthatch	*Sitta canadensis*	RBNU
White-breasted Nuthatch	*Sitta carolinensis*	WBNU
Brown Creeper	*Certhia americana*	BRCR
Carolina Wren	*Thryothorus ludovicianus*	CARW
House Wren	*Troglodytes aedon*	HOWR
Winter Wren	*Troglodytes hiemalis*	WIWR
Blue-gray Gnatcatcher	*Polioptila caerulea*	BGGN
Golden-crowned Kinglet	*Regulus satrapa*	GCKI
Eastern Bluebird	*Sialia sialis*	EABL

Supplement E.1 (continued). Bird species included in the bird community index (BCI)

Common Name	Scientific Name	Code
Veery	*Catharus fuscescens*	VEER
Hermit Thrush	*Catharus guttatus*	HETH
Wood Thrush	*Hylocichla mustelina*	WOTH
American Robin	*Turdus migratorius*	AMRO
Gray Catbird	*Dumetella carolinensis*	GRCA
Northern Mockingbird	*Mimus polyglottos*	NOMO
Brown Thrasher	*Toxostoma rufum*	BRTH
European Starling	*Sturnus vulgaris*	EUST
Cedar Waxwing	*Bombycilla cedrorum*	CEDW
Blue-winged Warbler	*Vermivora cyanoptera*	BWWA
Golden-winged Warbler	*Vermivora chrysoptera*	GWWA
Nashville Warbler	*Oreothlypis ruficapilla*	NAWA
Northern Parula	*Parula americana*	NOPA
Yellow Warbler	*Dendroica petechia*	YWAR
Chestnut-sided Warbler	*Dendroica pensylvanica*	CSWA
Magnolia Warbler	*Dendroica magnolia*	MAWA
Black-throated Blue Warbler	*Dendroica caerulescens*	BTBW
Yellow-rumped Warbler	*Dendroica coronata*	YRWA
Black-throated Green Warbler	*Dendroica virens*	BTNW
Blackburnian Warbler	*Dendroica fusca*	BLBW
Yellow-throated Warbler	*Dendroica dominica*	YTWA
Pine Warbler	*Dendroica pinus*	PIWA
Prairie Warbler	*Dendroica discolor*	PRAW
Cerulean Warbler	*Dendroica cerulea*	CERW
Black-and-white Warbler	*Mniotilta varia*	BAWW
American Redstart	*Setophaga ruticilla*	AMRE
Worm-eating Warbler	*Helmitheros vermivorum*	WEWA
Ovenbird	*Seiurus aurocapilla*	OVEN
Northern Waterthrush	*Parkesia noveboracensis*	NOWA
Louisiana Waterthrush	*Parkesia motacilla*	LOWA

Supplement E.1 (continued). Bird species included in the bird community index (BCI)

Common Name	Scientific Name	Code
Mourning Warbler	*Geothlypis philadelphia*	MOWA
Kentucky Warbler	*Oporornis formosus*	KEWA
Common Yellowthroat	*Geothlypis trichas*	COYE
Hooded Warbler	*Wilsonia citrina*	HOWA
Canada Warbler	*Wilsonia canadensis*	CAWA
Yellow-breasted Chat	*Icteria virens*	YBCH
Eastern Towhee	*Pipilo erythrophthalmus*	EATO
Grasshoppper Sparrow	*Ammodramus savannarum*	GRSP
Henslow's Sparrow	*Ammodramus henslowii*	HESP
Chipping Sparrow	*Spizella passerina*	CHSP
Savannah Sparrow	*Passerculus sandwichensis*	SAVS
Field Sparrow	*Spizella pusilla*	FISP
Vesper Sparrow	*Pooecetes gramineus*	VESP
Song Sparrow	*Melospiza melodia*	SOSP
Swamp Sparrow	*Melospiza georgiana*	SWSP
White-throated Sparrow	*Zonotrichia albicollis*	WTSP
Dark-eyed Junco	*Junco hyemalis*	DEJU
Bobolink	*Dolichonyx oryzivorus*	BOBO
Eastern Meadowlark	*Sturnella magna*	EAME
Summer Tanager	*Piranga rubra*	SUTA
Scarlet Tanager	*Piranga olivacea*	SCTA
Northern Cardinal	*Cardinalis cardinalis*	NOCA
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	RBGR
Blue Grosbeak	*Passerina caerulea*	BLGR
Indigo Bunting	*Passerina cyanea*	INBU
Red-winged Blackbird	*Agelaius phoeniceus*	RWBL
Common Grackle	*Quiscalus quiscula*	COGR
Brown-headed Cowbird	*Molothrus ater*	BHCO
Orchard Oriole	*Icterus spurius*	OROR
Baltimore Oriole	*Icterus galbula*	BAOR

Supplement E.1 (continued). Bird species included in the bird community index (BCI)

Common Name	Scientific Name	Code
House Finch	*Carpodacus mexicanus*	HOFI
Purple Finch	*Carpodacus purpureus*	PUFI
American Goldfinch	*Spinus tristis*	AMGO
House Sparrow	*Passer domesticus*	HOSP

Supplement E.2. Bird species assigned to sixteen response guilds included in the bird community index (BCI)

Biotic Integrity Element	Guild Category	Response Guild	Species
Functional	trophic	omnivore	AMCR, AMGO, AMRO, BAOR, BHCO, BLJA, BOBO, BRTH, CHSP, COGR, CORA, DEJU, EABL, EAME, EATO, EUST, FICR, FISP, GRCA, GRSP, HESP, HOLA, INBU, NOCA, NOMO, RBGR, ROPI, RTHU, RWBL, SAVS, SOSP, SWSP, VEER, VESP, WOTH, WTSP, YBCH, YBSA
	insectivore foraging behavior	bark prober*	BAWW, BRCR, DOWO, HAWO, PIWA, PIWO, RBNU, RBWO, RHWO, WBNU, YTWA
		ground gleaner*	HETH, KEWA, MOWA, NOFL, OVEN, WEWA, WIWR
		upper-canopy forager*	BGGN, BLBW, BTNW, CERW, GWWA, NOPA, OROR, REVI, SCTA, WAVI, YTVI, YTWA
		lower-canopy forager*	AMRE, BBCU, BCCH, BHVI, BTBW, BWWA, CACH, CARW, CAWA, SUTA, COYE, CSWA, GCKI, HOWA, HOWR, MAWA, NAWA, PRAW, TUTI, WEVI, YBCU, YWAR, YRWA
Compositional	origin	exotic / non-native	EUST, HOFI, HOSP, ROPI
	migratory	resident	AMCR, AMGO, AMRO, BCCH, BLJA, BRCR, CACH, CARW, CEDW, CORA, DEJU, DOWO, EABL, EUST, FICR, HAWO, HOFI, HOLA, HOSP, MODO, NOCA, NOFL, NOMO, PIWO, PUFI, RBNU, RBWO, ROPI, SOSP, TUTI, WBNU
		temperate migrant	BGGN, BHCO, BHVI, BRTH, CHSP, COGR, COYE, EAME, EAPH, EATO, FISP, GCKI, GRCA, GRSP, HESP, HETH, HOWR, PIWA, RHWO, RWBL, SAVS, SWSP, TRES, VESP, WEVI, WIWR, WTSP, YBSA, YRWA, YTWA
	number of broods	single-brooded*	ALFL, AMCR, AMGO, AMRE, BAOR, BAWW, BBCU, BCCH, BGGN, BHVI, BLBW, BOBO, BRCR, BTBW, BTNW, BWWA, CACH, CAWA, CEDW, CERW, CHSW, CLSW, COGR, CORA, CSWA, DOWO, EAKI, EAWP, FICR, CGFL, GWWA, HAWO, HOWA, KEWA, LEFL, LOWA, MAWA, MOWA, NAWA, NOFL, NOPA, NOWA, NRSW, OROR, OVEN, PIWA, PIWO, PRAW, PUFI, RBGR, RBNU, RBWO, REVI, SCTA, SUTA, TRES, TUTI, VEER, WAVI, WBNU, WEVI, WEWA, WIFL, WIWR, WTSP, YBCU, YBSA, YWAR, YTVI, YTWA
	population limiting	nest predator / brood parasite	AMCR, BHCO, BLJA, COGR, CORA, EUST, FICR

Supplement E.2 (continued). Bird species assigned to sixteen response guilds included in the bird community index (BCI)

Biotic Integrity Element	Guild Category	Response Guild	Species
Structural	nest placement	canopy nester*	ACFL, AMCR, AMRE, AMRO, BAOR, BGGN, BHVI, BLJA, BLBW, BTNW, CEDW, CERW, COGR, CORA, EAKI, EAWP, FICR, GCKI, LEFL, MODO, NOPA, OROR, PIWA, PUFI, RBGR, RTHU, SCTA, SUTA, WAVI, WOTH, YRWA, YTVI, YTWA
		shrub nester	ALFL, AMGO, BBCU, BLGR, BRTH, BTBW, CHSP, COYE, CSWA, GRCA, HOWA, INBU, MAWA, NOCA, NOMO, PRAW, REVI, RWBL, WEVI, WIFL, YBCH, YBCU, YWAR
		open-ground nester*	BOBO, BWWA, EAME, FISP, GRSP, GWWA, HESP, HOLA, SAVS, SOSP, SWSP, VESP
		forest-ground nester*	BAWW, CAWA, DEJU, EATO, HETH, KEWA, LOWA, MOWA, NAWA, NOWA, OVEN, VEER, WEWA, WTSP
	primary habitat	forest generalist	BBCU, BCCH, BGGN, BLJA, CARW, COYE, DEJU, DOWO, EAPH, EATO, EAWP, GCFL, GRCA, NOCA, NOFL, NOPA, PUFI, RBGR, RBWO, REVI, SUTA, TUTI, WEVI, WOTH, YBCU, YBSA, YTVI
		interior forest obligate*	ACFL, AMRE, BAWW, BHVI, BLBW, BRCR, BTBW, BTNW, CAWA, CERW, CORA, GCKI, HAWO, HETH, HOWA, KEWA, LOWA, MAWA, NOWA, OVEN, PIWA, PIWO, RBNU, SCTA, VEER, WBNU, WEWA, WIWR, YRWA, YTWA

Supplement E.3. Description of response guilds included in the bird community index (BCI)

The following (from O'Connell et al. 2008b) provides an overview, justification, and scaling rationale for all 24 response guilds considered in the development of the BCI. Response guilds marked with an asterisk (*) were removed from direct inclusion in the BCI due to a high degree of correlation with other guilds or a lack of discernible response along a gradient of human disturbance. Sixteen guilds were selected to comprise the final BCI. Also included is a discussion of the basis for treating each guild as a "specialist" or "generalist." Species assigned to the 16 guilds included in the BCI are listed in Supplement E.2.

Guild Category: Trophic Level

Omnivore: Species that routinely consume both animal and plant material during the breeding season. We ranked omnivores as generalists because of the wide variety of food items available to omnivores.

***Insectivore:** Species with breeding season diets restricted to, or largely dominated by, insects and other invertebrates. We consider insectivores to be specialists because of their high trophic position in the ecosystem and the potential for prey availability to be reduced in disturbed environments. We removed this guild from the BCI due to its high correlation with other guilds.

Guild Category: Insectivore Foraging Behavior

We consider all guilds under this guild category to be specialists due to the patchy distribution of their respective primary food source. For example, bark probers rely on a well-developed arthropod community that includes wood-boring species and species that occupy spaces on the bark of trees. Both upper and lower-canopy foragers depend on an abundance of insect prey occupying leaf surfaces. While the guilds in this category might just as easily be considered "structural" in nature, we treat them as "functional" in terms of their relationship to specific pathways of energy flow in the ecosystem. For example, the structural guild "forest-ground nester" indicates the physical condition of the forest floor; while the functional guild "ground gleaner" indicates the degree to which trophic energy flow provides an abundant food source for top predators that forage on the forest floor.

Bark prober: Species that obtain prey from the bark of tree trunks, branches, or twigs.

Ground gleaner: Species that forage for invertebrates at ground level.

Upper canopy forager: Species that forage in the leafy canopy, generally above 5m.

Lower canopy forager: Species that forage in the leafy canopy, generally below 5m.

***Aerial screener:** Species that forage in the air column, by flying with mouth agape to funnel in flying insects. This guild was removed from the BCI because of its ambiguous interpretation along a gradient of human disturbance. For example, chimney swifts and barn swallows, which we consider foraging specialists, nest almost exclusively on man-made structures and are most common in severely-degraded environments.

***Aerial sallier:** Species that fly out from exposed perches to snatch flying insects, and then often return to the same perch. We removed the guild from the BCI due to ambiguous response along a human disturbance gradient. For example, the Acadian, least, and great-crested flycatchers typical of forested areas are replaced by Eastern phoebes, willow flycatchers, and Eastern kingbirds in more open environments.

Guild Category: Migratory

Resident: Species that commonly occur within the Mid-Atlantic Highlands throughout the year. Some of these species, e.g., American robin, may be at least partially migratory within the region. We consider residents to be generalists because they are present in the landscape in which they breed, if not their specific home range, throughout the year. Relative to migrants, we expect resident species to be better able to locate critical resources during times of stress (e.g., ephemeral water sources during drought). Because residents establish breeding territories earlier than migrants and do not have to curtail breeding late in the season to prepare for a lengthy and arduous migration, residents also have more opportunities throughout the breeding season to re-nest after a nesting failure.

Temperate migrant: Species that winter south of the Mid-Atlantic Highlands, but mainly within temperate North America, i.e., generally north of 30° latitude. We consider temperate migrants to be generalists because, like residents, they enjoy a long potential breeding season relative to tropical migrants. Earlier arrival and later departure dates than tropical migrants should make temperate migrants comparatively better able to cope with breeding season stresses.

***Tropical migrant:** Species that winter primarily within the New World subtropics and tropics, generally south of 30° latitude. We consider tropical migrants to be specialists for several reasons. First, they typically arrive on their breeding grounds later and leave earlier than temperate migrants and residents, leaving less time for tropical migrants to attempt to re-nest following a nesting failure. Second, tropical migrants endure long-distance migrations across inhospitable barriers (e.g., the Gulf of Mexico). Thus, the very nature of their migration poses hazards which temperate migrants and residents do not face. Finally, tropical migrants face impacts on their wintering grounds (e.g., pesticide exposure, critical habitat loss) that may deplete populations below levels that can be sustained by a stressed breeding population. We removed tropical migrants from the BCI due to high correlation with other guilds.

Guild Category: Number of Broods

Single-brooded: Species limited to the production of one brood per breeding season. Some species in this guild may be able to re-nest following an early season nesting failure. We consider single-brooded species to be specialists because their intrinsic rate of population increase is lower than that of multi-brooded species. Thus, single-brooded species are more vulnerable to population level disturbances than are multi-brooded species.

***Multi-brooded:** Species that typically attempt to produce two or more broods per breeding season. We consider multi-brooded species to be generalists relative to single-brooded species because multi-brooded species exhibit a higher intrinsic rate of population increase.

Consequently, multi-brooded species should be more resilient to the effects of population level stressors than single-brooded species. We removed this guild from the BCI due to high correlation with other guilds.

Guild Category: Origin

Exotic: Species native to ecosystems other than the Mid-Atlantic Highlands, but introduced and naturalized in the study region through human activities. We consider exotics to be generalists due to their close association with human-dominated environments and their adaptability in surviving and thriving in "new" environments.

Guild Category: Population Limiting

Nest predator/brood parasite: Species whose activities as nest robbers or brood parasites can affect populations of target species. We consider members of this guild to be generalists because of their relatively indiscriminate attacks on the nests of other species.

Guild Category: Nest Placement

Canopy nester: Species that nest in the tree canopy, generally above 5 m in height. We consider canopy nesters to be specialists due to the absence of a well-defined canopy in most agricultural and urban environments.

Shrub nester: Species that nest among herbaceous or woody vegetation, above ground level, but generally below 5 m in height. We consider shrub nesters to be generalists due to the prevalence of a well-developed shrub layer in forested, agricultural, and many urban environments.

***Native cavity nester:** Species native to the Mid-Atlantic Highlands that nest in natural tree cavities or artificial nest boxes. We consider native cavity nesters to be specialists due to the patchy distribution of suitable nest cavities across the landscape. We removed this guild from the BCI due to ambiguous behavior of the guild across a human disturbance gradient. For example, the woodpeckers typical of forested environments tend to be replaced by Eastern bluebirds and tree swallows in more disturbed environments.

Open-ground nester: Species that nest at ground level in environments that lack a forest overstory canopy. We specifically selected this guild as a means to help rank bird communities in agricultural .settings. We consider the guild to be specialist due to the guild's dependence on thick herbaceous ground cover in large patch sizes.

Forest-ground nester: Species that nest at ground level in forested environments. We consider forest-ground nesters to be specialists due to their dependence on appropriate forest floor ground cover and isolation from nest predators.

Guild Category: Primary Habitat

***Grassland:** Species that occur primarily in herbaceous old-fields, hayfields, and other prairie-like environments. We consider grassland species to be specialists due to the rarity of their primary habitat type in the study area. We removed this guild from the BCI due to its correlation with other guilds.

***Edge:** Species that occur in residential and shrub-dominated environments, or literally within ecotones of two or more habitat types. We consider edge species to be generalists because of the abundance of "edge" habitat in the Mid-Atlantic Highlands. We removed this guild from the BCI due to its correlation with other guilds.

Forest generalist: Species that occur primarily in forested areas, but use these forests relatively indiscriminately. These species display no obvious trends toward requiring forest interior versus forest edge habitat, and no specific relationship to forest patch size larger than the home range. We consider members of this guild to be generalists due to the abundance of forested terrain in the study area.

Interior forest obligate: Species that occur in forest, but tend to partition forest patches and make preferential use of interior forest conditions within a core area of the forest patch. Unlike area sensitive species, which simply require large forest patches, species in the interior forest obligate guild demonstrate an avoidance of forest edge in the patches in which they reside. We consider the species in this guild to be specialists due to their dependence on interior forest conditions within blocks of forest.

Appendix F: Administrative Record of ERMN Streamside Bird Protocol

The administrative record of the streamside bird monitoring protocol includes the following components:

F.1. January 2007 bird monitoring workshop attendees and minutes.

F.2. January 2007 water quality workshop participants, minutes, and outcomes.

F.3. March 2010 decision to discontinue specialized surveys for Louisiana Waterthrush but retain and shift monitoring focus to entire streamside bird community.

F.4. April 2013 decision to discontinue sampling at original sites in Delaware Water Gap NRA and New River Gorge NR and subsequently develop a new site selection scheme.

F.1. January 2007 Bird monitoring workshop attendees and minutes.

ERMN Bird Monitoring Workshop Minutes

Minutes compiled by: Brady J. Mattsson

1/12/07

Attendees: Brady Mattsson, Matt Marshall, Rob Brooks, Terry Master, Tim O'Connell, Su Fanok, Brad Ross, Bob Mulvihill, Jim Sheehan, Felicity Newell, Stephanie Perles.

Everyone that was invited attended the meeting, except for Petra Wood. Tim O'Connell and Su Fanok joined us via speakerphone.

Matt: there will be funds to hire seasonal bird technicians for at least a few years. He will eventually take the lead on implementing the bird protocol.

Brady presented his proposed bird monitoring protocol.

There seemed to be consensus that observers should record all bird species detected, not just focal species. The focal species, however, should have priority during surveys and especially LOWA.

Mulvihill: helped develop survey protocol for PA breeding bird atlas. They use five 75-second intervals during each point count. They classify birds as being within or beyond 75 m.

Brad: analyzing occupancy at the level of an individual point count would be more sensitive to changes occurring across a single watershed.

Brooks: suggested lumping multiple adjacent points in the analysis. He also suggested running multiple 1–2-km transects for a single watershed to account for variation within watersheds.

Mulvihill: countered that random sampling of 1–2-km reaches across watersheds should account for variation within watersheds.

Brad: FRHI has 1 good, 1 medium, and 1 poor-quality tributary, and these could be selected as Tier-2 watersheds (i.e., stressor gradient).

Matt: 2007 will be considered as a pilot year at minimum.

Brooks: can provide GIS data on geology for ERMN.

Mulvihill & Matt: throw out 25-m distance band and consider using 75-m band instead. This would enable comparisons with the PA breeding bird atlas. They also suggested ignoring evidence of nesting/mating status for all bird species, except LOWA.

There seemed to be consensus that I should also calculate BCI scores and abundance estimates.

Tim: consider adding DEJU & BHVI to list of focal species.

Felicity: LOWAs in W PA had lower clutch sizes, lower return rates, and lower pairing success in acidified streams compared to acid-neutral streams. LOWA breeding density, however, is a superior indicator of acidification.

Terry: consider recording breeding activities of ACFL to account for adelgid-related impacts.

Jim told Brady that there is no evidence that ACFL breeding success varies between hemlock and hardwood-dominated stands.

Terry & Bob Ross told Brady that they displaced point-counts away from stream if it was too noisy.

Bob Ross told Brady that Brad Nelson is conducting bird surveys at Allegheny NF for the past 1–2 years.

Mulvihill: Resident birds and LOWAs dominate the community until third week of April. After this point, spring migrants begin arriving and/or passing through.

Mulvihill: limit analysis to singing birds.

There seemed to be consensus that we should conduct point counts during both 4-week sampling periods.

Brad: tributary reaches within W PA parks are < 1 km, except for ALPO

Matt: suggested that we customize survey protocols for W PA parks.

Stephanie: streams will move over time within the valleys, so point count stations might need to shift as well.

EPA PIs: 0–4 LOWA territories per 1 km reach.

There seemed to be consensus that sampling 20–30 watersheds in each NERI & DEWA would be sufficient for making management recommendations.

Mulvihill: suggested placing autonomous recording units in focal watersheds to calibrate our detection estimates.

There seemed to be consensus that we should visit a subset of watersheds to collect more intensive data on LOWA territories (e.g., color-banding and nest monitoring) during late mornings, early afternoons, and the 1st 3 weeks in May. We could use Terry's sites for this. This will be useful for calibrating our estimates of LOWA density.

Rob: suggested conducting a Stressor Checklist as part of our bird monitoring. He also suggested that we prepare for shifting a transect if it intersects a dangerous waterfall.

Brady: we could mask out steep areas based on a 10-m resolution DEM.

Mulvihill: he has observed LOWAs defecating while foraging on many occasions. He suggested only including fresh splay in the analysis. Feeder streams (i.e., those that flow into main tributary streams) may influence LOWA use of the main tributary stream channel for a short distance downstream of each confluence, especially if the main channel is acidified or otherwise impacted.

Brady: we can use the density of feeder streams as a covariate in the analysis.

There was consensus that carrying a measuring wheel during surveys would be unnecessary. We only need to classify LOWA observations on a 250-m interval for the analysis.

Bob & Terry: Tim has point count data for C PA from EPA project (Tim left the meeting before we talked about this).

EPA PIs: open to collaboration on meta-analysis of relationships between fragmentation & LOWA nesting success.

F.2. January 2007 water quality workshop participants, minutes, and outcomes.

Eastern Rivers and Mountains Network
Water Quality and Quantity Protocol Development
January 10–11, 2007
School of Forest Resources
Penn State University

Workshop Outcomes as seen by Matt Marshall

The primary purpose of this two-day workshop was to clearly articulate the objectives of the ERMN surface water quality and quantity protocol so that Pete Murdoch and Scott Sheeder had a clear picture of what to design. Overall, I felt this workshop was definitely a success and greatly appreciate everyone's time, thought, and input. While we did make some headway on formulating the specific objectives needed to move forward, these still need work. For now, I include these slightly more refined objectives and also outline what I perceived to be the major breakthroughs or decisions around which the group coalesced. More detailed meeting "minutes", as recorded by Brady Mattsson, are also included below as is the contact information of all meeting participants.

Monitoring Questions

While we didn't begin the workshop with the following overriding monitoring questions, we did visit them briefly on the second day and they seemed to capture the general thinking of those involved with ERMN program development over the past several years.

1. What is the existing status and variability of select water quality parameters (concentrations and loadings) and flow within lotic waters of the ERMN parks?

2. What are the seasonal, annual and long-term trends in select water quality parameters (concentrations and loadings) and flow within lotic waters of the ERMN parks?

3. Are selected ERMN lotic waters in compliance with designated EPA beneficial uses?

4. Are the existing chemical and physical ranges at selected times and sites consistent with established Outstanding Natural Resource Waters or Special Protection designations?

In the end the group seemed to reach consensus on three primary areas or ways by which the water quality and surface water hydrology protocol could address these questions.

1. Large Rivers - mainstem.

Objective: Document seasonal, annual and long-term status and trends in flow and select water quality parameter concentrations and loadings at a subset of existing USGS flow gages in the five ERMN riverine parks.

Given the existing park-based monitoring at NERI, GARI, and BLUE, as well as the monitoring associated with the Special Protection Regs at UPDE and DEWA, along with other logistical and sampling constraints, it was agreed that we should narrow our "mainstem" focus to collocating additional work at existing USGS gages. This would also meet our desire to calculate loadings at select sites.

The six existing USGS gage sites selected cover each of our five riverine parks and are as follows:

Callicoon or Lordsville (UPDE); Montague (UPDE and DEWA); Portland (DEWA); Thurmond (NERI); Belva (GARI); Pipestem (BLUE).

It is proposed that a continuous monitor (datasonde with core parameters and perhaps turbidity) be placed at each site. In addition, quarterly (seasonal) depth and width integrated samples will be collected. These samples will be analyzed for a "full suite" of parameters including the core parameters, Special Protection Regs parameters, and some 303(d)-listed constituents.

Target population consists of six "index" sites selected based on the current location of a USGS flow gage. We recognize that these non-random "index" sites don't allow inference to the full length of the section of mainstem river occurring within each park, but do allow for a comprehensive, periodic assessment of the mainstem waters at the gage sites as they flow through park property.

Sampling frequency is continuous with datasondes and quarterly/seasonal for depth/width integrated samples.

2. DEWA and UPDE Special Protection Regulations and Boundary Control Points

Objective: Document deviations away from existing condition at the 28 established mainstem and tributary boundary control points as specified by the Delaware River Basin Commission Special Protection Regulations for DEWA and UPDE.

Consensus was reached that the ERMN should help support/augment monitoring associated with the existing Special Protection designations at DEWA and UPDE. This corresponds to roughly 14 mainstem sites (7 DEWA and 7 UPDE) and 28 tributary "boundary control points" (roughly 14 in each of DEWA and UPDE, respectively). Current monitoring is bi-weekly from May through September (10 grab samples per year) for essentially the core parameters. Existing condition and corresponding anti-degradation criteria have been (or currently are being) established for several other parameters. Which parameters will be included and how this integrates with item 1 above and 3 below is yet to be determined. This will be a cooperative effort between the parks and the ERMN with the details (logistic and financial) to be worked out. (Al, Don, and Rich will help us flesh this out).

Target population consists of roughly 28 index sites (a.k.a boundary control points) that are part of the Special Protection Regulations. Sampling frequency is yet to be determined.

3. ERMN Tributary Watersheds and Streams

OK. Here is where things get a little more murky.

Objective: Document change of "x amount or percent" or exceedence of thresholds (parameter specific) in core (and select other) parameters over "y period of time" within select lotic waters of each ERMN park. Implicit in this objective is that there is some random or probability based sampling scheme so that inferences can be made to broader areas than the sample location. It was also argued that x and y may be different for each park and parameter. It was agreed that we'll pursue this and work with Penelope to conduct power analyses and other simulations to help address this component.

So, how do we go about meeting this objective and learn as much as we can about these ecosystems? How also can we integrate among the other protocols (vegetation, soils, invasive species, macroinvertebrates, riparian birds)? Pete Murdoch presented a compelling case for designing a tiered program (4 tiers) with full integration among the tiers. His powerpoint presentation spells this out and gives examples such as the Collaborative Environmental Monitoring and Research Initiative (CEMRI) project that Pete spearheaded in the past and included work at DEWA. Briefly, the Tiers include 1) focal areas or watersheds with more intensive sampling to get at ecosystem processes. This is also where the other protocols could focus their efforts as well (e.g., collocate sampling); 2) gradient sites representing a range or gradient of known degradation due to current stressors and issues; 3) a broad, random survey of lotic waters; and 4) landscape scale / remotely sensed data and mapping.

I think the group clearly agreed that such an approach has tremendous value, but voiced a couple concerns over its appropriateness or financial applicability to the ERMN. First, the Tier – 2 or gradient sites may be more appropriately addressed in a research or special project context and thus fall outside the realm of Vital Signs (which should focus on general status and trends rather than particular issues). These gradient sites would be selected to address specific contemporary issues (acidic deposition, climate change, fecal coliform bacteria, outside park development). It was argued that it would be hard to select the most pressing issues, and we probably should not design too much around particular issues in a long-term program in case these issues don't turn out to be the issues we care about 10 yrs later. This notion was countered by the idea that Vital Signs better be doing something about current issues and helping management address them if we want to be relevant and keep our funding. Second, there was immediate concern given the budget framework and staffing scenarios presented by Marshall that the ERMN could afford all three tiers (Tier – 4 is going to be addressed in the ERMN Landscape Dynamics protocol).

Furthermore, there were other suggestions and concerns about selecting some sites like gradient sites and focal watersheds deterministically rather than with some probability based scheme. Finally, it was argued that the Tier 3 with a fully random design may be better approached by incorporating some stratification to control for known, underlying, unchanging, natural differences/variability among streams.

After much discussion, it was agreed that we would proceed by pursuing basically two paths. First, Pete agreed to develop a straw-man incorporating all three tiers to evaluate cost concerns and other issues. Second, we will also proceed with evaluating a second, slightly different, approach that the group seemed to coalesce around; a compromise or what I will term a hybrid approach. It basically

would turn out to be Tier 1 and a hybrid of Tier 2 and 3 (at least in my mind). Tier 2 (gradient sites) would be incorporated into the design by including the "percentage of the tributary watershed occurring outside park property or some other form of permanent protection". The idea is to capture in a broad general way a watershed's susceptibility to many of the stressors we know about or could occur down the road simply because the land area is not protected (we may want to consider private in-holdings as well). This would be the only "issue" we would design around explicitly.

Furthermore, tier-3 would not be fully random, but instead be a stratified random approach to selecting watersheds for sampling. The stratification would reduce variance and increase power to assess status and trend by controlling for underlying geology and stream order/watershed size. Thus, three criteria would be evaluated (geology or a surrogate, stream order/watershed size, and percent of watershed outside preserved areas). This process would unfold by first evaluating how many strata we have for each criterion, and thus how many classes of watersheds we have. We then select x watersheds from each class for sampling. This approach allows for park-wide inference (assuming all areas of the park fall into a class included for sampling).

This process would also result in a scheme that allows us to address and evaluate many "issues" if we are able to sample enough watersheds. These issues include residential development, acidic deposition, and even climate change if we are able to find watersheds largely protected or within park property without explicitly "designing" around them. A good blend of issue-driven monitoring and more general status and trends monitoring, in my mind.

Tier-1 sites (focal watersheds sampled more intensively and collocated with other vital signs) would be established in a subset of watersheds selected by the stratification process. For each stratum, we would have one (two?) focal watershed. How we choose to select focal watersheds remains an open question. Perhaps some type of "pairing" approach so we have "controls", or perhaps choosing sites based on high NPS resource value, or perhaps based on other factors like access, existing monitoring, importance to other vital signs, etc.

Over the next several weeks, then, Brady and Scott will begin the largely GIS-based exercise of assembling needed and appropriate data layers for the stratification. They will coordinate with Murdoch and Marshall, obviously, but also Piekielek, Perles, Young, and GIS specialists at parks to gather data layers. Murdoch will also draft a strawman of all 3 Tiers for evaluation and comparison.

As a side note (and there are may I did not include in this document), I am assuming that once we agree on a way to select watersheds for sampling, we then use the GRTS framework already started by Pete to determine where within each watershed we actually sample. It probably won't be just a single site (1 km reach), so we'll have questions about how many sites need to be sampled per watershed in addition to how many watersheds should be sampled per strata. Or perhaps we will just sample one point, per watershed (the "pour" point). Also an open question.

Finally, it should be noted that we may take a different approach to site selection in our four smaller parks (ALPO, JOFL, FONE, FRHI) for obvious reasons.

That's about it for now. I encourage and appreciate feedback.

Matt

Workshop Participants and Contact Information

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Workshop Minutes

Brady J. Mattsson

1/10/07

Water covers three vital signs, including hydrology, core water chemistry, and expanded water chemistry

Monitoring will trigger actions that could be to just conduct further, more intensive research to identify the source/cause of the trigger.

Park managers inform the ERMN PIs (henceforth, we/us/our) about their needs for monitoring.

Our protocols will augment and/or integrate with existing water sampling in the parks.

Some key Attendees:

Scott Sheeder: water PI, works at ALPO, FRHI, JOFL, FONE

Craig Snyder: studies ecological thresholds with respect to macroinvertebrates, incorporates levels of uncertainty, will evaluate management alternatives via structured decision analysis

Pete Murdoch: It's all about nested monitoring; An integrated multi-tiered (1–4) approach is best. Studied relationships between habitat fragmentation and soil/water chemistry at DEWA.

Tier 1: Focal watersheds. Conducted continuous monitoring of streams in three watersheds which corresponded with FIA points up-gradient of these stations.

Tier 2: Samples (sampled randomly or deterministically) along a gradient of interest. He sampled boundary control points.

Tier 3: Random sample (stratified or not) across entire study area. EPA-EMAP hexagons.

Tier 4: Landscape metrics (i.e., remote sensing) across entire study area for complete coverage. NLCD (30-m resolution), DOQQs (1-m resolution).

Pete's proposed example design for WV parks:

Sampling frame: all tributary watersheds that feed into park rivers.

Tier 1: continous monitoring stations in a few focal watersheds

100% forest

<100% forest

Tier 2: sample existing monitoring stations along a stressor gradient, e.g. Jesse's sites.

Tier 3: probability sample of 1-km reaches. 23,000 such reaches across ERMN in tributary watersheds. These reside in an excel spreadsheet and may be harvested.

Matt clarified that Tier-1 sites are hand-picked for targeted reason(s) as Pete has laid it out.

Beth indicated that vital signs monitoring is part of a larger effort that could integrate all existing data, not just data collected as part of this program. The goal of vital signs monitoring is to assess status/trends, as opposed to relate vital signs to changing climate and land uses. Monitoring not research.

Rich Evans: scale of management in DEWA is at boundary control points (BCPs).

Matt: needs of individual parks are the top priority for this program.

Brady's thoughts: this meeting would be more efficient if we would split into groups of 4–5 to tackle the specific questions laid out in the original agenda. However, it would be difficult to assign these groups to account for all the dimensions of the program: parks, networks, expertise, stake-holders, etc.

Al: BCP's are priority because of development threat

Jesse: interested in BCPs, but many of these points are inaccessible for monitoring at NERI/GARI. Therefore, he would prefer broader monitoring effort that accounts for all stream/river sections rather than focusing on threats of development.

Kathy: no BCPs in the W PA parks, only headwaters. Therefore, she also prefers a broader, more flexible sampling design. There are, however, opportunities for more watershed-specific trend monitoring, e.g. Brook Trout.

Craig: Tier 2 (gradient/issue) sampling could be funded outside ERMN vital signs, and the ERMN should focus on Tiers 1 and 3.

Rich: hemlock forests are disproportionately important (culturally and ecologically). Water quality, however, is the top priority in DEWA, including the main stem & tributaries.

Jesse: concerned about fecal coliform, primarily, residential development could become a problem, too. He really was not sure beyond this. He seemed a bit disenfranchised at this time point.

Rich: reservoir management and climate change are also important. He stressed the importance of demonstrating the health of the park, which promotes public approval of the national park system.

Jesse: agreed with Rich's last statement.

Brady's thoughts: need to coordinate with Matt & Pete to select sites before March!

1/11/07

Rich: do not stratify by conditions that can change over time. He noted that most 1st & 2nd order watersheds are completely within park boundaries. Most 3rd order watersheds, however, originate beyond park boundaries. One notable exception is Van Campen's Creek.

Matt: a fully random Tier 3 facilitates network-wide or national-level objectives, but this level of sampling is less useful to park managers.

Craig: Tier 2 can also accomplish these broader objectives if a stratified random sample is used.

Matt: tributary streams are defined as perennial streams that flow into the main stem.

Brady: suggested that we stratify by % of watershed inside/outside park.

Brady's thoughts: so, we are excluding intermittent streams?

Jesse: NERI 1st order streams are usually ephemeral, and there is only one perennial watershed with <10% of its area outside park.

Pete: advocates for establishing focal watershed(s), e.g. intensive monitoring on watershed entirely within park boundaries.

Jesse: suggested that we look at gradient of % watershed outside park and/or conservation lands rather than using a 10% cut-off.

Brady's observation: there is consensus that we need to sample watersheds <10% area outside park boundaries.

Rich: best to focus on 2nd & 3rd order streams.

Pete: Tier 2 is not necessarily based on random selection, these sites can be hand-picked across a known stressor gradient.

Jim: 30% of state forests are preserved, maps may be downloaded for free on-line.

Craig: we could stratify by bedrock types with respect to their relative acid-neutralizing capacity (ANC): basalt (high), clastic (low)

Stephanie: she knows geology classes with respect to ANC for DEWA

Craig: look at distribution of measured values for each stratum across ERMN to assess which strata have sufficient number of watersheds for statistical analysis. The simplest metric for bedrock geology would be % carbonate.

UPDE manager told Brady that we would need to contact private landowners before establishing transects unless these are on state game lands adjacent to UPDE.

John told Brady that he has a complete DEM map for DEWA, and he can send distribute this via CD.

F.3. March 2010 decision to discontinue intensive transect surveys for Louisiana Waterthrush but retain and shift monitoring focus to entire streamside bird community.

March 2010

The following describes a series of discussions and subsequent decisions between the ERMN Program Manager (and Streamside Bird Protocol Lead) and the ERMN member park resource managers. It was during this exchange, specifically, that the decision to discontinue the intensive transect surveys for Louisiana waterthrush was made. Below are the three emails sent by Matt Marshall and the responses received.

Email 1 from Matt Marshall to the following:
Don Hamilton, Rich Evans, Alan Ambler, Jeff Shreiner, Pat Lynch, Allan Ellsworth, John Karish, Kathy Penrod, Connie Ranson, Jesse Purvis, John Perez, Mark Graham, Caleb Tzilkowski, Andy Weber, Stephanie Perles, Kristina Callahan, Jaime Meyer, Jim Comiskey, Larry Hilaire, Scott Stonum, and Rich Egan.

> *All,*
>
> *I have been thinking about water and waterthrush since the review. Part 1 of this series is a quick breakdown of what we might "save" by cutting back on the streamside bird protocol. A few thoughts and then the options:*
>
> *1. Regardless of future savings, we are committed to a "full" season this spring. Money is obligated, techs are hired, and we start in 1 month.*
>
> *2. I would like to thoroughly (statistically and otherwise) evaluate the "costs" of these "savings" starting this fall. We'll have four years of data which may be enough. We had planned on something similar after the 5th year, but we can get started earlier in light of our collective thinking.*
>
> *3. I have been doing some hard thinking about the budget these past few days and water is not the only area that has needs. I am considering these savings in terms of allocation to other program areas as well. There was fairly strong sentiment at the review that Rare Riparian Plants and long-term stability of the Veg and Soils protocols are important. Both could use some help ($) as well.*
>
> *4. The streamside bird protocol can be trimmed back in a couple ways. I present two options below.*
>
> *5. As I said at the review, 15% of my time went onto the "streamside birds" part of the pie. This certainly bumped up the size of that pie slice. I could have left it out since you are all stuck with me regardless of how I allocate my time. But somebody has to lead the protocol and do some analyses. So, I present value with and without my time.*

Option 1. This option cuts the protocol essentially in half by either (Option 1A) dropping the "early" visits to each transect which focus exclusively on LOWA. Or (Option 1B) by cutting the number of visits to each site down to just 1 (instead of two). Option 1A would keep the same number of field techs, but cut the length of the season in half. Option 1B would keep the season length the same, but cut the number of technicians in half. There are some smaller tradeoffs and problems with both options, but for simplicity I use the same dollar amount for both.

Option 2. This option drops the two "early" LOWA transect visits AND one of the two "late" visits. So, essentially, the protocol is a single visit to each transect during early summer. We could still record LOWA data and do the Point Counts (for all bird species), but we would only visit each transect 1 time. Two technicians could accomplish this by starting at BLUE in late-May and work their way north all the way through DEWA (in theory).

Here are the numbers with "savings" for each option:

74776 Current: w/o 15% of Matt's = 16% of pie
92326 Current: w/15% of Matt's time = 19% of pie (this value presented at 3-yr Review)

37500 Option 1: Cut program in half = 8% of pie
55050 Option 1: w/ 15% of Matt's time = 12% of pie
37500 Option 1 savings

14865 Option 2: Cut program to only 2 techs for point counts (1 visit per transect) = 3% of pie
32415 Option 2: w/ 15% of Matt's time = 7% of pie
59911 Option 2 savings

Stay tuned for the next installment of "Water and Waterthrush",

-Matt

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~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

Email 2 from Matt Marshall to the following:
Don Hamilton, Rich Evans, Alan Ambler, Jeff Shreiner, Pat Lynch, Allan Ellsworth, John Karish, Kathy Penrod, Connie Ranson, Jesse Purvis, John Perez, Mark Graham, Caleb Tzilkowski, Andy Weber, Stephanie Perles, Kristina Callahan, Jaime Meyer, Jim Comiskey, Larry Hilaire, Scott Stonum, and Rich Egan.

OK, now let's talk about water.

Most of my/our thinking since the review has been on the comments from a variety of people that the ERMN should focus on a core, baseline, water quality program that is consistent with the I&M mission (status and trends of a few ecological indicators). For the sake of discussion, let's move away from the idea of the ERMN supporting the DEWA UPDE "Scenic Rivers Monitoring Program" and present a brief vision of what a sustainable, core, baseline, water program that focuses on a few indicators could look like. This is hard to do over email, but I wanted to float an actual idea or "model" as a strawman. It may also be more than just a strawman, I also tried to justify why I think this may be the best approach given available resources and our core mission. But it is all tradeoffs and pros and cons...

Three guiding thoughts:
1. Focus on the "core" water quality parameters (Temp, Conductivity, pH, DO) and perhaps turbidity. A lot of thought by a lot of people went into the decision to call these the "core" parameters; and for good (ecological) reason.

2. Focus on continuous monitoring via multiparameter sondes. This approach better captures the dynamic nature of these systems and the nested "layers" of variability inherent in wq data that is missed by the grab-sample approach.

3. Focus on what we (primarily Caleb, Andy, and Kristina) can accomplish in a self-sustained, reliable, and stable program. Build out from there with partnerships and the hope of more money in the future.

Monitoring Objective:
Document the status, variability, and long-term trends in core parameters at diel, seasonal, and annual time scales at selected sites within ERMN park units.

Limitations of this approach.
1. While continuous sondes capture data at a high temporal resolution, the obvious tradeoff is the lack of spatial coverage.

2. Limited to the core parameters.

What would it look like?
The idea is for us to manage and deploy a small "fleet" of continuous sondes. I am not sure how many we could actually handle in our fleet but let's start with 5–8 as a goal (phased in over the next few years). We have 2 currently that are ready for some form of pilot work this spring. This means a total of 8 sites monitored at any one time (did I mention lack of spatial

coverage?). We can increase the number of sites by going with a rotating/panel design (up to 24 sites across the ERMN if we "sample" every 3 years, for example). Or a combination of fixed and rotating sites. How do we choose the sites? Well, we look to you resource managers for that, but here are some ideas. Given the small number of sites that can be incorporated, we can take a largely hand-picked or "index" site approach. We could also use the "bird and bug" stratified random design and pick a stream in each meaningful strata ("index" site for that strata). Just ideas.

Or:
1. River sites. Lordville or Callicoon? Montague? Jesse has one at Thurmond (New River) already. Bluestone at Pipestem? Gauley or Meadow River? All could be co-located with USGS flow gages. Fixed or rotating? Justification: One site per river is not much, but would be the first data of its kind.

2. Protected trib sites. Dare I say "Tier 1" sites? Dowdy Creek, Bucklick Branch, Laurel Creek (Backus Mtn) are relatively "protected" by NPS ownership. As are VanCampens Brook, Dunnfield Creek, Caledonia, Dry Brook, and others. Justification: A long-term record of what is happening in our most protected sites seems like it would have a lot of value. These would be the "benchmark" sites against which other sites could be compared.

3. Resource value. Flat Brook jumps out. As does Blair Gap Run at ALPO.

Other thoughts:
1. What to do about the SRMP? I honestly don't know. One idea is not think of that program in a "monitoring" context but to think of it in a periodic "assessment" context. Essentially go out and find money every few years to do a good and thorough job "assessing" whether any degradation is occurring.

2. What to do about UPDE? We may have to keep some sort of partnership or extra money for UPDE on the table to do something more at this park since several other protocols are NOT being implemented there.

3. What to do about the small parks? Focus on ALPO.

4. Several other I&M Networks have taken the approach I describe above. Upper Columbia Basin Network has 3 sondes and 9 index sites in their program. Northern Colorado Plateau Network has about 9 sondes and 12–16 index sites in their program. UCBN has a very nice protocol and both networks have worked out many of the SOPs and issues. We could get up to speed quickly. Here are a few links if you are interested:

http://science.nature.nps.gov/im/units/ucbn/monitor/waterchem/waterchem.cfm

Example 2009 Annual Report:

> *https://science1.nature.nps.gov/naturebib/biodiversity/2010-2-22/UCBN_2009_WQ_Annual-Report_BIHO_20100222.pdf*

Example 2009 Resource Brief:

http://science.nature.nps.gov/im/units/ucbn/docs/Resource_Briefs/BIHO_WQ_ResourceBrief_20091012.pdf

http://science.nature.nps.gov/im/units/ncpn/WQBrief.cfm

So, hopefully you all did your homework on the drive home to help us make some decision soon. Call, email, whatever, ***but please give some feedback over the next week and a half. I see a conference call in our future...***

-Matt, Caleb, Andy and Kristina

Email 3 from Matt Marshall to the following:
Don Hamilton, Rich Evans, Alan Ambler, Jeff Shreiner, Pat Lynch, Allan Ellsworth, John Karish, Kathy Penrod, Connie Ranson, Jesse Purvis, John Perez, Mark Graham, Caleb Tzilkowski, Andy Weber, Stephanie Perles, Kristina Callahan, Jaime Meyer, Jim Comiskey, Larry Hilaire, Scott Stonum, and Rich Egan.

All,

I recently revisited all of your responses to the "Water and Waterthrush" Parts 1 and 2. I have them available as a word file if anyone is interested.

In sum:
1. Strong support for a modification to the LOWA portion of the protocol including dropping the "early" surveys from the protocol which, essentially, cuts the work/$$ in half. Final decisions will be based on analysis and a better understanding of what we would lose in addition to what money we would save. We'll end up considering a variety of options and then make a decision in time to implement changes next field season.

2. Strong support for the development of a water quality protocol based on a small fleet of continuous datasondes (core parameters + perhaps turbidity). We will go down this path. Starting this year (next month) Andy will deploy the two ERMN sondes and a loaner from Ellsworth at either DEWA or UPDE and manage them through the fall (monthly data downloads and calibration). A pilot run. Streams only this year. Rivers will come later. I will also use the entire $60,000 WRD funds for this year to purchase as many additional sondes (and accessories) as I can. Given contracting timelines, it is safe to assume they will not be available for use until next year. Next steps will occur over the winter when we come back to you to discuss sites (which, how many, and why). We'll develop a strawman to get the discussion going. I envision the ERMN managing a small fleet that would be rotated throughout the network. I also envision some fixed sites where a sonde is deployed every year. Park-based help (willingness to do monthly data downloads and calibration) will likely be essential for these fixed sites.

3. I think we can develop and implement a wq protocol based on sondes (see #2) without using all of the money we "save" from a modification to the Streamside Bird Protocol. I know that this discussion started with "cut back on LOWA to do more water", but other protocols

have needs too. We will beef up the water slice of the pie, but I want to be up front that I am constantly running through other financial scenarios as well. Specifically, I am trying to rework the budget to see if we can add another GS-7 technician to work with Stephanie and her programs.

Won't make any final decisions on any of this without further input from you all.

Thanks,
Matt

Below are all the responses received with the signature of the writer included. Responses are not ordered in any particular way.

Response 1

Matt,

After I sent my e-mail on water I realized my part 2 suggestion is not realistic - putting one at each park would be a disproportionate allocation of resources. A spatial-size weighting however, leaves out the small (and possibly mid-size) parks altogether. I looked at the acreages of parks yesterday, and realize one sonde for the four small parks is the best we can probably do. I'm not very familiar with FONE streams, but if there are any extras, two would be better than one. I don't think ALPO's data is transferable to FONE. (FRHI could use FONE data and JOFL could piggyback on ALPO.)

This is a draft table I was playing with to see what a "fair allocation" might look like. We are definitely constrained below optimum on the number of sondes.

[attachment "park acreages.xlsx" deleted by Matt Marshall/PHILADELPHIA/NPS]

Do you think I should cc everyone with these thoughts, or is it enough to have this discussion with you? I would not send the table as it is up to those parks to decide, not me - but I do think we could allocate so many per park and let the parks decide on a sampling design.

Thanks,
Kathy

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Response 2

Hi Matt and others,

I'm finally getting back to everyone on the water/waterthrush discussion:

Part 1:
I place a third vote for Option 1A, pending a more formal analysis of the options this fall. As Rich and Don mentioned, I also would like to see more than one visit per site. However, I was taught any sample size less than four is precarious. So, I'm not sure if two will be much better than one. Nonetheless, the early LOWA counts seem the logical place to cut - especially if LOWA are widespread, their value as an "indicator" species may not be very good. Matt suggested at the meeting that territory size may be responsive to watershed health, but I believe that goes too far beyond our monitoring objectives to quantify. Overall, I would like to keep some bird counts and get some data on their status. So, I am in favor of keeping this as a "reduced" vital sign.

What is the rationale/power to detect trends of other networks using only one point count per site per season?

Part 2:
I also like the idea of continuous sondes. I'm not sure I like the idea of totally dropping all small parks. I am concerned about the need to report on WQ status and the fundamental purpose of the network. Eight (or nine) sondes...nine parks... I'm thinking not to try to cover any tribs, but do try to get one "outflow" measurement from each park. If something is detected, it would mean additional reconnaissance to find the problem (which would likely be the park's responsibility). But, at least each park could have one point. The drawback is there would be no network-wide or park-wide inference, just a point-specific trends analysis. I doubt we are capable of getting enough points to make those inferences given the budget constraint anyway.

Regarding the suggestion to use the bird and bug stratified design - how many strata are there in total? This seems that it would also be problematic if more than eight or nine.

Skipping years (rotating panel design) - it seems that this would make it more difficult to detect trends - at three-year intervals, it could take 9–12 years before we see trends. If this is done, I suggest keeping the "basic" eight or nine sondes in place and rotating those in excess of eight or nine.

How important is flow data in detecting trends? I know it is important in dealing with issues - but, the network purpose is to detect the trend.

That's my thinking so far. I look forward to re-visiting this at the end of the sample season.

Kathy

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Response 3

Don Hamilton/UPDE/NPS

03/12/2010 04:28 PM

To Richard Evans/DEWA/NPS@NPS

cc Alan Ellsworth/PHILADELPHIA/NPS@NPS, Allan Ambler/DEWA/NPS@NPS, Andrew Weber/NERO/NPS@NPS, Caleb Tzilkowski/NERO/NPS@NPS, Jeffrey Shreiner/DEWA/NPS@NPS, Jesse Purvis/NERI/NPS@NPS, Jim Comiskey/FRSP/NPS@NPS, John Karish/PHILADELPHIA/NPS@NPS, John Perez/NERI/NPS@NPS, Kathy Penrod/ALPO/NPS@NPS, Kristina Callahan/NERO/NPS@NPS, Larry Hilaire/DEWA/NPS@NPS, Mark Graham/NERI/NPS@NPS, Matt Marshall/PHILADELPHIA/NPS@NPS, Patrick Lynch/DEWA/NPS@NPS, Scott Stonum/NERI/NPS@NPS, Stephanie Perles/PHILADELPHIA/NPS@NPS, Jamie Myers/UPDE/NPS@NPS, Richard Egan/Partner/NPS@NPS

Subject Re: Water and Waterthrush - part 2(1)

Matt and all:

Sorry it's taken a while to get back to you on this, but have had a few other things to focus on of late.

After reviewing the options presented, and discussing a vision for a future WQ monitoring program with Jamie and Rich, here are a few of our collective thoughts:

Option 1A seems to makes the most sense to transition into after this season. With another year of early visit LOWA data, you may have adequately established their status on these streams, against which future (multi-year interval) monitoring can be compared. The higher resolution data is nice for early detection of meaningful change, but might it also be detecting a change in this species' winter habitat, or a migratory weather event resulting in fatalities? And basing a measure of ecological health of riparian forests on (2) point counts of multiple species, and using a bird index that holds promise as a trends measure (and is being adopted by others), sounds like a good way to go.

The $37,500 ann. savings could purchase a number of sondes (5–6) with the core parameters.

What should we do about continued bacteria monitoring if we're relying heavily on sondes?

The SRMP will likely need to be thought of as a "periodic assessment" program, with the limitations on resources.

Higher priority tribs up here would likely be some we (may) have SPW standards established for.

We may be able to do more BMI trib sites here (with cooperative landowners), or deploy additional sondes in the river, as a more equitable sharing of network I & M funds.

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Response 4

Richard Evans/DEWA/NPS

03/02/2010 12:15 PM

To Matt Marshall/PHILADELPHIA/NPS@NPS

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Subject Re: Water and Waterthrush - part 2(2)

Thanks Matt for laying out these Options and the associated $$ savings (included below). Some thoughts:

I'm not sure how we could really save much $$ by removing Matt's time, because somebody else would have to do the work Matt has been doing (I assume Matt's doing real work here!), & that would cost $$. Also, Matt is an Ornithologist and quantitatively competent, so he's a

good person to do this work. So it seems we should include Matt's time in evaluating the Options.

I think we really need to analyze the bird data and identify the types and amounts of information we would lose by each of these Options before making a final decision. Having said that, I'm very sceptical and hesitant about Option 2, because the information provided by one visit per site may be too minimal to detect trends etc., which is the goal of this program. Random factors e.g. bad weather etc. become more influential with only one visit per site. We might be able to make inferences about the park as a whole, but I think much less likely to be able to make conclusions about each individual site. What about the western PA parks - would they only get one visit per site too? If so, I don't think that we'd be able to learn much from that, unless something drastic happened.

So I'm only considering Option 1 w/ Matt's time, which would apparently "free-up" about ~37,500. I don't know how much WQ work we could buy with this amount; it doesn't seem like a trivial amount (hey, it's more than half the amount of the WRD $$!), but it doesn't seem like a lot either. Hopefully, Matt, Al, Don, & Jesse could suggest what kinds of WQ info. we could buy with this amount.

Depending on results of analyzing the bird data, I'm inclined to suggest that we seriously consider this Option 1 for next year. At the ERMN review Matt & I talked about the possibility of conducting more intensive LOWA studies periodically, e.g. every 4 or 5 years, which would be really nice to do if we could. (Matt, is there an ecological rationale for choosing a time interval for this, e.g. LOWA life history patterns?)

I've been an advocate for continuous WQ monitoring for a long time, and I like the proposal to deploy sondes. My experience with WQ makes me think that it'd be more cost effective & valuable to get solid scientific information about diel variations in DO, for example, at one site, than a bunch of DO grab samples from several sites. Continuous sondes will capture temporary but potentially critical episodic events e.g. low DO, low pH, or high conductivity or turbidity, which grab samples are very unlikely to detect. The example from BIHO NB revealed how conductivity, pH, and turbidity all "spiked" as a result of a fire in the watershed upstream. This episodic event may be as - or more - important to the ecology of the stream than the usual prevailing conditions. The daily variation (variance) of parameters like DO, pH, & conductivity may be more important than the "typical" value captured by a single morning or afternoon grab sample value.

For reference, here are the numbers Matt provided for each option (I assume the numbers on the left are actual $$ amounts, e.g. $ 74,776 = 16% -right Matt?):

74776 Current: w/o 15% of Matt's = 16% of pie
92326 Current: w/15% of Matt's time = 19% of pie (this value presented at 3-yr Review)

37500 Option 1: Cut program in half = 8% of pie
55050 Option 1: w/ 15% of Matt's time = 12% of pie
37500 Option 1 savings

14865 Option 2: Cut program to only 2 techs for point counts (1 visit per transect) = 3% of pie
32415 Option 2: w/ 15% of Matt's time = 7% of pie
59911 Option 2 savings

- Rich

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Response 5

Hi Rich,

I still like Option 1 the best since we can include all birds but also keep the LOWA surveys - just not as many of them. June may not be the ideal time to survey LOWA, but they are still fairly conspicuous. Your point in your other email about random factors (particularly daily weather conditions) affecting individual surveys is very important and very true when it comes to counting birds. Cutting the first and last dates and keeping the middle two seems like a split that may lead to doing neither very well.

As for being logically consistent, I am open to a discussion of re-evaluating a few vital signs all together. The cons are the amount (time and $) we already invested in birds (not just LOWA) and the fact that "breeding birds" was the last VS to fall into the second tier. So, I kind of feel we're OK with breeding birds even if LOWA doesn't prove to be the primary component. Regardless of how we revamp it, LOWA should be called out as a key measure of the protocol and reported on.

You just want brook trout. I know. But, really, what VS would you advocate for if not birds?

As for LOWA on degraded streams: the literature shows that there are fewer (not always completely absent) birds, more unpaired males (fewer breeding pairs), larger territories, lower nesting success, and decreased use of the main channel (increased use of presumably less-impaired side channels and seeps) on degraded streams. What we're seeing is not inconsistent with what we knew going in. You weren't "sold" something - they do seem to respond to in-stream degradation (not JUST the overall riparian condition even though they respond to that TOO). However, I am not sure we appreciated how difficult it would be to

tease apart these more subtle responses over such a large area using the methods we proposed. We knew it would take effort/data, hence 8 temporal replicates. The studies that have shown this are similar to Terry's work where a few streams and breeding populations are studied in detail with banded birds and nest monitoring, etc. We thought we could get at measures like "pairing success", "number of intervals occupied (akin to territory size)", "use of main channel" (Brady had a whole section in the earlier reports on "channel birds" trying to get at this, but I nixed it because the reports were 50 pages long and full of AIC values, etc.), etc. But this is proving difficult - at least with 3 years of data.

So, I was/am trying to be honest about what is working and what isn't working with the streamside bird protocol. By saying at the review that we have some outliers where LOWA are present on streams we know are impaired may have overstated things a bit and hastened their demise ("axeing the LOWA"). Across the 61 sites in the ERMN we do have a gradient. Many streams seem to be occupied by 4 breeding pairs per transect (the theoretical max). Many sites have all 4 intervals occupied by LOWA, but only 1–3 confirmed breeding pairs. Many sites have fewer than all four intervals occupied. Some sites have no LOWA at all.

Does this gradient ONLY reflect in-stream condition. No. But I certainly hope you never thought it would. I thought we were pretty clear all along that LOWA respond to instream condition, the riparian zone, and even the surrounding forest cover/structure. Which is why I was never an advocate of doing LOWA instead of benthic macros (as Brady thought possible). LOWA just provide part of the story. To me, the premise was that we have a bird species that responds to all the usual terrestrial stuff but ALSO responds to instream condition. That is what made it attractive.

AMD is also an interesting stressor in that a stream's contributing watershed can be in great shape, but you have this point source trashing the stream itself. Our outlier (Ice Pond Run at FRHI) is an otherwise "nice" watershed but has a severe AMD problem. LOWA are present, nest along the stream, but are not foraging in the stream. Does this invalidate LOWA as an indicator? I don't think so (unless you think LOWA only reflect instream condition, then yes). But it does make interpretation much harder (What are they indicating?) which violates a key attribute of a good indicator.

More later,
-Matt

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Response 6

Richard Evans/DEWA/NPS

03/02/2010 02:20 PM

To Matt Marshall/PHILADELPHIA/NPS@NPS

Subject Riparian Bird monitoring(1)

Matt,

Just another idea about how to "slice the pie": In your response to Jeff, you indicated that LOWA are pretty quiet by the last surveys. How about cutting the first and last dates, and keeping the middle two (and keeping the LOWA surveys, not just the point counts)? We started this VS based on LOWA; if we get rid of good LOWA surveys, maybe we should revisit the rationale for and value of this VS (to be logically consistent).

Also, I was surprised to learn at the ERMN review that LOWA at NERI nested adjacent to some pretty severely polluted streams. I thought the premise here was that LOWA would respond to stream degradation, and that the science of that had been pretty well worked out by Brady, Master, etc. I guess LOWA are better indicators of riparian condition (?).

-Rich

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---

(1) –

1. Seems like the only way to do it since we have already invested so much. The more I think about this the more I realize that we will scale back in some way...no other vital sign is measured so intensively.

2. I too like the bird index and as it turns out NETN, NCRN and probably MIDN will be using the index as well (based on a single visit to each site I believe). Hope it is not just bitterness that brook trout and bog turtle weren't included. Just kidding.

3. We were working towards being able to estimate the occupancy/abundance of LOWA with a high degree of precision - hence the temporal replication (multiple visits to the same

transect in both the early spring and during june). Assuming good estimates with high precision, we could detect meaningful changes sooner rather than later. Moreover, we were working towards using more ecologically informative measures like breeding pairs, stream use (as opposed to side channels and seeps), etc. than we could detect using point counts (which give us estimates of "singing male birds"). LOWA are also pretty quiet come June when we do the point counts because they are such early breeders. Point count data is also inherently "noisy" so, presumably, our ability to detect changes is less than what we could have achieved with more intensive effort on this riparian obligate species.

4. We are the only network/agency that I am aware of that has attempted to use LOWA in such an intensive effort. However, several agencies/groups are using a course measure of LOWA presence or something similar in broader riparian assessments.

5. We certainly could. Or if we pick a couple "focal watersheds" for more intensive wq monitoring or something, we could focus additional LOWA attention there instead of everywhere. I am most curious to see how well our current point counts track what we are finding with the more intensive LOWA surveys. Our first look at this in the 2007–2009 reports was somewhat inconclusive.

Thanks for the questions/comments. Keep 'em coming...

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Response 7

Jeffrey Shreiner/DEWA/NPS

03/02/2010 08:40 AM

To Matt Marshall/PHILADELPHIA/NPS@NPS

cc Alan Ellsworth/PHILADELPHIA/NPS@NPS, Allan Ambler/DEWA/NPS@NPS, Andrew Weber/NERO/NPS@NPS, Caleb Tzilkowski/NERO/NPS@NPS, Don Hamilton/UPDE/NPS@NPS, Jesse Purvis/NERI/NPS@NPS, Jim Comiskey/FRSP/NPS@NPS, John Karish/PHILADELPHIA/NPS@NPS, John Perez/NERI/NPS@NPS, Kathy Penrod/ALPO/NPS@NPS, Kristina Callahan/NERO/NPS@NPS, Larry Hilaire/DEWA/NPS@NPS, Mark Graham/NERI/NPS@NPS, Patrick Lynch/DEWA/NPS@NPS, Richard

Evans/DEWA/NPS@NPS, Scott Stonum/NERI/NPS@NPS, Stephanie Perles/PHILADELPHIA/NPS@NPS

Subject Re: Water and Waterthrush - part 1(1)

Matt et al.

The plan to analyze the data-cost of reducing the number of samples makes sense.

I never favored centering a vital sign around a single species and was glad that the point counts have been incorporated. I was also pleased to learn about the bird index which, though not tested over time, holds promise as a trends measure.

What do we lose by dropping the early season LOWA work, in terms of measuring the ecological health of the riparian forests?

How widespread is the use of LOWA vs point counts across networks or agencies?

Could we consider an intensive LOWA component every 5 years or something like that, to supplement annual point count data?

==========

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(1) - Notes:///85256D75004888B2/38D46BF5E8F08834852564B500129B2C/F3454DE842B10A21852576D400569D91

You are correct and I still feel justified in using the funds in support of the SRMP for that reason. The only constraint is that we measure the "core" parameters if we measure anything at all. We're already doing this. So we've met the contraints. WRD has also said to me that we could use the the money to support the benthic macro program if we decided to (for example) so long as we continue to also measure the core parameters. The point is that WRD seems pretty relaxed on how the money is used as long as everyone in the ERMN is happy with how it is being used.

I should also add that what I proposed does not preclude us from using the data in a regulatory framework. It would obviously be limited to the core parameters, but if a state regulatory criteria says something like DO cannot go below 8.0 mg/l on any given day or below 9.5 mg/l for a "7-day mean" we could use the data collected in this regulatory way. (see attached resource brief for BIHO as an example of what I just described).

The biggest problem I see for the SRMP is that the DRBC protocol calls for bi-weekly sampling for 5 months. In other words, a different sampling protocol. However, we may be able to do something that DRBC says is OK (like "pull out" 10 samples from the continuous record on days when Al would normally collect a sample following the SRMP protocol). But, again, only for the core parameters. The other really big problem/shortcoming is that nutrients are a key part of the SRMP objectives and that would obviously be dependent on other money (in the current, but by no means final, proposal).

I don't necessarily see what I proposed most recently as being completely incompatible with the SRMP. It would obviously be a subset of the parameters and number of sites. And would require working with DRBC to see if we could develop a way to use the continuous data in the SRMP regulatory arena. That may be a good question for Al to ask Bob Limbeck.

By the way, you are the first to send any comments/questions whatsoever. Please keep them coming.

[attachment "BIHO_WQ_ResourceBrief_20091012.pdf" deleted by Matt Marshall/PHILADELPHIA/NPS]

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Response 8

Jeffrey Shreiner/DEWA/NPS

03/01/2010 01:07 PM

To Matt Marshall/PHILADELPHIA/NPS@NPS

Subject Re: Water and Waterthrush - part 2(1)

Matt: somewhere I got the idea that the WRD $ are earmarked for regulatory monitoring, hence the support of the SRMP for DEWA/UPDE. What are the constraints, if any, on these funds? Please clarify. Thanks.

==========

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(1) - Notes:///85256D75004888B2/38D46BF5E8F08834852564B500129B2C/54DCCDEDC41E35EA852576D40064422F

F.4. April 2013 decision to discontinue sampling at original sites in Delaware Water Gap NRA and New River Gorge NR and subsequently develop a new site selection scheme.

Background and Purpose of Sampling Design Review

In February, 2013 the Eastern Rivers and Mountains Network (ERMN) initiated a review of its Streamside Bird and Wadeable Stream (a.k.a., Benthic Macroinvertebrate) monitoring protocols. While this type of review is not nationally formalized across the I&M Program in the same way that the "3-year start-up reviews" occurred, it is essential that each monitoring protocol is reviewed early (and continuously) in the data collection process to allow for any needed corrections and modifications to occur.

This review coincided with the final internal review of the Wadeable Streams protocol (just prior to sending the document to external reviewers) and occurred less than one year after publishing Version 2.0 of the Streamside Bird protocol. Regardless of protocol completion/publish status, each had been implemented (i.e., data collected) for five (Wadeable Streams) and six (Streamside Birds) years, respectively.

The review focused on the Sampling Design (i.e., where we sample and how those sites were selected). It is important to note that almost every *other* aspect of each monitoring protocol (e.g., field methods, field logistics, lab methods, hiring, training, safety procedures, data management, data analysis, reporting, budgeting, contracting, etc.) was continuously evaluated and modified during the prior 5-6 years of protocol development. All of these decisions and modifications have been incorporated into the most recent versions of the protocols. That said, the sampling design has *not* been thoroughly reviewed since it was peer-reviewed during 2009 as part of the Streamside Bird protocol peer-review process.

A very succinct description of the sampling design used at Delaware Water Gap NRA and New River Gorge NR is as follows (with details provided in the protocols):

<u>Sampling Design/Sample Site Selection:</u>
The sampling design was a two-stage design: Stratified random sampling during the first stage and simple random sampling during the second stage. Stream "segments" (i.e., length of stream between a confluence and the park boundary) were selected for inclusion during the first stage and subsequently (the second stage) sampling sites (a.k.a. reaches) were selected from within each stream segment identified during the first stage. Each stream segment had a maximum of one sampling site (reach).

It should be noted that the Cooperator developing the Streamside Bird Protocol employed this sampling design including the stratification component based on the explicit recommendations of NPS (ERMN, member park, and WRD), USGS (NY Water Science Center and Leetown Science Center), and University subject matter experts convened to discuss protocol development in 2007. At the time, the overriding objective was to "relate attributes of the bird community (in an occupancy framework) existing along ERMN tributaries to conditions of the surrounding watershed in an effort to guide management actions in these parks. We define tributary watersheds as those that contain ≥ 1

km of contiguous 1st-3rd order stream length within park boundaries" (Mattsson, protocol version 0.1, March 2007). To reiterate, there was emphasis placed on larger, "management relevant" streams and to select among streams based on characteristics of their contributing watersheds. Moreover, the explicit analysis approach was intended to be occupancy modeling and the target taxon was birds even though we had always intended for a common sampling design for multiple protocols.

A key point of this document is the recognition that the monitoring objectives shifted somewhat over the years from occupancy modeling of birds in "management relevant streams" (and how watershed characteristics affect bird community attributes) to a more general status and trends objective across wadeable streams, multiple taxa, and analyses including, but not limited to, occupancy modeling. Portions of the discussion below should be interpreted in that light.

Goals of the Review

The review began internally (ERMN staff) to evaluate whether:

1. The target population/sampling area ("wadeable streams") had been consistently and accurately defined and identified across all parks and park areas;

2. The intent and benefits of the stratification process used to select sites at Delaware Water Gap NRA and New River Gorge NR are being met;

3. The sampling design produced a random, representative, sample of wadeable streams that can be analyzed appropriately and effectively; and

4. Co-locating benthic macroinvertebrate sampling sites (the core of the Wadeable Streams protocol) and fish sampling sites (recently funded as of 2012 project to evaluate if the ERMN can add a Fish Monitoring Protocol) with sites selected for Streamside Bird monitoring is justified and can meet each protocol's objectives.

As the ERMN staff was discussing and conducting analyses to address these review goals, additional issues and questions arose. The ERMN then assembled and had multiple meetings with a group of trusted, external (non-NPS), subject matter experts to discuss a number of topics.

<u>The group included:</u>
Duane Diefenbach, USGS Pennsylvania Cooperative Fish and Wildlife Research Unit
Tyler Wagner, USGS Pennsylvania Cooperative Fish and Wildlife Research Unit
Walter Tzilkowski, Penn State Professor of Wildlife Ecology (retired)
Laura Leites, Penn State Assistant Professor of Quantitative Forest Ecology

Each of the above review goals and other topics that arose during the review process are addressed case-by-case in the section below.

Review Topics

1. *Evaluate whether we have consistently and accurately defined and identified the target population/sampling area ("wadeable streams") across all parks and park areas.*

The intent of both current protocols (and the anticipated fish monitoring protocol) was to sample and make inferences to perennially flowing wadeable streams of member parks. This target sampling area was identified in a GIS environment using Digital Elevation Models (DEMs) and flow accumulation modeling in 2007 prior to fieldwork. "Wadeable" was defined as a stream with a catchment area between 1 and 100 km^2. "Streams" with catchment areas <1 km^2 were defined as "ephemeral" and removed from the target sampling area. "Streams" with catchment areas > 100 km^2 were defined as "not wadeable" (i.e., "small rivers") which are not safely wadeable or feasible to sample for either protocol; thus excluded from the target sampling area.

Based on the collective field experience of ERMN personnel between 2007 and 2012 at the parks, these *a priori*, GIS-based definitions, while not perfect, adequately reflected conditions in the field and the decision was made during this review to keep the 1-100 km^2 criteria for defining wadeable streams moving forward (NOTE: it was later decided to increase the minimum flow accumulation to 2 km^2). However, we wanted to be sure that consistent methods and criteria were employed during the flow accumulation modeling exercise. To that end, the ERMN Data Manager completely "re-did" the analysis in a consistent manner for all ERMN parks. In the end, the results did not differ substantially from the effort conducted in 2007 by the Cooperator developing the Streamside Bird protocol. Listed below are the exceptions:

New River Gorge NR: The ERMN Data Manager identified five streams within the park boundary that met the 1-100 km^2 criteria that were NOT included in 2007 (Coal Run, Rush Run, two UNTs to Laurel Creek, and one UNT to the New River upriver of Fire Creek). Three streams included in the target area in 2007 (none of which were selected for sampling) did NOT meet the criteria when the analysis was "re-done" (one UNT to Mann's Creek, one UNT to Buffalo Creek, and one UNT to Meadow Creek). With the exception of Coal Run which appears to have simply been "missed" in 2007, the remaining streams were all "borderline" in size (each was approximately 1 km^2) and the inclusion/exclusion decision was likely an artifact of slight differences in methods.

Delaware Water Gap NRA: All streams segments meeting the criteria in 2007 also met the criteria when "re-done" by the ERMN Data Manager in 2013. In addition, the ERMN Data Manager identified seven streams within the park boundary that met the 1-100 km^2 criteria that were NOT included in 2007 (Crawford Branch, UNT to Bushkill Creek, UNT to Delaware River, two UNTs to Vancampens Brook, UNT to Flat Brook, and UNT to Sandyston Creek).

Sampling sites at the remaining six parks were selected in a different manner (i.e., a targeted approach) but the intent was to define "wadeable streams" the same way.

Gauley River NRA: Approximately 25 additional short stream segments were identified in 2013 (as a result of #2 below).

Bluestone NSR: Two additional short stream segments identified in 2013.

Allegheny Portage Railroad NHS: No differences.

Johnstown Flood NMem: The South Fork of the Little Conemaugh River (SFLCR) has a flow accumulation >100 km^2 and is therefore categorized as a "small river".

Fort Necessity NB: Two stream segments included in 2007 [(UNT Scotts Run (Picnic Loop) and UNT Scotts Run (Rankin Road)] did not meet the minimum 1 km^2 flow accumulation criteria and are now considered "ephemeral".

Friendship Hill NHS: No differences.

Possible solutions or changes include:
A. No change. Ignore the differences discovered between the 2007 and 2013 flow accumulation modeling efforts given that the differences were slight.

B. Include stream segments identified in the 2013 effort for New River Gorge NR and Delaware Water Gap NRA by assigning them a random number and sampling them if the random number dictates (and exclude appropriate stream segments).

C. Include/exclude as appropriate based on an entirely new site-selection scheme.

2. *Quantify and evaluate decision to exclude stream segments <1 km in length.* The sampling unit for the Streamside Bird Protocol was a 1 km stream reach with five point count stations spaced at 250 m intervals along the reach. The protocol describes why this length was chosen, but a consequence of this choice was that all stream segments that met the "wadeable" criteria described above but were <1 km were removed from the target area *a priori* because they were too short to contain the streamside bird sampling unit. This decision and the number of affected streams/stream segments was clearly acknowledged and presented in the protocol. However, the cumulative stream length affected was never quantified.

Based on the 2013 analysis conducted by the ERMN Data Manager, New River Gorge NR contains 125 wadeable stream segments with a cumulative length of 155.9 km. Seventy one (71) stream segments were individually <1 km and excluded *a priori*. These 71 stream segments total 29.6 km (19% of total wadeable stream length).

Delaware Water Gap NRA contains 90 wadeable stream segments with a cumulative length of 134.9 km. Forty seven (47) stream segments were individually <1 km and excluded *a priori*. These 47 stream segments total 20.9 km (15% of the total wadeable stream length).

It was a surprise to ERMN staff and was a concern that we excluded such a large percentage of our supposed target area ("all wadeable streams") as a result of this decision. In retrospect, given the overall size and variable shape of the park boundaries, a 1 km sampling unit seems "too big". Moreover, only the Streamside Bird protocol called for a 1 km reach length. The Wadeable Stream sampling unit is 150 m to 500 m depending on stream size and the proposed Fish Monitoring sampling unit is a fixed 100 m sampling unit.

Possible solutions or changes include:
A. No change. Accept and clearly articulate (through maps and descriptive summaries) that the actual target population is not ALL wadeable streams, but only wadeable streams consisting of segments > 1 km within the park boundary. Indeed, this is explained in the current protocol(s) and has the benefit that most sampling is being conducted along "main stems" of the primary park streams as opposed to small (but "wadeable") segments near the park border, for example.

B. Incorporate the 29.6 km (NERI) and 20.9 km (DEWA) of wadeable stream, respectively, not currently included in the target population. This could be accomplished by adding sites (i.e., a new stratum) to the current design.

C. A new site-selection scheme that explicitly includes (rather than explicitly excluding) these areas. Note that it is likely that some change to the 1 km streamside bird sampling unit would need to occur if co-location of the various protocols is still desired.

3. *Evaluate the stratification used to select sites at New River Gorge NR and Delaware Water Gap NRA.* As fully described in the protocols, stream segments were selected for inclusion based on four characteristics of their contributing watersheds (watershed size, watershed bedrock geology, percentage of watershed protected by NPS or State Park ownership, and watershed topography). Each of these four continuous variables was broken into two classes; "high" and "low" (e.g., "large watersheds" and "small watersheds"). Four variables and two classes per variable resulted in 16 different strata. Again, it should be noted that the Cooperator employed this design based on the explicit recommendations of NPS (ERMN, member park, and WRD), USGS (NY Water Science Center and Leetown Science Center), and University subject matter experts convened to discuss protocol development in 2007. Regardless, with so many strata it was inevitable that many strata would not have any candidate stream segments. Indeed, nine of the 16 strata at New River Gorge NR had 0 (8 strata) or 1 (1 stratum) candidate stream segment(s). Similarly, 11 of 16 strata at Delaware Water Gap NRA had 0 (5 strata) or 1 (6 strata) candidate stream segments. This resulted in a situation where the potential benefits of stratification (variance reduction) could not necessarily be realized because a stratum-specific estimate of the variance could not be estimated.

Possible solutions or changes include:
A. No change. The number of strata, in itself, is not an insurmountable problem with the sampling design and, indeed, was an intentional component. However, in retrospect, it seems unnecessarily complicated (also see #4 below) and perhaps not beneficial to have so many strata and such a large proportion of strata without candidate streams. Moreover, it is unclear what, if anything can be done with strata represented by only one stream segment (other than compare it to itself over time).

B. It is possible to remove the stratification *a posteriori* and the ERMN Program Manager explored the implications of doing so by re-sorting (without stratification) the candidate stream segments based on their original random number. Not surprisingly, a number of streams segments originally included due to strata membership would be excluded and vice versa. Assuming we sampled the same number of sites, we would have to add three new sites and drop three currently sampled sites at New River Gorge NR (relatively minor adjustments). The sites included would remain the same at

Delaware Water Gap NRA because all candidate stream segments were ultimately included (which highlights another analytical issue to contend with: finite population correction factor approaching zero such that the variance approaches zero).

C. Develop and implement a new sampling design.

4. *Two-stage Sampling Design.*

a. The first stage of the two-stage sampling design called for selecting stream segments in a stratified random manner. The stratification is described above where each stream segment was assigned a random number and stream segments were selected based on strata-membership and random number. All stream segments, regardless of length, had equal probability of inclusion within a stratum. In retrospect, it would have been better to weight each stream segment according to its length so that longer segments (contributing more stream length to the total target area of "wadeable streams") had a higher probability of inclusion.

b. The second stage of the two-stage sampling design called for a simple random selection to determine the actual sampling site (i.e., "reach") within each of the stream segments (selected during stage one). Again, only a single, 1 km reach was selected for sampling within each stream segment. In retrospect, it would have been better to have selected at least two sampling reaches per stream segment (and perhaps select multiple reaches in proportion to stream length). In classic multi-stage sampling, the idea is to estimate a variable of interest and its variance among primary sampling units (stream segments) by first estimating that variable and its variance within each primary sampling unit based on the secondary sampling units (reaches). Here, again, without multiple reaches per stream segment it is not possible to calculate a variance. It should be noted that there was some discussion during the 2009 peer review of the streamside bird protocol over whether or not the five point count stations (for streamside bird monitoring) could serve as within-stream segment replicates. Regardless, there is currently no analogue for benthic macroinvertebrates and nothing similar planned for fish.

c. During the 2013 review of the two-stage sampling design, it came to the Program Manager's attention that the secondary samples (reaches) were chosen by randomly selecting either the most upstream or most downstream end of the stream segment (meaning that all sampling sites were either at the park boundary or the confluence with another stream segment or the river). This also meant that for any stream segment > 2 km in length, the "middle" section had no chance of being selected. Eight stream segments at Delaware Water Gap NRA have a "gap" in the middle and four stream segments at New River Gorge NR have a "gap" in the middle.

Possible solutions or changes include:

A. No change. Items 4a and 4b are not insurmountable problems with the sampling design. It is possible to calculate the actual inclusion probability for each sampling site and incorporate these (in the forms of weights) into all future analyses. That said, longer stream segments would have higher weights and all "weighting" would be based on a single sampling site per stream segment. There are many reasons why we may not want to assume that the single sample per stream segment is representative of the entire stream segment and weight it accordingly.

Item 4c is also not an insurmountable problem. It is possible to add additional sites to fill in these "gaps". Several possible ways have already been considered. That said, the two-stage sampling design not only would have to explicitly incorporate stratification in all future analyses, but also calculate and incorporate site-specific weights into all future analyses. It is unclear at this time how these weights can be incorporated into some analysis frameworks such as occupancy modeling (although complex extensions could possibly be developed).

B. Develop and implement a new sampling design.

Conclusions

After considerable thought and discussion (and angst) particularly given the substantial investment in data collection that has already occurred, the ERMN has decided to develop and implement a new sampling design at New River Gorge NR and Delaware Water Gap NRA. While the current design selected sites in a "random" fashion and is likely to be "representative" of the target population of wadeable streams, it is certainly not without substantial problems. None of the problems identified, individually, are truly "fatal" resulting in a decision to scrap the entire design. However, in total, the design and required "fixes" are overly and unnecessarily complex (stratification + multi-stage + weighting + "gap-fixing") leading to extremely complex analyses for the duration of the monitoring program. It is also likely that some future analysis that would be desirable may not be possible given the complexity. A long-term monitoring program should not be based on a sampling design that is so complex that very few individuals actually understand all the nuances, changes, and statistical implications. It seems likely that stakeholder trust and confidence will be severely impacted if they cannot understand how sampling sites were selected.

Despite the obvious implications of developing and implementing a new site selection scheme (e.g., reduced value of the investment in data collection thus far) it seems preferable to make changes now that result in a clear, understandable, and defensible sampling design to carry the program into the future. Moreover, several other issues can also be addressed simultaneously including:

1. Properly addressing topics 1 and 2 above.
2. Defining a "sampling unit" that properly corresponds to streamside bird, benthic macroinvertebrate, and stream fish sampling.
3. Addressing some concerns with "stream noise" and a fairly narrow area of inference (100 m buffer around wadeable streams) associated with the Streamside Bird protocol.
4. Developing a more flexible sampling design where the number of sites sampled can vary by protocol (depending on objectives) and over time (depending on resources available).

Appendix G: GAR (GREEN-AMBER-RED) Risk Assessment Model.

This appendix describes application of the GREEN-AMBER-RED (GAR) Risk Assessment Model as outlined in the NPS Operational Leadership Student Manual (Version 2; July 2011) to the ERMN Streamside Bird Monitoring Protocol.

The GAR model allows for a general assessment of a task or operation and generates communication concerning the risks of an activity (in this case, conducting the field-based activities of the ERMN Streamside Bird Monitoring Protocol). The most important part of the process is the team discussions leading to an understanding of the risks and how they will be managed.

The GAR is a seven step process. Each step is defined and explained in the context of the ERMN Streamside Bird Monitoring Protocol below.

Step 1: Define the Mission or Task

The ERMN Streamside Bird Monitoring protocol includes a field-based activity of surveying birds along forested streams in ERMN member parks (SOP 2 – Field Crew Training and Safety). Individual field crew members are part of a team, but work independently when conducting the activity. The activity is conducted away from roads and trails and the terrain can be extremely rugged and steep. Numerous potential safety hazards including operation of motor vehicles (along with mitigation measures) have been identified in a Job Hazard Analysis (JHA; SOP 2 – Field Crew Training and Safety). Of specific concern is that crew members will regularly be hiking adjacent to, and periodically wading through, flowing surface water (i.e., streams and small rivers) in narrow, steep, ravines. A drowning fatality is possible and is the most severe risk encountered when conducting this activity.

Step 2: Define the Threats

The threats/hazards for this activity along with mitigation measures are described in the associated JHA (SOP 2 – Field Crew Training and Safety).

Step 3: Assess Risk and Assign a Numerical Value

The initial numerical ranks (Table G.1) were assigned by Matt Marshall the ERMN Program Manager and the Protocol Lead for the ERMN Streamside Bird Monitoring Protocol. It should be noted that at the time numerical values were assigned (January 25, 2012) the protocol had been in operation for five years and considerable time and effort had already gone into evaluating and mitigating risks.

The following text explains the process as described in NPS Operational Leadership Student Manual (Version 2; July 2011):

To compute the total level of risk for the activity, assign a risk code of 0 (For No Risk) through 10 (For Maximum Risk) to each of the eight elements below and then total the risk codes. This is the Total Risk Score and is your personal estimate of the risk.

SUPERVISION

Supervisory Control considers if supervision is present, how qualified the supervisor is, and whether effective supervision is taking place. Even if a person is qualified to perform a task, supervision acts as a control to minimize risk. This may simply be someone checking what is being done to ensure it is being done correctly. The higher the risk, the more the supervisor needs to be focused on observing and checking. A supervisor who is actively involved in a task (doing something) is easily distracted and should not be considered an effective safety observer in moderate to high-risk conditions.

PLANNING

Planning and preparation should consider how much information you have, how clear it is, and how much time you have to plan the evolution or evaluate the situation, and the presence of Standard Operating Procedures or Pre-Plans.

COMMUNICATION

Communication should include physical (dispatch present, effective repeaters) communication and as assessment of personal communication among team members (assertiveness, climate that values input, high degree of accountability) and the presence of briefs and debriefs.

CONTINGENCY RESOURCES

Contingency resources refer to readily available trained assets, and whether there is an established agreement and SOP with the cooperating agency (i.e., local law enforcement agencies, fire departments, ambulance, military units, etc.)

TEAM SELECTION

Team selection should consider the qualifications and experience level of the individuals used for the specific event/evolution/incident. Individuals may need to be replaced during the incident. The same concerns apply to the reliefs.

TEAM FITNESS

Team fitness should consider the physical and mental state of the team. This is a function of the amount and quality of rest a team member has had. Quality of rest should consider potential sleep length and any interruptions. Fatigue normally becomes a factor after 18 hours without rest; however, lack of quality sleep builds a deficit and worsens the effects of fatigue.

ENVIRONMENT

Environment should consider factors affecting personnel performance and factors affecting equipment. This includes, but is not limited to, time of day, temperature, humidity, precipitation, wind, terrain, and elevation.

EVENT or EVOLUTION COMPLEXITY

Event/Evolution complexity should consider both the required time and the situation. Generally, the longer one is exposed to a hazard, the greater are the risks. However, each circumstance is unique. For example, more iterations of an evolution can increase the opportunity for a loss to occur, but may have the positive effect of improving the proficiency of the team, thus possibly decreasing the chance

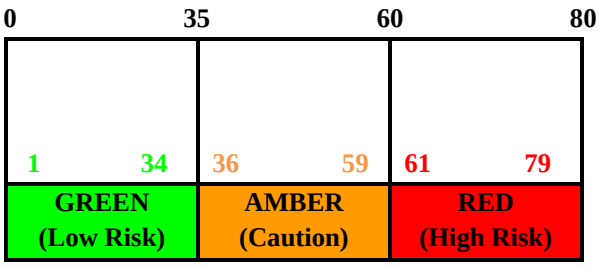
of error. This would depend upon the experience level of the team. The situation includes considering how long the environmental conditions will remain stable and the complexity of the work.

Table G.1. ERMN Streamside Bird Monitoring Protocol assigned risk codes of 0 (For No Risk) through 10 (For Maximum Risk) to each of the eight elements.

Element	Rank
Supervision	4
Planning	2
Communication	2
Contingency Resources	6
Team Selection	4
Team Fitness	3
Environment	7
Event/Evolution Complexity	5
Total Risk Score	**33**

The activity risk can be visualized using the colors of a traffic light. If the total risk value falls in the GREEN ZONE (1-35), risk is rated as low. If the total risk value falls in the AMBER ZONE (36-60), risk is moderate and you should consider adopting procedures to minimize the risk. If the total value falls in the RED ZONE (61-80), you should implement measures to reduce the risk prior to starting the event or evolution.

GAR Evaluation Scale
Color Coding the Level 0f Risk



The ability to assign numerical values or "color codes" to hazards using the GAR Model is not the most important part of risk assessment. What is critical to this step is team discussions leading to an understanding of the risks and how they will be managed.

Step 4: Identify Risk Control Options

Element	Mitigation Factors
Supervision	The ERMN Streamside Bird Protocol clearly identifies personnel, roles and responsibilities, and a chain of command. A score of 4 (instead of a lower score) was assigned due to the fact that crew members (2 at a park) work alone in the field. Moreover, once the training is complete the Protocol Lead (designated supervisor) is not duty-stationed with either field crew. However, one of each of the crew members is identified as crew leader (functional supervisor).
Planning	The ERMN Streamside Bird Protocol includes numerous SOPs that explain hiring, training, personal safety, emergency communication (equipment and contacts), and appropriate field activities. Due to this advance planning, written documentation, and training procedures, a low score (2) was assigned.
Communication	Routine and emergency communication equipment and procedures are explained in the relevant SOPs. This includes coordination with park natural resource managers, rangers, and dispatch. It also includes a daily check-out/check-in procedure for all crew members to ensure that a responsible party knows if someone has not returned from the field activity in a timely manner. Due to this advance planning, written documentation, and training procedures, a low score (2) was assigned.
Contingency Resources	Contingency resources include communication equipment and procedures that explicitly involve park rangers, park dispatch, and 9-1-1. Crew members are also provided with a Personal Locator Beacon should either the cell phone or park radio not work. In spite of these resources, a score of 6 (instead of a lower score) was assigned because it could take hours for emergency personal to arrive after initial contact due to the remote location(s) of the activity. See also “Environment” below.
Team Selection	The Hiring SOP clearly identifies the essential skills and abilities required to execute this protocol in a competent manner. Prior experience is required. Crew members are screened, interviewed, and their references are checked prior to hiring. In spite of these measures, a score of 4 was assigned (instead of a lower score) because it is impossible to ensure that crew members fully understand the field conditions they will face prior to hiring. Beginning in 2012, the crew will be taken to one of the most challenging sampling sites during training to provide an opportunity for individuals to reassess whether they are competent enough to carry out the activity. This also offers the Protocol Lead an opportunity to witness and evaluate potential crew member competency and act accordingly.
Team Fitness	Team selection should ensure a high level of initial team fitness. Crew members are only in the field for approximately four hours per day (not including drive times) and have two off-duty days per week allowing for adequate rest and recovery. Regardless, a score of 3 was assigned (instead of a lower score) because the work is strenuous and involves waking before dawn for consecutive days. Crew members will have to be diligent about adequate rest and nourishment to ensure that fatigue does not become a factor.
Environment	Environment was assigned a higher score (7) primarily because individuals are working alone when carrying out this activity and the activity is performed around water. Despite training on safe stream crossings, encouragement to NOT cross streams unless it can be done safely, and the requirement that helmets be worn for all stream crossing, the possibility exists for an individual to slip and be rendered unconscious potentially leading to a drowning. A possible mitigation factor would be to have a second crew member present during all field activities to respond should someone become unconscious. See “Step 5” below.
Incident Complexity	Incident complexity was also assigned a higher score (5) mostly because daily field conditions change due to weather (e.g., rainfall and stream flow). Individual crew members must use judgment and experience to respond appropriately.

Step 5: Evaluate Risk vs. Gain

The Protocol Lead has determined that the activity, if carried out in accordance with all SOPs, has an acceptable level of risk.

One specific potential mitigation factor considered, but not adopted, is worth describing here. Related to "Environment" category above, the Protocol Lead considered having individuals work as pairs (i.e., individuals could no longer conduct the activity alone). The benefit would be that a second person is available to assist in the event of an incident and specifically help prevent a drowning should someone be rendered unconscious (a second person could move the individual away from water). A drowning fatality is possible and is the most severe risk encountered when conducting this activity. The probability of this event happening is low. At the time of writing, the Protocol Lead is not aware of any similar incidents in the NPS (even though there have been several line of duty deaths due to drowning). Having a second field crew member present would lower the probability of a drowning death, however it doubles the exposure of other, more likely, accidents occurring (e.g., sprains, strains, snake encounters, ticks, etc.). Because a drowning death has a very low probability of occurring, the Protocol Lead decided the benefit of further lowering this probability did NOT outweigh the additional risk due to exposing a second crew member to other known and higher probability hazards. Therefore, the decision was made to allow individuals to conduct this activity alone.

Step 6: Execute Decision

The decision made by the Protocol Lead is to conduct the activity in accordance with ERMN Streamside Bird Monitoring Protocol Standard Operating Procedures (SOPs).

Step 7: Supervise – Watch for Change

The Protocol Lead continually solicits feedback from crew members on safe execution of the protocol including risk control options not considered thus far.

Signatures

1/26/12

Streamside Bird Monitoring Protocol – Personal Safety SOP, JHA(s), and GAR prepared by:
Matt Marshall, Eastern Rivers and Mountains Network Program Manager — Date

1/26/12

Streamside Bird Monitoring Protocol – Personal Safety SOP, JHA(s), and GAR approved by:
John Karish, Northeast Regional I&M Program Manager — Date

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NPS 962/132802, May 2016

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