A STUDY PLAN TO INVENTORY VASCULAR PLANTS AND VERTEBRATES: NATIONAL CAPITAL NETWORK, NATIONAL PARK SERVICE

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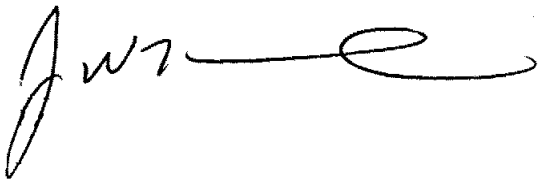

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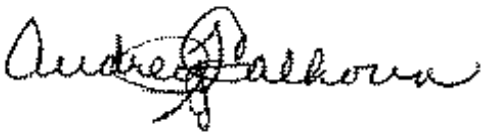

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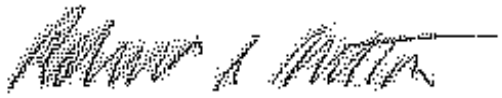

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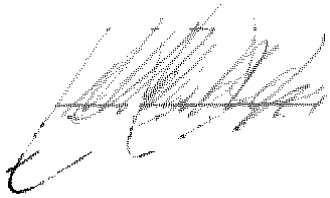

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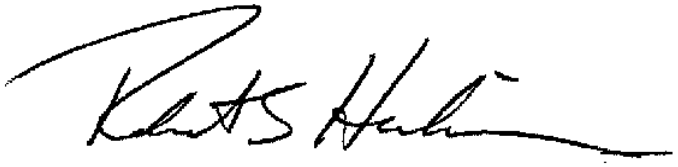

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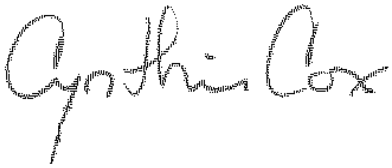

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I. INTRODUCTION

Since 1916, the mission of the U.S. National Park Service (NPS) has been "… *to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations*" (National Park Service Organic Act, 1916). Providing for the public enjoyment of America's greatest natural and cultural resources while simultaneously conserving these resources for future generations has and will continue to be a difficult task. Many parks have suffered environmental degradation due to factors both inside and outside the park. Visitor use and enjoyment has been historically emphasized in the national parks, leading to degradation of natural resources within many parks (Sellars 1997). In addition, problems such as acidic deposition, air pollution, introduction of non-native species, and changing land uses outside the park threaten park natural resources.

Species inventories in national parks are critically important. Species lists are useful for visitor appreciation of natural resources as well as for conservation of species on a broad geographic scale. For management decisions within the park, knowledge of which species are present (particularly species of special concern) and where they occur is a necessity. Inventories can identify important habitats, such as riparian areas, which are critical habitats for species of special concern or are 'hot spots' with respect to species richness. Inventories also provide the basis for making long-term monitoring decisions (such as which species and parameters to monitor) as well as the data for long-term monitoring of community parameters such as species diversity. Losses to native diversity have occurred in a number of parks (e.g., Drayton and Primack 1996, Turner et. al. 1995, Newmark 1995), perhaps as the results of non-native species invasions, land-use changes, climatic changes, and other environment effects. Baseline species inventories of major taxa such as the vertebrates and vascular plants will provide a benchmark against which future floral and faunal changes can be gauged.

Basic biological information, including plant and animal inventories, is lacking for many parks. As of 1994, the majority (>80%) of 252 US national parks surveyed did not have complete inventories of major taxonomic groups (Stohlgren et al. 1995). Inventory data is particularly lacking in smaller parks and for parks created to protect cultural resources. Falkner and Stohlgren (1997) show that small national parks established as cultural or historical parks add considerably to the biological diversity of a region. These parks often represent critical natural areas in fragmented landscapes, providing refuges for many species, serving as migration or movement rest stops for wildlife, and serving as living classrooms to the adjacent human communities.

Recognizing the need for essential basic data on park ecosystems in order to better manage park natural resources, the NPS initiated its Inventory and Monitoring (I&M) Program in the early 1990's. The purpose of the I&M program is to increase scientific research in national parks and detect long-term changes in biological resources (National Park Service 1992). Although the prototype parks that were designated as models for NPS made significant headway in species inventory and monitoring programs, by the late 1990's the majority of parks still lacked basic inventories. In 1998, funding for the establishment of baseline information and long-term trends in National Park System resources was

obtained by Congress (National Park Service 1999). Thirty-two networks of national parks with significant natural resources service-wide were formed and asked to develop study plans to obtain basic inventories of vertebrates and vascular plants. This study plan is for the National Capital Network (NCN).

The purpose of this study plan is to complete basic inventories for vascular plants and vertebrates in parks of the National Capital Network in Maryland, Virginia, West Virginia, and the District of Columbia. In addition to gathering all existing data on species presence and distribution in the eleven parks in the Network, we propose to conduct field investigations for vascular plants, fish, mammals, amphibians/reptiles, and birds in parks that currently have inadequate information for these five taxonomic groups. These inventories will be carried out over the next several years using repeatable study designs.

Specific objectives of this study are to:

1. Complete the compilation of existing (historic and recent) data for all species of vascular plants and vertebrates in NCN parks from a variety of sources, including museum records of voucher specimens, previous studies, park databases, etc., and enter these data into the appropriate NPS I&M databases.

2. Complete field investigations for vertebrates and vascular plants in NCN parks with the goal of documenting 90% of all species presumed to occur in each park.

3. Conduct inventories for species of special concern, such as threatened and endangered species and other species of special management concern to provide park managers with estimates of relative or absolute abundance and distribution maps in GIS.

4. Provide the baseline information needed to develop general monitoring strategies and designs which are tailored to specific park threats and resource issues and can be implemented by parks once inventories have been completed.

As part of the initial steps for this study, we compiled most existing data into the NPSpecies database. We have also evaluated the quality of these data, identified information gaps, and determined priorities for field sampling. In this proposal, we outline specific steps for completing inventories as described in the 1999 NPS Guidelines for Biological Inventories (National Park Service 1999).

National Capital Network

The Network includes eleven National Park units with significant natural resources (Table 1; refer to Appendix A for additional information about parks). The parks range in size from 53 to 7,788 hectares (ha) and encompass the Ridge and Valley, Blue Ridge, Piedmont, and Coastal Plain physiographic provinces (Table 1). All parks in the Network have active relationships with local entities including other state and federal government agencies, educational and non-profit institutions, municipalities, and the general public. The Natural Resources Advisory Team (NAT), consisting of park natural resource

managers, and specialists from the regional support office (Natural Resources and Science, NRS) meets bimonthly to serve as an advisory group to the Cluster Steering Committee, coordinate natural resource activities among parks, and to discuss common issues such as funding initiatives, GPRA goals, and management plans.

Table 1. Parks of the National Capital Network.

Park	Park code	Size (hectares)	Physiographic province
Antietam National Battlefield	ANTI	1,318	Ridge and valley
Catoctin Mountain Park	CATO	2,336	Ridge and valley
Chesapeake and Ohio Canal National Historical Park	CHOH	7,788	Coastal plain, Piedmont, Blue ridge, Ridge and valley
George Washington Memorial Parkway	GWMP	3,198	Coastal plain, Piedmont
Harper's Ferry National Historical Park	HAFE	926	Ridge and valley
Manassas National Battlefield Park	MANA	2,064	Piedmont
Monocacy National Battlefield	MONO	667	Piedmont
National Capital Parks – East	NACE	4,378	Coastal plain, Piedmont
Prince William Forest Park	PRWI	7,518	Coastal plain, Piedmont
Rock Creek Park	ROCR	710	Coastal plain, Piedmont
Wolf Trap Farm Park	WOTR	53	Piedmont

Antietam National Battlefield is managed within the historical context of General Robert E. Lee's first invasion of the North in September 1862 during the Civil War. The battle claimed more than 23,000 men (killed, wounded, and missing) in one single day, September 17,1862, and led to Lincoln's issuance of the Emancipation Proclamation. The 1,318 ha park is located in the heart of Maryland surrounded by rolling hills dotted with farm fields and pastures reminiscent of the day of the battle.

Patches of forests, open meadows, and croplands are found within the park. Significant natural resources include sensitive habitats along Antietam Creek, unique limestone upland forests (Snavely Woods), and three state rare, threatened, and endangered species, including the loggerhead shrike (*Lanius ludovicianus*), goldenseal (*Hydrastis canadensis*), and the butternut (*Juglans cinerea*). Possible white-tailed deer (*Odocoileus virginianus*) overabundance and the presence of the gypsy moth (*Lymantria dispar*) and woolly adelgid (*Adelges tsugae*) are management concerns.

Catoctin Mountain Park originated as a Recreation Demonstration Area (RDA) under the National Industrial Recovery Act of 1933. Catoctin was transferred to the National Park Service in 1936 and has remained under its jurisdiction due to the historical events of national and international interest associated with the Presidential Retreat, Camp David, contained within. Although the area is managed by the National Park Service for its recreational use and the conservation of it cultural and natural resources, existing enabling legislation does not provide clear and concise management goals.

The park encompasses 2,336 ha of forested landscape located in the mountains of the Catoctin Ridge in

the north-central portion of Maryland. Unique geological formations consisting of metamorphic sandstones and greenish-gray metabasalts forming cliffs occur in the park. Several overlooks illustrate the forces of volcanism, folding, faulting, and weathering. Catoctin has a maturing forest of chestnut oak (*Quercus prinus*), hickories (*Carya* spp.), and maples (*Acer* spp.) and over 650 species of vascular plants. It has two diverse aquatic streams crossing the park.

Management issues include the effects of white-tailed deer overpopulation, exotic invasive plants, gypsy moth (*Lymantria dispar*), hemlock woolly adelgid (*Adelges tsugae*), and Dogwood anthracnose. Forest health and structure are being affected by these threats. Numerous plant species have already become extirpated or run the risk of being eliminated from the park's plant community. Also, water quality degradation is a concern as residential and agricultural activity increase along the park's 35 km of boundary.

The **Chesapeake and Ohio Canal National Historical Park** stretches along the Potomac River for 297 km from Washington, D.C. to Cumberland, MD. The park's 7,788 ha cut through four geographic provinces and include riparian and upland habitat. The canal operated from 1828-1924 as a transportation route, primarily hauling coal from western Maryland to the port of Georgetown in Washington, D.C. Legislation signed in 1924 set aside portions of this land to preserve forests and natural scenery. In 1971, legislation authorized the National Park Service to preserve and interpret the historic and scenic features of the Chesapeake and Ohio Canal. Hundreds of original structures, including 74 lift locks, lockhouses, and aqueducts, serve as reminders of the canal's role as a transportation system during the Canal Era. In addition, the canal and towpath are open to outdoor recreation.

At least 169 rare species occur in the park, including one snake, five bird, three mammal, and over 100 plant species. Harperella (*Ptilimnium nodosum*), a federally endangered vascular plant, is found in the park. The main management concerns focus on the rapid spread of exotic and weedy species invading natural areas along the canal.

George Washington Memorial Parkway was developed in 1932 as a memorial to George Washington and to protect the scenic view along the Potomac River shoreline and its tributaries in the D.C. area between Mt. Vernon and Great Falls. The park's 3,198 ha offer opportunities to travel to historical, natural, and recreational areas located within the park. In addition, the park provides refuge for native species in close proximity to a large urban population that can witness the natural relationships and beauty within a short walk. Distinct administrative units protect significant natural resources and provide refuge for native species including at least 28 state-listed plant and animal species. Along the steep ravines bordering the Potomac River are possibly the best representation of mature second growth forest in the immediate D.C. area. Units with significant natural resources include:

Arlington House – managed as a memorial to Robert E. Lee, contains a small mature oak forest that is maintained in pre-Civil War conditions.
Dyke Marsh – covers approximately 150 ha of tidal marsh, floodplain, and swamp forest.
Great Falls – the 300 ha park is covered by second growth deciduous forest.

Theodore Roosevelt Island – 35 ha; this natural island is located in the Potomac River and is a tribute to Theodore Roosevelt. Hiking trails pass through marsh, swamp, and upland forest communities.

Turkey Run - contains over 280 ha of mostly deciduous forest and includes a well-developed floodplain forest that may be up to 180 m wide and extends for nearly 5 km along the Potomac River shore.

Exotic species are a concern in several natural areas including Dyke Marsh where porcelainberry (*Ampelopsis brevipedunculata*), Japanese honeysuckle (*Lanicera japonica*), and Asian bittersweet (*Celastus orbiculatus*) are spreading. Overabundance of white-tailed deer is a known problem and may have significant impacts on natural vegetation within the parkway as well. Traffic associated with the parkway and development close to the park's boundaries also pose potential threats to the area's wildlife.

Harpers Ferry National Historical Park is located at the confluence of the Shenandoah and Potomac Rivers in West Virginia, Virginia, and Maryland. The 926 ha park is within the Blue Ridge physiographic province and contains forested mountains, riparian habitats, and floodplains that surround the park's historic town area.

Natural resource issues for Harpers Ferry NHP include impacts from external developments, adjacent landowners, and private and public land uses within the park. One hundred fifty-five exotic species have been identified in the park, and of these, 34 are considered to be invasive and a concern to the park because of their effects on native plants. The most obvious threats to vegetation have come from diseases or insect infestations on the park's eastern hemlock *(Tsuga canadensis*), butternut (*Juglans cinerea*), American elm (*Ulmus americana*) and oaks (*Quercus* spp.). The status of the native eastern dogwood (*Cornus florida*) is unknown, but suspected to be affected by disease.

Manassas National Battlefield Park was established in 1940 to preserve the scene of two major Civil War battles that took place a few miles north of the prized railroad junction of Manassas, Virginia, in 1861 and 1862. The 2,064 ha park is located approximately 72 km southwest of Washington, D.C. within the Triassic basin of the northern Virginia Piedmont. The park is characterized by gently rolling hills with a patchwork of open fields and a successional range of oak-hickory forests with riparian vegetation along the streams.

Like other Civil War parks, Manassas NB has the unique challenge of combining the retention and re-creation of a historic landscape with natural resource management. Maintenance of the historical landscape, except in extreme cases, must take precedence due to the park's enabling legislation. However, this leaves flexibility for the management and preservation of the natural resources of the park and for the enjoyment of those resources by the public. Rare plants founds in the park include: Appalachian quillwort *(Isoetes appalachiana)*, marsh hedgenettle *(Stachys pilosa var. arenicola*), blue-hearts *(Buchnera americana)*, hairy beardtongue *(Penstemon hirsutus)*, and buffalo clover *(Trifolium reflexum).* In addition, several rare community types are found in the park, including oak-

hickory forest, eastern white pine forest, Piedmont/mountain swamp forest, and upland depression swamp.

Natural resource issues for Manassas include suburban sprawl, potential overpopulation of white-tailed deer and beaver (*Castor canadensis*), exotic species, and a shortage of natural resource staff.

Monocacy National Battlefield is located in central Maryland along the Monocacy River and is dominated by active farms with some second generation mixed hardwood forests and field/edge habitat. This park is managed as a cultural resource commemorating the Civil War battle that took place on July 9, 1864. Significant natural resources include three state endangered plants: Short's rockcress (*Arabis shortii*), dwarf larkspur (*Delphinium tricorne*), and harbinger-of-spring (*Erigenia bulbosa*) which have been located in the extreme southern section of the park.

Potential threats to the conservation of the park's natural resources include the release of airborne pollutants from industrial plants located southwest of the park and from heavy traffic on I-270 which bisects the park. Encroaching suburban sprawl makes the park an important preserve for wildlife and the spread of exotic plants has already been documented. An over-abundance of white-tailed deer may be altering the habitat in undesirable ways and needs to be evaluated.

National Capital Parks - East includes 12 major park areas covering 4,378 ha within the District of Columbia and three nearby counties in Maryland. The parks lie entirely within the upper Coastal Plain physiographic region and are managed for a variety of natural, cultural, and recreational resources. Several administrative units provide significant natural resources including:

Anacostia Park – 272 ha recreational park.

Fort Circle Parks – 457 ha; Ft. Davis, Ft. Dupont, Ft. Foote, Ft. Mahan, Ft. Stanton, and the Shephard Parkway are primarily managed for their historical significance. Natural areas include small tracts of deciduous hardwoods and a 10 ha stand of loblolly pine (*Pinus taeda*).

Fort Washington – 138 ha; remains of several forts built between 1808 and 1902 highlight changing military tactics. Approximately 2/3 of the park consists of deciduous forest.

Frederick Douglas Home – home of the important historical civil rights figure. The property also contains woodlands but is primarily managed for its cultural and historic significance.

Greenbelt Park – 475 ha; oak-hickory woodland provides outdoor recreational activities.

Harmony Hall – 27 ha; borders the Potomac River and is largely wooded.

The Kenilworth Park and Aquatic Gardens – 285 ha; the only National Park Service site devoted to the propagation and display of aquatic plants.

Oxon Cove Park and Oxon Hill – 196 ha; farm representative of the early 20th century and demonstrates historic farming principles and techniques. The land area varies from low flat

river shoreline to high river terraces with intermediate rolling hills created by a reclaimed sanitary landfill which existed on the site until the mid-1970s.

Oxon Run Parkway – 51 ha; an island sanctuary that is composed of deciduous forest and includes wetlands and floodplain areas.

Piscataway Park – Stretches 9.7 km from Piscataway Creek to Marshall Hall (634 ha); established in 1952 to preserve the river viewshed from Mount Vernon as it was in George Washington's days.

Suitland Parkway – 247 ha; the limited access scenic roadway passes through deciduous forest, meadows, and maintained lawns.

Significant communities in the park include rare upland communities such as the glauconite rich shell-marl ravine forest and the northern (McAteean) magnolia bog. The state rare grass-leaved arrowhead tidal community alliance is also found. At least 60 rare plants have been documented in the parks. Nesting bald eagles are found along the park's 50 km of shoreline.

Prior to the 1700's, the area now covered by the 7,518 ha **Prince William Forest Park** was forested by deciduous trees. Conversion to intensively managed tobacco plantations left the soils depleted after a few years, the lands were abandoned, and pine forests took their place. In 1933, an Act of Congress declared the area as one of 46 recreation demonstration projects in 25 states. The Civilian Conservation Corps (CCC) constructed five cabin camps, numerous roads and lakes, and miles of trails to provide recreational opportunities.

Management of the recreation area was turned over to The National Park Service in 1948. The park is centered around the Quantico Creek watershed, which drains into the nearby Potomac River. Because the park includes two physiographic provinces (Piedmont and Coastal Plain) and lies in the transition zone between northern and southern climates, it exhibits a wide range of habitat and vegetative communities. It is now the only natural area in the National Park System that contains a significant expanse of Piedmont Forest. Despite its history of human activity, the recovery of the area has led to its recognition as one of the least impacted watersheds in the State of Virginia. The park contains several rare communities including a seepage swamp and remote stands of eastern hemlock that contain old growth specimens. Two rare plants include the federally threatened small-whorled pogonia (*Isotria medeoloides*) and a state endangered sedge (*Carex vestita*). The star-nosed mole (*Condylura cristata*), although secure in its range, is considered rare in Virginia and is abundant in the park. The first documented observation of a timber rattlesnake (*Crotalus horridus horridus*) in Prince William County was recorded in the park in 1992. Subsequent sightings of the timber rattlesnake indicate that a relict population may exist in the park.

Rock Creek National Park administers 710 ha set aside in 1890 by Congress for the preservation "of all timber, animals, or curiosities... and their retention in their natural condition." Besides being one of the oldest parks in the National Park Service, Rock Creek is also one of the largest forested urban parks in the United States, containing a wide variety of natural, historical, and recreational features in the midst of Washington, D.C. The park also administers a series of historic sites, from Civil War earthwork forts to colonial buildings.

The park surrounds the mouth of Rock Creek and its tributaries as the drainage drops from the piedmont plateau to the coastal plain. The park represents an isolated natural system surrounded by urban areas, which have impacted the park in significant and fundamental ways. The largest contiguous section of the park contains 726 ha of natural forests along Rock Creek. A landscaped Parkway follows Rock Creek to the Potomac River and connects this natural section to D.C.'s city center. The oak-beech forests, streams, and sensitive floodplain communities contain a variety of wildlife, including 22 state or watch-listed plant species, and 2 state-listed birds.

Introduction of invasive non-native species into natural areas, extirpations or reductions of sensitive native species, and the artificial inflation of a few native species' populations adversely affect other native plants and wildlife.

Wolf Trap Farm Park encompasses 53 ha of rolling hills and woods originally donated to the National Park Service by Catherine Filene Shouse to be used exclusively for the performing arts. It is now the only National Park dedicated to the performing arts, and its largest venue seats over 7,000 people.

Wolf Trap Farm Park lies entirely within the Piedmont Province. Within the boundaries of the park are streams, meadows and heavily wooded areas.

II. PROJECT DESCRIPTION

A. Existing Information

We began compiling and assessing existing information on vertebrate and plant inventories, species observations, natural resource publications, voucher specimens and photographs, GIS theme layers, and natural resource datasets in 1999. Information is stored at a variety of locations including the parks, regional offices, museums, and external institutions. We are using several NPS national databases to organize this information, including NPSpecies, the Natural Resource Bibliography (NRBib), and the Dataset Catalog. We intend to fund two new positions, a Data Manager and a Biological Technician, to assist with data entry, compilation, and management. Inventory funds may cover a portion of these costs, with the remaining funding coming from the monitoring phase of the program, which will receive partial funding in fiscal year 2001. A data management plan will be developed for the Network by the Data Manager to establish data management and maintenance protocol for the various databases (see E. Data Analysis, Management, and Reporting). We will continue to compile information and update our databases throughout the duration of this project.

NPSpecies

In 1999, the National Capital Network began to assess and compile existing information on vertebrates and vascular plants in Network parks to populate NPSpecies. Documents stored in a variety of locations including the park and regional files were copied and supplied to Mark Wotawa and his colleagues at the Inventory and Monitoring Program Washington Support Office (WASO). These documents, including park reports, published material, notes, letters, checklists, lists or databases of

voucher specimens and original observation records, were used to populate NPSpecies. In addition, Mark transferred existing data summarized in NPFlora and NPFauna into the database and he is currently adding voucher information from the Automated National Catalog System (ANCS+).

A summary of existing inventory information by taxonomic group for each park is found in Appendix A. Although many inventories of vertebrates and vascular plants have taken place in the parks during the past century, the completeness and spatial extent of these inventories varies widely among taxonomic groups and parks. In some cases, historical records exist but the areas have not been inventoried recently. In addition, many species on park lists do not have sufficient verification.

After the initial data was uploaded and a copy of NPSpecies was provided to the region and its parks, we began to verify the contents, make corrections, and add further data. Data were checked by the parks' resource managers, the Biological Inventories Coordinator, or the Inventory and Monitoring Coordinator. All changes made by the parks were imported into a central database housed at the regional office. An additional accuracy check of our NPSpecies records was conducted by subject experts. The subject experts (Dr. Richard L. Raesly, Frostburg State University – fishes, Dr. Joseph Mitchell, University of Richmond – reptiles and amphibians, Dr. Richard Thorington, Smithsonian Institution – mammals, Deanna Dawson, U.S. Geological Survey – birds, and Chris Frye, Maryland Natural Heritage Program and Chris Lea, NPS Assateague Island – vascular plants) assigned to each taxonomic group have reviewed our NPSpecies records to check for accuracy, identify information gaps, and evaluate whether we had reached the goal of documenting the occurrence of 90% of the vertebrates and vascular plants in each park (see below, 90% Species Lists for further information). As expected, the quantity and quality of existing inventory information varied greatly among parks and taxonomic groups, and we will continue to update our databases to complete this project. Information gaps for inventories are presented under B. Park-Specific Objectives.

NRBib

From 1995-1997, bibliographic references such as reports and publications were entered into each park's NRBib. Since that time, few parks have kept up with entering new references due to turnover of park personnel, lack of training, and lack of time. Therefore, the current version of the database is approximately 5 years out of date. In 2000, the National Capital Region received a new Museum Resource Center (MRC) that will also house a central library for the region. Throughout the project, the Data Manager and Biological Inventories Coordinator will work with the parks and MRC staff to update and maintain NRBib and centralize the storage and archiving of reports and publications.

Dataset Catalog

The Data Manager and Biological Inventories Coordinator will ensure that all GIS and non-GIS data (e.g. databases and spreadsheets) are entered into the Dataset Catalog. We will begin by visiting parks and compiling information on all data sets in existence. We plan to train park personnel to automatically add new information to the Dataset Catalog via the online forms, and in the future, contractors and cooperators will be required to provide metadata in a format compatible with Dataset Catalog. Our goal is to bring the Dataset Catalog up to date over the course of this project.

Voucher Specimens and Photographs

Plant voucher specimens are currently being maintained by CATO, GWMP, HAFE, NACE, and PRWI. Additional parks are looking into developing storage facilities to house voucher specimens and maintain records of their content. In addition, the region's new Museum Resource Center is now able to store voucher specimens including photo vouchers in a climate controlled and safe storage facility.

Voucher records are currently documented in ANCS+ will be imported into NPSpecies at WASO. In addition, the Biological Inventories Coordinator and Biological Technician will contact the region's natural history museums to search for voucher specimens collected in the Network parks. Museums and collections in the area include: Carnegie Museum of Natural History, Pennsylvania; Frostburg State University, Maryland; George Mason University, Fairfax, Virginia; University of Maryland; Georgetown University, Washington D.C.; University of Virginia, Charlottesville; Virginia Polytechnic Institute and State University, Blacksburg; and the Smithsonian Institution, Washington D.C. This list may be revised when WASO begins to inventory museums on a nationwide level. New voucher records will be imported or entered into NPSpecies by the Data Manager.

In addition to museum searches, the Biological Inventories Coordinator and Biological Technician will search park files for voucher photographs. Voucher photographs are considered to be suitable records only if the identification of the species and location can be unambiguously determined. The photo vouchers will be entered into NPSpecies by the Data Manager.

Observation Records

Most Network parks have years of observation cards that were turned in by visitors and staff. Observations are of limited value and generally cannot be used to confirm species presence; however, for some groups such as large mammals that have sparse distributions, observations may provide the only form of species documentation. For most parks, it is difficult to access information from observation cards because they are not organized. In some cases, parks have already entered these observations into a MS Access database. The Data Manager will import existing databases and enter observation records into NPSpecies throughout the duration of this project. The Data Manager will coordinate with the park natural resource managers so that future observations will be entered directly into NPSpecies at the park level once the database becomes available online.

GIS Theme Layers

Most parks in the Network have complete GIS coverages for topography, hydrology, boundaries, and soils (Table 2). These layers will be a valuable tool for designing inventories for each park. Only two parks have GIS coverages of species distribution (ROCR – plants; MANA – exotic plants). We will work with the GIS Specialist for NCR to obtain GIS theme layers for completed inventories with distributional information. All new inventories conducted in the Network will require GIS themes including location data for sampling sites and species occurrences that are compatible with NPSpecies and the GIS data browser.

Table 2. Existing GIS data themes for the National Capital Network.

GIS Layer	ANTI	CATO	CHOH	GWMP	HAFE	MANA	MONO	NACE	PRWI	ROCR	WOTR
Boundary	x	x	x	x	x	x	x	x	x	x	x
Topography	x	x	x	x	x	x	x	x	x	x	x
Hydrology	x	x	x	x	x	x	x	x	x	x	x
DEM	x	x	x	x	x	x	x	x	x	x	x
DRG	x	x	x	x	x	x	x	x	x	x	x
Vegetation					x	x			x	x	x
Soils	x	x	x			x		x	x	x	x
Trails	x	x	x		x	x			x	x	x
Roads	x	x	x	x	x	x	x	x	x	x	x
Structures	x	x	x	x	x	x	x	x	x	x	x
DOQQs	x	x	x	x	x	x	x	x	x	x	x
Digitized USGS Maps[a]	x	x	x	x	x	x	x	x	x	x	x
Herp Distribution											
Mammal Distribution											
Bird Distribution											
Fish Distribution											
Plant Distribution						x				x	
Fire											
T & E Species		x			x					x	
Other											
High Resolution photography			X[b]		x	x		x	x	x	

[a] These include Digital line graphs and Digital Raster Graphs (DRG - which are scanned USGS 7.5 min. quads.)
[b] Only for miles 0-22 and 99-100.

90% Species Lists

The main goal of the inventory program is to document the existence of 90% of vertebrates and vascular plants in each park. For the vertebrates, we have chosen to estimate the number of expected species in each park using a combination of state agency information, range maps and expert advice. We provided each subject expert (Dr. Richard L. Raesly, Frostburg State University – fishes, Dr. Joseph Mitchell, University of Richmond – reptiles and amphibians, Dr. Richard Thorington, Smithsonian Institution – mammals, and Deanna Dawson, U.S.G.S. – birds) with a preliminary checklist of expected species based on data (usually by county) from state agencies and natural heritage programs. The experts edited this list, removing species which were not expected in a given park due to habitat or other considerations and adding any species we had missed. Expected species in each park are listed in Appendix B. These lists were compared to existing park data to determine gaps in our knowledge of park fauna (refer to B. Park-Specific Objectives for analysis). As animal surveys are conducted, we will continue to refer to the list to determine percent completeness for each park. In addition, species

accumulation curves (comparing number of new species discovered with sampling effort) will be used to estimate percent completeness.

For the vascular plants, compilation of a list of expected species for each park was not feasible. Instead, we asked our subject experts (Chris Frye, MD Natural Heritage Program and Chris Lea, NPS Assateague Island) to estimate percent completion for each Network park based upon their knowledge of vascular plant distribution in the region. The BONAP database was particularly useful in this task. The experts discovered that park plant lists were typically lacking in specific families of vascular plants (refer to B. Park-Specific Objectives). We will use this information to target specific families or specific habitats that need to be surveyed to complete park floral lists.

B. Park-Specific Objectives

Biological inventory priorities for parks were determined through a series of meetings of the NCN Inventory and Monitoring Steering Committee and evaluations of existing inventory information. Priorities for the two general categories of inventories (each major taxa and species of special concern) were established at a scoping session of the NCN Inventory and Monitoring Steering Committee. Prior to the meeting, we developed a matrix of estimated completeness for presence-absence inventories for each taxonomic group within each park based upon subject expert review (Tables 3 and 4). At the meeting, we prioritized inventory gaps for both major taxonomic groups (Table 5) and species of special concern, which were developed by park natural resource managers (Table 6). These estimates of need and priority are based upon information currently available. As new data becomes available, there may be a need to adjust the overall inventory plan.

Inventory Priorities

In allocating resources for inventories, we faced a trade-off between funding general inventories and funding inventories for species of special concern. Because a number of parks are lacking basic knowledge of what species are present, the NCN Inventory and Monitoring Steering Committee decided that general inventories should be the highest priority, followed by species of special concern. Because outside funding for research on species of special concern is often available, we hope to use the current project to gather basic information on these species, while working to increase our knowledge of them through seeking other funding sources and collaborating with universities and other agencies.

General Presence-Absence Inventories

The need for general presence-absence inventories varies among parks, but the majority of parks are lacking general inventory information on three or more taxonomic groups (ANTI, CATO, CHOH, GWMP, HAFE, MANA, MONO, WOTR, Tables 3, 4). NACE, PRWI and ROCR have fairly complete inventories; whereas, WOTR has inventory needs in all five taxonomic groups. The objectives for inventories of each major taxonomic group are the same for all parks: to confirm the occurrence of 90% of species present using a repeatable, scientifically-valid study design. Detailed project statements documenting objectives and methods are found under C. Study Design and Appendix C. An implementation schedule is found under Section VII and a budget in Section VI.

Table 3. Number of fish, mammal, reptile and amphibian (herps), and vascular plant species expected in each park based on expert knowledge, state and county databases, and range maps. The number of species recorded in each park is compared to the number expected to assess each park's percent completeness in the National Capital Network. Percentages in bold indicate an inventory need for the park.

		Number		Percent			Number		Percent
Taxon	Park	Recorded	Expected	Recorded/ Expected		Park	Recorded	Expected	Recorded/ Expected
Fishes	ANTI	24	37-52	**46-65%**	Mammals	ANTI	22	48	**45.8%**
	CATO	16	17-23	70-94%		CATO	38	56	**67.9%**
	CHOH	2	51-68	**2-3%**		CHOH	6	57	**10.5%**
	GWMP	22	31-58	**38-71%**		GWMP	0	46	**0%**
	HAFE	0	19-38	**0%**		HAFE	23	54	**42.6%**
	MANA	33	20-35	94%+		MANA	15	46	**32.6%**
	MONO	0	22-33	**0%**		MONO	36	48	**75.0%**
	NACE	43	27-51	84-100%		NACE	26	46	**56.5%**
	PRWI	49	12-36	100%		PRWI	38	45	**84.4%**
	ROCR	44	28-50	88-100%		ROCR	31	44	**70.5%**
	WOTR	0	6-19	**0%**		WOTR	0	41	**0%**
Herps	ANTI	10	48	**20.8%**	Vascular Plants	ANTI	378	n/a	
	CATO	31	50	**62.0%**		CATO	625	n/a	
	CHOH	30	66	**45.5%**		CHOH	2495	n/a	90%
	GWMP	30	56	**53.5%**		GWMP	735	n/a	
	HAFE	1	51	**2.0%**		HAFE	675	n/a	
	MANA	7	53	**13.2%**		MANA	106	n/a	
	MONO	0	46	**0.0%**		MONO	318	n/a	
	NACE	49	54	90.7%		NACE	896	n/a	90%
	PRWI	75	53	100%		PRWI	428	n/a	
	ROCR	16	54	**29.6%**		ROCR	664	n/a	
	WOTR	0	49	**0.0%**		WOTR	3	n/a	

Table 4. Number of bird species expected in each park based on expert knowledge, state and county databases, and range maps. The number of species recorded in each park is compared to the number expected to assess each park's percent completeness in the National Capital Network. Percentages in bold indicate an inventory need for the park.

		Number		Expected		Percent	
Taxon		Breeding	Total	Breeding	Total	Breeding	Total
Birds	ANTI	74	98	97	191	**76%**	**51%**
	CATO	96	140	98	147	98%	95%
	CHOH	98	116	114	197	86%	59%
	GWMP	105	170	108	212	97%	80%
	HAFE	98	148	109	194	90%	**76%**
	MANA	83	91	103	194	**81%**	**47%**
	MONO	79	101	98	189	81%	53%
	NACE	109	214	112	218	97%	98%
	PRWI	74	100	84	164	**88%**	**61%**
	ROCR	64	117	74	150	86%	78%
	WOTR	12	13	69	128	**17%**	**10%**

Table 5. Summary of inventory needs by major taxonomic groups for parks in the National Capital Network. Cells in bold indicate that inventories will be completed as part of this project and an 'X' indicates that the inventory is already complete. For all taxonomic groups except birds, 'High' priority indicates that inventory completeness is less than 60% for a given park, 'Medium' priority indicates that the inventory is 60-80% complete, and 'Low' priority indicates that the inventory is 80-89% complete. For birds, 'High' priority indicates that inventories are needed during all seasons (breeding, migrating, wintering) of the year, 'Medium' priority indicates that the inventories are needed during portions of the year, and 'Low' priority indicates that fieldwork has been completed but database work is still needed.

Park	Birds	Fish	Mammals	Herps	Vascular plants
ANTI	**High**	**High**	**High**	X (In progress)	**Low**
CATO	Low	X	**Medium**	**Medium**	**Medium**
CHOH	Low	**High**	**High**	**High (reptiles only)**	**X**
GWMP	Low	**High**	**High**	**High**	**X (in progress)**
HAFE	**Medium**	**High**	**High**	**High**	**X**
MANA	**Medium**	X	**High**	**High**	**X (in progress)**
MONO	Low (In progress)	**High**	**Medium**	**High**	**Low**
NACE	Low (In progress)	X	**High**	X	**X**
PRWI	**High**	X	Low	X	**High**
ROCR	Low	X	**Medium**	**High**	**X**
WOTR	**High**	**High**	**High**	**High**	**High**

Birds

Analysis of bird data took into account their seasonal occurrence in the region, either breeding, migrating, and/or wintering in the park. CATO and NACE have complete inventories but data still needs to be entered into NPSpecies. According to the subject expert (Deanna Dawson, USGS-BRD), data is also available to complete inventories for CHOH, GWMP, and ROCR; these data need to be obtained and entered into NPSpecies. MONO and NACE have full inventories underway. All other parks will be inventoried fully or in part for breeding, migrating, and/or wintering birds.

Fish
Five of 11 parks have documented 90% of the expected fish species (Table 3). The remaining six parks (Table 5) will be surveyed for fishes in this project.

Mammals
No park has reached 90% inventory completeness for mammals (Table 3). Parks are particularly lacking in bat presence information, and many parks need small mammal inventories. In this project, we will inventory all National Capital Network parks except PRWI. PRWI has 84% of expected mammal species documented. Most of the missing mammal species are expected to be documented when complete museum searches are conducted and additional references are located.

Herps
Two of 11 parks have documented 90% of the expected reptile and amphibian species, and ANTI has a herp inventory in progress that is expected to document 90% of the species present (Tables 3 and 5). CHOH has documented over 90% of their amphibian species but will be surveyed for reptiles. The seven remaining parks (Table 5) will be surveyed for reptiles and amphibians.

Vascular Plants
The vascular plant subject experts are still reviewing some of our park species lists; therefore, this section represents our best estimate of data gaps at this time. Although several parks have 90% or more of their vascular plants documented, all parks need at least some vascular plant inventory work. PRWI and WOTR have had little or no vascular plant inventories and represent the Network's highest priority parks for vascular plants. CATO had a comprehensive inventory in 1977 but has not had any recent work done. ANTI and MONO have fairly complete species lists but need some additional inventory work to reach 90% documentation. The remaining six parks (CHOH, GWMP, HAFE, MANA, NACE, and ROCR) have 90% of their species documented or have comprehensive inventories in progress. We anticipate conducting limited vascular plant inventories in these parks to address particular plant families for which the region is lacking information such as the grasses (Poaceae), sedges (Cyperaceae), rushes (Juncaceae), and aquatic plants. In addition, CHOH and NACE need further inventory work because all the vascular plant inventories in these parks have been concentrated in particular park subunits with large portions of the parks having no vascular plant information.

Inventories of Species of Special Concern
Parks within the National Capital Network are responsible for managing a variety of species of special management concern, including two federally listed threatened and endangered plants, a number of rare species with state conservation status, and invasive exotic species (Table 6). In addition, white-tailed deer overpopulation is a management concern in many parks. Network Invasive exotic plants such as Japanese honeysuckle, garlic mustard, tree of heaven (*Ailanthus altissima*), purple loosestrife (*Lythrum salicana*), kudzu (*Puevaria lobata* var. *montana*), etc. will be treated and mapped by the Exotic Plant Management Team (EPMT) of the National Capital Region. Therefore, no surveys of these species are planned at this time. Abundance and distribution of the federally threatened vascular

plant small whorled pogonia (PRWI) is already known and further work will not be conducted on this species.

The federally endangered vascular plant harperella (CHOH), white-tailed deer, and a number of state-rare birds, mammals, and vascular plants are targeted for focused inventories that will provide distribution and relative abundance data. We will inventory for these species of special concern in conjunction with the general inventories. Detailed studies of absolute density will not be conducted for most species with one exception – white-tailed deer.

Inventories of Habitats of Special Concern

Habitats of special concern in Network parks include mostly riparian areas, springs, vernal pools, rocky outcrops, talus slopes, and other habitats that warrant consideration as unique habitat for particular species. We have incorporated surveying for these special habitats into our study design for each taxonomic group.

Table 6. Species of special concern in National Capital Network parks. Species in bold will be surveyed as part of this project.

Park	Birds*	Mammals	Herps	Vascular plants
ANTI	**Loggerhead shrike**	**White-tailed deer**		**Butternut**
CATO		**White-tailed deer**		**American chestnut, long-bracted orchid, pale corydalis, leatherwood, American ginseng, purple fringed orchid, Torrey's mountain mint, false penney royal, nodding trillium**
CHOH	**Yellow-throated warbler, golden-winged warbler, nesting peregrine falcon**	**White-tailed deer, Small-footed bat, Allegheny woodrat**	Rainbow snake	**Harperella (FE), 24 species of native vascular plants**
GWMP		**White-tailed deer**, f**lying squirrel, star-nosed mole, gray fox**	Box turtle, wood turtle, copperhead snake	**White oak, virginia pine, wild rice** Exotic/invasive: mile-a-minute weed, purple loosestrife, kudzu
HAFE		White-tailed deer		Exotic/invasive: Japanese honeysuckle, garlic mustard, tree of heaven
MANA	**Scarlet tanager**	**White-tailed deer**	Spotted salamander, chorus frog	**American bittersweet** Exotic/invasive: tree of heaven, multiflora rose, Japanese honeysuckle, stiltgrass
MONO		**White-tailed deer**		
NACE	**American bittern, least bittern**	**White-tailed deer,** bobcat	Eastern scarlet snake, corn snake, eastern ribbon snake	**Spotted joepyeweed, smartweed dodder, clasping leaf St. Johnswort, taperleaf waterhorehound, common reed, woodland horsetail, small white fawnlily** Exotic/invasive: Asian spiderwort
PRWI		**White-tailed deer,** star-nosed mole	Northern dusky salamander	
ROCR	**veery, hooded warbler**	**White-tailed deer, gray fox, red fox, flying squirrel**	Box turtle	
WOTR				

* In addition to the species listed by parks, bird species of special concern include priority species identified by the Mid-Atlantic Coastal Plain Bird Conservation Plan (PIF 2000a) and the Mid-Atlantic Piedmont Bird Conservation Plan (PIF 2000b) of Partners In Flight. These species include:

Deciduous and Mixed Forest: **Wood Thrush, Louisiana Waterthrush, Cerulean Warbler, Kentucky Warbler, Worm-eating Warbler.**
Forested Wetlands: **Acadian Flycatcher, Prothonotary Warbler.**
Shrub-scrub/barrens: **Northern Bobwhite, American Woodcock, Whip-poor-will, Prairie Warbler, Field Sparrow.**
Agricultural grasslands: **Henslow's Sparrow, Grasshopper Sparrow.**

Marsh: **American Black Duck.**

C. Study Design

In this section, we review considerations in designing an effective inventory program. We will use a combination of sampling approaches depending on park size and the status of inventory completeness for a given taxonomic group within each park. The 11 network parks have been divided into three sampling groups based on park size: 1) small parks (<1500 ha; ANTI, HAFE, GWMP in part, MONO, NACE in part, ROCR, WOTR), 2) large parks (1500+ ha; CATO, MANA, PRWI), and 3) linear parks/parkways (CHOH, GWMP in part, NACE in part).

Within all parks, the objective is to sample the dominant community and land types in addition to habitats of special concern. The sampling strategy for all parks will consist of two steps: 1) establishment of a coarse grid network of grid points across the entire park, and 2) intensive searches of habitats of special concern. In large parks and some small parks, a third step will be added – location of additional sample sites using a stratified random design (see below). The use of a coarse grid to establish sample sites ensures that sampling sites are located evenly across an entire area. However, one of the inherent weaknesses of a grid design is that it tends to over-sample common habitats and under-sample rare and spatially-scattered habitats (Fortin et al. 1989, Legendre and Fortin 1989). Since rare habitats are often characterized by high biological diversity, sampling these areas is critical. We plan to use a widely-spaced grid to avoid over-sampling common habitats. Once grid points are established, additional sample sites will be randomly located within under-sampled habitat types. In addition, we will survey areas of known (i.e., historical) or likely occurrence for species of special concern.

Small Parks

National Capital Network small parks range in size from to 53 to 1318 ha (ANTI, GWMP in part, HAFE, MONO, NACE in part, ROCR, WOTR). We will use a coarse grid to determine sampling locations within the parks. Areas of the parks that are hazardous to sample, such as cliff faces, will not be included in the grid. We do not expect that small parks will require stratified sampling. If stratified sampling is required in small parks, they may be stratified and sampled based upon available GIS data layers. In addition, intensive searches of habitats of special concern will be conducted.

Large Parks

National Capital Network large parks range in size from 2064 to 7518 ha (CATO, MANA, PRWI). We will use a coarse grid to determine sampling locations within the parks. Areas of the parks that are hazardous to sample, such as cliff faces, will not be included in the grid. Using an iterative approach, stratified sampling will ensure that delineated strata are adequately sampled. Since sample sites established in this study may eventually serve as locations for long-term monitoring, stratifying by vegetative cover is problematic. Therefore, we will use topography and edaphic characteristics (elevation, slope, aspect, slope position, soil and geologic data, etc.) to stratify the parks when possible. When other data layers are unavailable or inappropriate (for example parks that do not have sufficient topographic relief to stratify based upon aspect, slope, or slope position), we will use broad vegetation

classes that are more stable over time than narrower classification units. As with the smaller parks, habitats of special concern will be differentiated and sampled separately.

Linear Parks/Parkways

The National Capital Network has three parks that are considered linear parks or parkways, CHOH, GWMP (in part), and NACE (in part). CHOH stretches along the Potomac River for 297 km from Washington, D.C. to Cumberland, MD. The park's 7,788 ha cut through four geographic provinces and include riparian and upland habitat. GWMP was developed to protect the scenic view along the Potomac River shoreline and its tributaries in the D.C. area between Mt. Vernon and Great Falls. GWMP also contains 5 administrative units. NACE contains 12 major administrative units, 3 of which include parkways: Baltimore-Washington Parkway, Shephard Parkway, and Suitland Parkway. These parkways will be sampled as a transect with sampling points established on each side of the road at a regular interval. Road mileposts will be used to locate transect points, and if needed, additional points may be added based upon stratified random sampling. In addition, intensive searches of habitats of special concern will be conducted. Administrative units of GWMP and NACE will be sampled as small parks.

Parks with Nearly Complete Inventories

For parks and taxonomic groups with more than 50% inventory completeness, we may utilize targeted inventories to fill gaps as opposed to using a comprehensive inventory study design. A comprehensive inventory design would likely yield information on common and widespread species for which we already have documentation. In addition, NCN inventory funding will not cover park-wide comprehensive inventories for all five taxonomic groups. Therefore, in parks with nearly complete inventories, we may conduct inventories at specific habitats or locations that are most likely to discover undocumented species and species of special concern.

Sample sizes

At this time, it is not possible to know how many samples we will need to achieve our inventory goals. The number of samples needed will vary depending on the taxon, time of year, sampling effort, and variability of species occurrence. We will assess inventory completeness throughout the study through species accumulation curves, comparisons between documented and expected species lists, and other methods. We will use these assessments to adjust our sampling effort accordingly.

Recording Incidental Observations

The above study design includes a standardized repeatable sampling design that will allow us to make inferences to the entire park. However, the incidental sighting of species by researchers and specimen collection (such as roadkills) will be an important component of our study. Credible sightings will be entered into NPSpecies.

Relationship of Inventories to Monitoring Programs

We have designed these inventories to complete information gaps in general inventories. Although sampling site locations and methods can be used in future monitoring efforts, we did not design an inventory strategy that will lead to the monitoring plans for each park. However, data obtained from the

inventory project will provide a strong information base for developing the monitoring program, which will be initiated in fiscal year 2001.

D. Survey Methods

In this section, we describe the methods we will use to sample each major taxonomic group, including specific approaches to sampling species and habitats of special concern. The same methods will be used in each park to ensure relevant inter-park comparisons of flora and fauna.

Birds

As with other taxa, no one method of sampling will work for inventorying all species of birds. Therefore, it will be necessary to design an inventory program that takes into account the life-history characteristics of different species. The main goal of the inventory is to simply document which species occur in the parks throughout the year. Recommended survey methods described by Fancy and Sauer (2000) will be followed.

The first step will be to completely update NPSpecies with existing data. The subject expert review pointed out that additional data exists for CHOH, GWMP, and ROCR which is expected to provide evidence for 90% of the species expected in each park including breeding birds, wintering birds, and migrating birds.

Given the high public interest in this taxonomic group, we will be able to make extensive use of volunteer efforts to inventory birds on a year-round basis at parks that do not have full inventories including ANTI, HAFE, MANA, PRWI, and WOTR. Volunteers have already contributed significant efforts to similar projects in the area under the direction of the Fairfax Audubon Society, The Nature Conservancy, and the Maryland Ornithological Society.

We will develop a grid-based sampling framework to allow integration of volunteer-collected data into GIS maps and to ensure adequate coverage throughout the parks. Volunteers will be provided with background information, training, maps, and data sheets (Appendix D). Volunteers will be asked to generate seasonal checklists of birds in the parks for each grid cell. By using standard Breeding Bird Atlas methodology (American Birding Association 2000), volunteers will be able to determine breeding status. Surveys will be conducted during the peak breeding season, spring and fall migration periods, and winter to fully document all species found in the parks. In addition, we will make special requests to survey in rare or unique habitats and habitats of special concern. Secretive taxa such as nocturnal raptors, goatsuckers, or rails may require specialized survey methods such as tape playbacks to document their presence (Bibby et al. 1992, Fuller and Mosher 1987). Special efforts will be made to verify breeding status and generate distribution maps of species of special concern when they are located during surveys.

Fish

Six parks (ANTI, CHOH, GWMP, HAFE, MONO, and WOTR) are in need of inventories for fishes (Tables 3, 5). At this time, there are no fish species that are species of special concern. All parks occur within the Potomac River drainage, a transitional region that is a range boundary for several freshwater fishes (Lee et al. 1980, Hocutt et al. 1986). This simplifies the sampling procedure as the Potomac basin forms a cohesive biogeographic unit. We will use methods similar to those developed

by the Maryland Biological Stream Survey to inventory fishes. We will begin by digitizing all blue-line streams in each park from a 1:250,000-scale U.S. Geological Survey topographic map. All stream segments will be categorized by Strahler order (Strahler 1957). The basic sampling unit on stream segments Strahler order 1-3 will be 75 m, which has been shown to be adequate for smaller streams (Roth et al. 1999). Larger sampling units, 100-150 m, will be established on streams categorized as Strahler order 4-5.

We will conduct stratified random sampling of stream segments within each park. The number of segments sampled per park will be proportional to the number of stream kilometers of each order within a park. Sampling units will be selected randomly within each stratum. Sampling will be conducted during low-flow conditions in summer and early fall. This will maximize efficiency since habitat volume is lower at this time and fishes are easier to capture.

Block nets will be deployed at the lower and upper ends of each stream segment sampled to prevent fishes from entering or leaving the reach during sampling. Electrofishing of each site will be conducted using backpack or boat electrofishing gear, depending on stream size. Seines may also be used in habitats not easily sampled with electrofishing gear. This technique is likely to produce the most uniform sampling effort and results across the Network. The number of electrofishing units used per site will depend on stream size. Two passes of electroshocking per segment will be suitable for inventories. We will use three passes in selected sites in order to calculate absolute densities of fishes using the methods of Zippen (1958). Sampling effort can be quantified using electroshocking seconds.

Fish captured during each pass will be maintained live until completion of sampling. Species and the number of individuals caught per species will be recorded. Most fishes will be released alive, but vouchers will be retained for all samples. Voucher fishes will be anesthetized in MS-222 and fixed in 10% buffered formalin. All individuals not readily identified on site will be retained along with the vouchers and identified in the laboratory.

Mammals

Surveying for mammals requires the use of a variety of techniques to provide the most complete coverage for each park. Small mammals will be surveyed at ANTI, CATO, CHOH, GWMP, HAFE, NACE, ROCR, and WOTR using a series of focal points. At each focal point we will establish eight 9-inch Sherman live-traps, two 16-inch Tomahawk traps, and one pitfall array. If the focal point is in a wooded habitat, one of the Tomahawk traps will be attached to a tree via a platform to sample flying squirrels. The pitfall array will be composed of 4 water-filled pitfalls, i.e. a central pitfall and 3 additional pitfalls connected to the central pitfall with a 1-m length of wire mesh screening. The traps would be placed around the pitfall array within 11 m. Traps will be placed within tunnels at any sites with evidence of subterranean activity. Most shrews will be killed through capture in the pitfall array, but we know of no techniques to sample shrews for live release. The pitfalls will be small enough (one pint) to allow larger mammals to escape capture. Each array will be pre-baited for 2 days, followed by 5 days of live-trapping. The pitfalls will be filled with water at the time of pre-baiting, so they will operate for 7 days. Traps will be checked twice daily, with all captured animals identified, marked, weighed, and released. These batch marks will allow for obtaining relative abundance estimates.

Sampling will occur from April through the end of October when small mammals are active. Voucher specimens will be individuals found dead in traps. Voucher photographs will also be used for species that can be reliably identified using photographs. If point sampling does not produce evidence of moles, targeted sampling of tunnel systems in appropriate mole habitats will be conducted to sample this group, which includes a species of special concern, the star-nosed mole (*Condylura cristata*).

To survey predators, we will place infrared-triggered cameras at 6 sites per park. ANTI, CHOH, GWMP, HAFE, and ROCR are in need of predator surveys. We will bait the cameras with predator lure and a small piece of meat to increase the likelihood of obtaining photographs. The cameras will be operated twice during the year; for one week during the small mammal survey period and for one week during the winter. An abundance index of number of pictures/hour of coverage will be calculated to determine relative abundance. Predator sampling will also provide information on bobcat, gray and red fox, which are species of special concern in several Network parks. Photographs of animals will be used as vouchers for species such as foxes that are not appropriate to take as specimens. Because many of the Network's parks are concerned with their flying squirrel populations and these squirrels are best captured during the winter, tomahawk traps will be placed in trees at each site to obtain additional information on this species of special concern.

The Allegheny woodrat (*Neotoma magister*) has been identified as a species of special concern at CHOH. This species is restricted to rock escarpments. Therefore, we will conduct a specialized search for this rare species in the appropriate habitats along the canal using a combination of live trapping and searches for active dens.

Overabundance of white-tailed deer resulting in poor seedling growth and forest regeneration is a concern in the Network. We will obtain density estimates of this species using distance sampling (Burnham et al. 1980, Buckland et al. 1993, Underwood et al. 1998) in all Network parks for which the technique can be applied. HAFE does not have the network of road coverage required for the technique and WOTR is too small to yield biologically significant deer density estimates (H. B. Underwood, pers. comm.). Deer density estimates using pellet counts will be conducted at HAFE with other funding.

Bat surveys are needed in 10 out of 11 Network parks. We will use techniques outlined in Wilson et al. (1996) to survey for bats. A variety of techniques may be used such as mist netting at the entrance to roosts and over water sources frequented by bats, surveys of known and potential roost sites, and identification of sounds produced during echolocation.

Reptiles and Amphibians

Reptiles and amphibians are not easily inventoried. They tend to be very habitat-specific and are unlikely to be well sampled using a random grid approach. We will focus sampling attention on the habitats that are most likely to harbor reptiles and amphibians (wetlands, ponds, vernal pools, streams, terrestrial areas around wetlands) rather than employ a randomized or stratified random sampling design. Herps also exhibit highly seasonal activity patterns, therefore, we will conduct intensive surveys during their periods of activity.

We will use a variety of methods to survey for reptiles and amphibians in order to document 90% of our park's reptiles and amphibians (Heyer et al. 1994, Mitchell 2000). Determination of their presence or absence requires a variety of specialized techniques, especially for secretive species such as snakes. A combination of sampling techniques is most likely to yield 90% or more of the species present. Efforts will be made to collect voucher specimens or photographs of all species at each park.

Small parks will be sampled a minimum of four 2-3 day site visits during each season in which herps are active. At least one site visit will be conducted in late winter to early spring for the early-breeding amphibians, and 2-3 site visits will be done in May and June for the warm season breeders. In large parks, multiple site visits would be conducted from March through September.

The outline below summarizes the techniques we will use to sample amphibians and reptiles in the National Capital Network.

I. Amphibians
   A. Frogs
      1. Frog call surveys – Each aquatic site in each park will be visited several times each year (March-June) to listen and record all frogs that are calling (Rosen and Lowe 1995). Sites will be visited from just after sundown to midnight or 0100 h. The timing of this sampling effort is critical because many species will aggregate for only a few nights during the spring or summer.
      2. Dipnet and minnow trap surveys – D-ring dipnets and minnow traps set in shallow water with tops exposed will be used to capture tadpoles in wetlands. Multiple dips (20-50) and at least 10-30 minnow traps will be used in each wetland. Sampling will be conducted monthly during spring and summer months.
      3. Visual encounter surveys – Random walk-through surveys will be used in terrestrial and wetland habitats to survey for juvenile and adult frogs. Binoculars will be used to scan shorelines of wetlands.
   B. Salamanders
      1. Dipnet and minnow trap surveys – D-ring dipnets and minnow traps set in shallow water with tops exposed will be used to capture salamander larvae. Multiple dips (20-50) and at least 10-30 minnow traps will be used in each wetland. Sampling will be conducted monthly during spring and summer months.
      2. Visual encounter surveys – Random walk-through surveys will be used in terrestrial habitats and around wetlands to survey for adult and juvenile salamanders. Cover (boards, logs, rocks) will be turned over during the surveys to find hidden salamanders. Walk-through surveys of vernal pools at night will also be conducted.
      3. Artificial coverboards – Coverboards may be used in some parks to sample salamanders. Typically, coverboards yield fewer captures of salamanders than the visual encounter surveys, therefore use of this technique will be limited.
      4. Drift fence/pitfall technique – This technique may be used strategically in some parks to document rare salamanders not picked up by other techniques. Drift fences will be

composed of three strips of 7.5 m aluminum flashing or black silt fencing and will be arranged in an exploded "Y" configuration. Pitfalls (5 gallon plastic buckets filled with about 15 cm fresh water) will be placed at the end of each fence and checked at least every 1-2 days. The arrays will be operated for 2-3 sessions in late winter and early spring and 2-3 sessions in May and June if needed.

II. Reptiles
   A. Lizards – Lizard surveys will be conducted through visual encounter surveys in terrestrial habitats.
   B. Snakes
      1. Minnow trap surveys – Minnow traps will be set in shallow water with the tops exposed in wetlands to capture semi-aquatic snakes. At least 10-30 traps will be used in each wetland. Sampling will occur for several days per month during spring and summer months.
      2. Visual encounter surveys – Random walk-through surveys in terrestrial habitats and around wetlands will be conducted to survey for adult and juvenile snakes. Binoculars will be used to scan shorelines of wetlands for basking snakes. Cover (logs, boards, rocks) will be turned over during the surveys and visual searches will include night sampling in and around ponds and vernal pools.
      3. Road surveys – All roads will be driven slowly at night in summer months to search for crossing snakes (Rosen and Lowe 1994, Sullivan 1981). Time and distance covered will be standardized, and all herps encountered will be identified, and sex, age, and condition will be recorded if possible. Animals found dead in reasonable condition can be used as vouchers, and locations of all observations will be recorded.
      4. Artificial coverboards – Coverboards may be used in some parks to sample snakes. Because this technique may yield low rates of capture, its use may be limited.
      5. Drift fence/pitfall technique – This technique may be used strategically in some parks to document rare snakes not picked up by other techniques. Drift fences will be composed of three strips of 7.5 m aluminum flashing or black silt fencing and will be arranged in an exploded "Y" configuration. Funnel traps made of window screening will be placed along each fence and checked at least daily or several times a day to prevent snakes dying from exposure. The traps will be shielded from the sun with some form of cover.
   C. Turtles
      1. Turtle traps – Traps will be set in shallow water and baited with a perforated can of sardines. Traps will be checked daily and reset.
      2. Visual encounter surveys – Aquatic habitats will be scanned with binoculars or spotting scopes to reveal turtles basking or at the water's surface.

Vascular Plants

To measure herbaceous vegetation in non-forested habitats, we will use 1 x 1 m quadrats placed over the focal point. Focal points will be randomly selected within grids. The quadrat sampling procedure will allow us to estimate species diversity and density (abundance) for extrapolation over larger areas. Density is defined as the number of rooted plants per quadrat. In forested communities, we will use

circular quadrats (18 m radii) centered over the focal point (Higgins et al. 1994). Within each quadrat we will list all known plant species. Each circular quadrat will be walked in a back and forth sweep to exhaustively sample all plant species. Unknown taxa will be collected, processed, and later identified for addition to the inventory species list. As described in Steps 3 and 4: Study Design, special efforts will be made to survey rare habitats such as riparian zones, rock outcrops, meadows, and other areas harboring rare plants.

Timing of plant surveys is crucial. Some plants, for example, may not appear every year. The seeds of many plant species can remain dormant for years and perennials such as orchids can persist underground for long periods of time; inter-year and inter-seasonal explosions of species diversity can occur. We will survey twice per season (spring, summer, fall, and winter) or more frequently as necessary during each year of the study.

Because many species are not distributed randomly, care must be taken to determine adequate sample size (number of quadrats) to measure species diversity and density of rare plants. The programs SPECRICH, available at http://www.mbr-pwrc.usgs.gov/software.html, will be used to determine species richness and measure if adequate sample size has been reached.

E. Data Analysis, Management, and Reporting

Efficient and effective data management is critical to the success of an inventory and monitoring program. In order to make informed resource management decisions, information must be accessible to park managers in a user-friendly format. We will prioritize the development of an integrated Network data management system and we will use databases and tools such as the GIS data browser that are user-friendly and widely used with the National Park Service. A well-designed, up-to-date data management system will ensure that the data generated from this program will be accessible and available for years to come, despite frequent turnover in park and regional staff.

Database Management

One of the primary responsibilities of the Data Manager will be to develop a centrally managed database for all inventory-related data. The Washington Support Office is developing a sample MS Access Database Management System (DBMS) to store Network inventory and monitoring data that we will modify for this Network. The Data Manager will coordinate database development with all inventory contractors and cooperators to add new fields and make necessary modifications. At a minimum, the DBMS is expected to contain standardized occurrence and location data for all parks and taxonomic groups. The database will also provide for links to existing databases such as NPSpecies, NRBib, GIS Data Browser, Dataset Catalog, and contain the original study plans and proposals. The structure of the relational database will allow data summaries at the inventory site level, park level, and Network level. We will also work with the Service-wide I&M program to develop the system in such a way that information from the Network can be accessed for national summaries that may be needed.

To facilitate data exchanges and management, all new inventories will be required to produce electronic databases or spreadsheets that are compatible with DBMS. Contractors and cooperators will also be

required to submit metadata utilizing Dataset Catalog standards and GIS metadata following FGDC standards. Metadata for the Dataset Catalog can be entered online once the internet database becomes available.

Each field team will receive a copy of the database and supporting documentation from the Data Manager to facilitate data entry in the field or shortly after each field visit. Data entry forms should follow the datasheet formats to facilitate data entry. "Lookup tables", "range checking", and other automated data verification methods will be utilized to reduce data entry errors. Backups onto zip disks will occur nightly on equipment used in the field. Original datasheets and backups should be copied and stored in an offsite location on a weekly basis.

At the end of each field season, the Data Manager will integrate data received from contractors into a master version of the DBMS maintained by the Data Manager at the NCR – I&M office. Copies of original datasheets will also be required at the end of the field seasons to allow the Data Manager to follow quality control measures (i.e. verify random sample of data). NPSpecies, NRBib, Dataset Catalog, and other national databases will be updated as appropriate. The master DBMS will be backed up on zip disks regularly, archived on CD, and distributed to the parks annually. The Data Manager will create an on-line version of the database to facilitate backups and data sharing among parks and field researchers.

Species Distribution Mapping

For all species, GIS compatible location data such as GPS points in UTM coordinates and presence/absence data will be collected to allow for map development as needed. For rare species and species of special concern, presence/absence distribution will be plotted using ArcView and specific GPS locations. For some special status species, relative or absolute abundance and breeding localities may also be mapped. In addition, contractors will be required to submit metadata following standard FGDC and Dataset Catalog standards. The Data Manager will work with the contractors and the region's GIS specialists to ensure that proper protocol are being followed. Newly generated GIS data will be archived at the regional GIS office and distributed to the appropriate parks.

Models for Estimating Inventory Completeness

Inventory completeness will be determined by comparing the number of species encountered to the number expected and by developing species accumulation curves. To estimate inventory completeness for vertebrates, we will compare survey results with the number of species expected to be present based on range maps, state databases, and expert opinion. For vascular plants, species lists are available which are not based on a systematic inventory design. In these cases it is difficult to determine inventory completeness. We will plot the number of species encountered as a function of the number of sampling days. To determine completeness, we will compare the mean encounter rates of undocumented plants to documented ones. "New" species should make up less than 10% of all species encountered for each strata for the previous inventory to be considered to be 90% complete.

Data Analysis and Reports

A variety of techniques will be used to summarize and analyze inventory data. Contractors and cooperators are required to provide written annual and final reports that summarize their findings. Reports will include site descriptions, methodology, results, discussion, and summary sections, as well as data, GPS sample locations and GIS themes, and metadata utilizing FGDC standards.

Data analyses may include histograms, graphs, indexes, and GIS maps to present data. Species accumulation curves will be used to assess inventory progress. Specific statistical procedures will be used for estimating species richness, species evenness, absolute or relative abundance based on quadrat counts, capture-recapture data, depletion estimates, and encounter rates. At the end of each inventory, the Data Manager will archive the study protocol and data using the DBMS and will update the appropriate I&M databases. The Biological Inventories Coordinator will distribute copies of reports along with updated databases (NPSpecies, NRBib, Dataset Catalog, etc.) to the parks, regional offices including the library at the Museum Resource Center, and the service-wide Inventory and Monitoring Program.

III. COORDINATION AND LOGISTICAL SUPPORT

The success of inventory and monitoring efforts is dependent on effective communication and support. We intend to staff this program with a four-person team, consisting of the NCN Inventory and Monitoring Coordinator, Biological Inventories Coordinator, Data Manager (to be hired), and Biological Technician (to be hired). The Data Manager and Biological Technician will also work on vital signs monitoring. Inventory funds may cover a portion of these costs, with the remaining funding coming from the monitoring phase of the program, which will receive partial funding in fiscal year 2001. The team will work closely with the regional Inventory and Monitoring Steering Committee to implement the program. This study plan was developed with input from all of the Network parks. We have worked closely with each park to determine the status of park inventories, identify species and habitats of special concern, and to populate the I&M databases. We will continue to work with the parks to coordinate the program and field work, provide logistical support to the contractors, including providing housing to field biologists, making equipment available, and assisting in site selection.

IV. VOUCHER SPECIMENS

We aim to have voucher specimens or photographs for all species. Once the extent of existing voucher collections and holdings are known, we can determine which species need additional collecting. Whenever possible, and for all federally threatened and endangered species, voucher specimens of animals will be those found dead (roadkills, animals found dead in traps, etc.). For many groups such as medium and large mammals and birds, animals will not be killed for voucher specimens, and voucher photographs will be used (see below). Voucher specimens will be required for all plants, small mammals, fish, most reptiles, and amphibians.

For individuals that are not found dead, specimens will be collected and euthanized only after NPS or university protocols have been approved. Specimens collected will be catalogued in NPSpecies and ANCS+. Specimens will be deposited in park collections or at the region's Museum Resource Center if that is preferred by parks; in most cases, specimens will be deposited in university natural history museums or the National Museum of Natural History.

For species that are rarely found dead, we will use voucher photographs. Species identification must be unequivocal to be retained as voucher photographs. For medium and large mammals, voucher photographs will be obtained using infrared-triggered photography. Voucher photographs will be clearly labeled with the park where collected, the specific location, date, scientific name, and photographer. Copies of voucher photographs will be deposited in park collections or at the region's Museum Resource Center if that is preferred by parks; photographs may also be deposited at the National Museum of Natural History or the regional I&M office for permanent archiving.

V. ACKNOWLEDGEMENTS

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VI. BUDGET

NA

VII. PROJECT COMPLETION SCHEDULE

October 2000-March 2001

- Complete compilation and entry of existing inventory data
- Evaluate and identify GIS resources and needs
- Refine inventory study plans
- Develop database structures
- Assemble workforce
- Initiate field work on scheduled inventories
  - White-tailed deer density estimates: ANTI, CATO, CHOH, GWMP, MANA, MONO, NACE, PRWI, ROCR
  - Birds – wintering: ANTI, CATO, HAFE, PRWI, WOTR

March 2001-October 2001

- Allocate funding, develop field schedule
- Continue field work on scheduled inventories
  - White-tailed deer density estimates: ANTI, CATO, CHOH, GWMP, MANA, MONO, NACE, PRWI, ROCR
- Initiate field work on scheduled inventories
  - Birds – migrant and breeding: ANTI, CATO, CHOH, HAFE, MANA, PRWI, WOTR
  - Small mammals: ANTI, CATO, CHOH, GWMP, HAFE, NACE, ROCR, WOTR
  - Medium/Large mammals: ANTI, CHOH, GWMP, HAFE, ROCR
  - Herps: CATO, CHOH, GWMP, HAFE, MANA, MONO, ROCR, WOTR

October 2001-March 2002

- Review first field season, refine study plans if needed
- Compile, enter, and analyze data
- Continue field work on winter-active species
  - Medium/Large mammals: ANTI, CHOH, GWMP, HAFE, ROCR
  - Birds - wintering: ANTI, CATO, HAFE, PRWI, WOTR
- Develop 2002 field schedule

March 2002-October 2002

- Complete second year of field work on ongoing inventories
  - Birds – migrant and breeding: ANTI, CATO, CHOH, HAFE, MANA, PRWI, WOTR
  - Small mammals: ANTI, CATO, CHOH, GWMP, HAFE, NACE, ROCR, WOTR
  - Medium/Large mammals: ANTI, CHOH, GWMP, HAFE, ROCR
  - Herps: CATO, CHOH, GWMP, HAFE, MANA, MONO, ROCR, WOTR
- Initiate field work on scheduled inventories
  - Plants: CATO, PRWI, WOTR
  - Fish: ANTI, CHOH, GWMP, HAFE, MONO, WOTR

October 2002-March 2003

- Review first field season of newly begun inventories, refine study plan if needed
- Compile, enter, and analyze data on all inventories to date
- Finish data analyses and report writing for completed inventories
- Continue field work on winter-active species
  Medium/Large mammals: ANTI, CHOH, GWMP, HAFE, ROCR
  Birds - wintering: ANTI, CATO, HAFE, PRWI, WOTR
- Develop 2003 field schedule

March 2003-October 2003

- Complete second year of field work on ongoing inventories
  Plants: CATO, CHOH, GWMP, PRWI, WOTR
  Fish: ANTI, CHOH, GWMP, HAFE, MONO, WOTR
- Initiate field work on scheduled inventories
  Bats: ANTI, CATO, CHOH, GWMP, HAFE, MANA, MONO, NACE, ROCR, WOTR

October 2003-March 2004

- Review first season of newly begun inventories
- Compile, enter, and analyze data on all inventories to date
- Finish data analyses and report writing for completed inventories
- Develop 2004 field schedule

March 2004-October 2004

- Complete field work on most inventories
  Plants: ANTI, CATO, CHOH, GWMP, HAFE, MANA, MONO, NACE, PRWI, ROCR, WOTR
  Fish: ANTI, CHOH, GWMP, HAFE, MONO, WOTR
- Continue with data entry and analyses

October 2004-March 2005

- Complete field work on winter-active species
- Compile, enter, and analyze data on all inventories
- Final Report due March 31, 2005

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