PHOTO INTERPRETATION REPORT

USGS-NPS VEGETATION MAPPING PROGRAM

ROCK CREEK PARK

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I. INTRODUCTION

The National Park Service (NPS), in conjunction with the Biological Resources Division (BRD) of the U.S. Geological Survey (USGS), has implemented a program to "develop a uniform hierarchical vegetation methodology" at a national level. The program will also create a geographic information system (GIS) database for the parks under its management. The purpose of the data is to document the state of vegetation within the NPS service area during the 1990's, thereby providing a baseline study for further analysis at the Regional or Service-wide level. Aerial Information Systems (AIS) was subcontracted by Environmental Systems Research Institute (ESRI), the prime contractor, to perform the photointerpretation for the program. ESRI subcontracted The Nature Conservancy (TNC) to conduct the field sampling effort and to support the development of the National Standard Classification.

Several parks, representing different regions, environmental conditions, and vegetation types, were chosen by BRD to be part of the prototype phase of the program. The initial goal of the prototype phase is to "develop, test, refine, and finalize the standards and protocols" to be used during the production phase of the project. This includes the development of a standardized vegetation classification system for each park and the establishment of photointerpretation, field, and accuracy assessment procedures.

Rock Creek Park, established in 1890, was designated as one of the prototype parks. The park is located on the fall line between the Atlantic coastal plain and the piedmont. The main portion of the park is bounded on the north by the Maryland State line and on the south by the Potomac River. Its western edge follows along Oregon Avenue, and it is bounded on the east by 16th Street. Outlying portions of the park extend from the Palisades in the west to Barnard Hill at its eastern edge (see Figure 1 - Map of Rock Creek Park Boundary).

The park is noted for having exceptional resources, including six natural resources that maintain its significance within the National Park System. Included in these six natural resources, are three that are directly related to the vegetation of the park. They are: 1) Deciduous forests, 2) Wetlands, and 3) Plant species protected in both Virginia and Maryland. Based on these and other resources, Rock Creek Park is divided up into nine management zones pertaining to vegetation, automobile access, recreation, administration, and cultural resources.

Rock Creek is one of the largest forested urban parks in the United States, with more the 3/4 of the park's approximately 1,750 acres covered by mature deciduous forest. A significant portion of this forest is second growth, with a moderately high diversity in canopy and understory species.

II. ROCK CREEK PARK - GENERAL DESCRIPTION

Rock Creek Park is made up of steep canyons and side slopes that bisect several significant east-west trending ridgelines. The park descends along the fall line through numerous small rapids along the creek. Rock Creek itself, descends over 150' from the state line to its confluence with the Potomac River. Flood plain development is fairly restrictive, limited primarily to Rock Creek itself. Broad Branch, the main tributary to Rock Creek within the park, flows southeasterly and joins Rock Creek towards the southern portion of the park. At the confluence, the park boundary significantly narrows in its east-west extent. All sections are accessible either by automobile or by hiking. Most portions of the park are accessible through short hikes, usually under one mile. Gradients above the floodplain are surprisingly steep, and make for some moderate hiking.

For purposes of vegetation mapping, the park was divided into four sections pertaining primarily to its location on the fall line between the coastal plain and piedmont. The park was further divided into the main portion of the park (containing Rock Creek), and the various outliner portions of the park to the east and west. The following shows the four regions of the park defined (see Figure 2 - Rock Creek Park Zones).

Forest Zone - The main portion of the park located north of the National Zoological Park. A management zone composed largely of undisturbed second growth deciduous forests and a narrow flood plain zone.

Glover Archbold Park and Environs - A region near the west edge of the park containing significant stands of unbroken forests and a riparian corridor.

Fort Totten Park, Barnard Hill Park and Environs - Located in the eastern extremities of the park, this area is primarily on the lower coastal plain, and contains vegetation from areas nearer the coast and further south including Loblolly pine.

Land Use areas of the Park - Outliner urbanized portions of the park and areas south of the National Zoological Park.

The following paragraphs briefly describe the vegetation and ecology of each of the four sections:

The Forest Zone

The forest zone contains the main portion of Rock Creek Park north of the National Zoological Park. This is an area composed of relatively undisturbed second growth forests, less mature successional forests and a narrow flood plain zone. Three upland communities as defined by The Nature Conservancy make up the majority of this region in addition to a seasonally flooded forest type bisecting the center of the zone.

The most xeric of the communities *Quercus (prinus, velutina)/Gaylussacia baccata* Forest is found primarily along the ridgelines and upper side slopes south of Military Road. A good example of this community is located just west of the equitation field about 1/2 mile south of the park headquarters. Further down the side slopes and adjacent to the floodplain, a dry mesic community (*Fagus grandifolia - Quercus alba / Podophyllum peltatum* Forest) dominates. This is overall the most extensive community type in the forest zone. Throughout this zone, there are significant stands of forests containing primarily *Liriodendron tulipifera* in the canopy overstory. This successional forest (*Liriodendron tulipifera* Forest) is a provisional community type, and can be found extensively just south of Wise Road in the northwestern portion of the zone. Along the wider portions of the Rock Creek floodplain, a seasonally flooded community *(Platanus occidentalis - Fraxinus pennsylvanica* Forest) can be found. This community is especially well developed at the confluence of Rock Creek and Fenwick Branch. In this area, there are some fairly extensive stands of Fraxinus pennsylvanica in a seasonally flooded water regime.

In addition to the three major upland communities, small areas of the *Pinus virginiana - Quercus (alba, stellata, falcata, velutina*) Forest can be seen on isolated ridges throughout the southern portions of this zone. Since most of this region has not been harvested in over 100 years, most of these examples are dwindling in extent. Small areas of these *Pinus virginiana - Quercus (alba, stellata, falcata, velutina)* Forest type are found near the park administration buildings. In addition, significant areas representing both cultural and recreational value are located within the perimeters of the forest zone. These include the Rock Creek golf course, the park administration buildings and visitor center, Fort De Russey, and the Carter Barron Amphitheater.

Glover Archbold Park and Environs

The Glover Archbold Park and Environs region located northwest of Georgetown University and south of Massachusetts Avenue contains steep side slopes and a narrow floodplain corridor. Elevations in this portion of the park range from nearly 350 feet in the north to below 50 feet where the environs meet the Potomac. Within this area, significant stands of the *Fagus grandifolia - Quercus alba / Podophyllum peltatum* Forest are found just east of Foxboro Road. The *Liriodendron tulipifera* Forest provisional community is represented by some extremely tall even age homogenous stands of *Liriodendron tulipifera,* also to the east of Foxboro Road. A significant but narrow riparian corridor containing a *Platanus occidentalis - Fraxinus pennsylvanica* Forest community runs primarily in a north-south direction through the center of the area. A large community garden is located just to the east of a good example of this floodplain community.

Fort Totten Park, Barnard Hill Park and Environs

Located in the eastern edge of the park, the **Fort Totten Park, Barnard Hill Park** and **Environs** region is noteworthy because it contains examples of communities that are represented in the Atlantic coastal region. Elevations in this area range from over 300 feet at Fort Totten to below 200 feet in the eastern most regions of the park. A primary example of the *Pinus taeda - Quercus (alba, falcata, stellata, velutina*) Forest community occurs in the Fort Totten Park. To the east, on Barnard Hill, another example of this community occurs, with a dominant overstory of several species of oak. It is interesting to note some of the influences from past civil war activities on the tree canopy especially at Fort Totten.

Land Use Areas within the Park

Much of the significant land use portions within the jurisdiction of the park boundaries lie south of the National Zoological Park, and throughout the numerous corridors connecting the different portions of Rock Creek Park. Much of this region is occupied by historical sites, roads, maintained lawns, community gardens, golf courses, monuments, and planted trees.

III. SUMMARY OF THE MAPPING EFFORT AT ROCK CREEK PARK

The following section is a short outline, listed in chronological order, of the vegetation mapping effort at Rock Creek Park. For a detailed description of the tasks listed below, refer to sections IV, V, and VI.

October 29, 1996
- Aerial photography for Rock Creek Park is flown

February 25, 1997
- Initial meeting at Rock Creek Park headquarters - acquisition of aerial photography and ancillary data including existing vegetation maps

March - April 1997
- First cut delineations onto aerial photography of the photo signatures (see Figure 3 - Rock Creek Park Photo Index).

May 12 - 16, 1997
- Photointerpretation field reconnaissance trip
- TNC training of park biologists in field sampling methodology

May - June 1997
- Develop initial list of photo signature types
- Revise initial delineations based on field reconnaissance findings
- Label existing polygons with photo signature types
- Deliver copies of overlays to park biologists for plot selection and feedback

June - September 1997
- Park vegetation sampling effort

February 19, 1998
- Received draft TNC report of the vegetation classification for Rock Creek

March 1998
- Received final TNC report on the vegetation classification for Rock Creek
- Received plot data and locations for vegetation sampling effort
- Received TNC key for communities
- Development of PI signature / TNC community lookup table
- Polygons attributized with initial communities

April 1998
- Received DOQQ files (April 1989)

May 11-12, 1998
- Photointerpretation field verification trip

May 1998
- Revise photo signature / TNC community lookup table
- Update and correct PI community calls and PI linework

June - October 1998
- Data rectification and conversion
- Interim files and plots delivered to NPS-ROCR
- Final documentation

IV. VEGETATION MAPPING AT ROCK CREEK PARK

One of the most important mandates of the Vegetation Mapping Program is the consistent capture and classification of vegetation types through photointerpretation and field sampling methodologies. Mapping criteria and procedures developed during the prototype parks are currently being tested and revised. The first two parks that were mapped, Assateague Island National Seashore and Tuzigoot National Monument, utilized a vegetation layer mapping approach. Layer mapping consists of photointerpretation of multiple canopies of vegetation that are visible on the aerial photography. Canopies are normally defined by the structure of the vegetation (trees, shrubs, or herbaceous growth). Where possible, individual plant species are interpreted for each layer of vegetation. These data are then re-aggregated into the appropriate alliance or community as defined by TNC. Subsequent parks, including the Nebraska grassland parks, Congaree Swamp National Monument, and Rock Creek Park, involve mapping an initial photosignature type describing multiple vegetation canopies. These photo signature types are then translated into a TNC community type or alliance. Height, density and pattern are additionally assigned to each polygon. Photointerpretation signature types are retained to further describe at a more detailed level the attributes visible on the aerial photography for each polygon.

Rock Creek Park Initial Meeting

A one-day meeting was held February 25, 1997 at the park headquarters to bring together project team members from the National Park Service, AIS, and TNC. This meeting focused primarily on discussing the Vegetation Inventory and Mapping Program, existing park data, and specific interests and issues of the park.

During the meeting, imagery, basemaps, and other pertinent collateral materials were reviewed and evaluated. Included in this inventory were the following data:

- Existing park boundary (electronic format - source & reliability at the time were unknown)
- 1974 vegetation map delineated on an orthophotography base generated by the American University
- GIS overlay data including roads, floodplains, soils, trails, and other pertinent data
- Supplemental leaf off aerial photography (1995)
- Data on Park plant species and exotics
- Dogwood Anthracnose study
- Gypsy moths Tree Inventory - (Gives % Oaks in each plot)
- Washington DC soils map
- Digital orthophotography

Park specific issues were also discussed. These issues are addressed later in the General Mapping Criteria section.

Development of Photointerpretation Mapping Procedures

The normal process in vegetation mapping is to conduct an initial field reconnaissance, map the vegetation units through photointerpretation, then conduct a field verification. The field reconnaissance visit serves two major functions. First, the photointerpreter keys the signature on the aerial photos to the vegetation on the ground at each signature site. Second, the photointerpreter becomes familiar with the flora, vegetation communities and local ecology that occur in the study area. Park and /or TNC field biologists that are familiar with the local vegetation and ecology of the park are present to help the photointerpreter understand these elements and their relationship with the geography of the park.

Upon completion of the field reconnaissance, photo interpreters delineate vegetation units on mylar that overlay the 9x9 aerial photos. This effort is conducted in accordance with the TNC vegetation classification and criteria for defining each community or alliance. The initial mapping is then followed by a field verification session, whose purpose is to verify that the vegetation units were mapped correctly. Any PI related questions are also addressed during the visit.

The vegetation mapping at Rock Creek Park in general followed the normal mapping procedure as described above. However, a TNC vegetation classification did not exist for Rock Creek Park at the time the initial delineations commenced. The TNC ecologist and AIS photo interpreters worked together to develop a temporary signature key which addressed what was known at the time. Unlike most parks, no existing plot data was available to create an interim classification.

Development of Photointerpretation Mapping Criteria

From the onset of the Vegetation Inventory and Mapping Program, a standardized program-wide mapping criteria has been used. The mapping criteria is a set of documented working decision rules used to facilitate the maintenance of accuracy and consistency of the photointerpretation. This criteria assist the user in understanding the characteristics, definition and context for each vegetation community.

The mapping criteria for Rock Creek Park was composed of four parts:

The standardized program-wide general mapping criteria

- A park specific mapping criteria
- A working photo signature key
- The TNC classification, key and descriptions

General Mapping Criteria

The mapping criteria listed below is a modified version of that developed during the Assateague Island National Seashore mapping effort. The criteria will serve as the standard for future photointerpretation efforts in the Vegetation Inventory and Mapping Program to ensure a consistent standard of mapping on a nationwide basis.

Height

Height describes average height of the life form of the specific alliance/community association unit. If there are significant height differences within an alliance/community association unit, then the unit can be subdivided to reflect those differences, provided they meet the minimum mapping unit (MMU) resolution.

- Height Categories
  < 0.5 meters
  0.5 - 2 meters
  2 - 5 meters
  5 - 15 meters
  15 - 5 meters
  35 - 50 meters
  > 50 meters
  Not Applicable

- Height Mapping Criteria

  To determine the average height of the vegetation of the same life form, determine the percentage of the vegetation at each height category. If 10% of the trees are 30m tall and 50% are 36m tall, then they will fall into a height class category of 35-50m. If 80% of the trees are 30m tall and 20% are 36m tall, then the height class category assigned to the polygon will be 15-35m.

  If there are seedlings and mature growth of the same species, the dominant growth form will be the determining factor. For instance, if a polygon contains Pinus palustris seedlings <. 5m tall and mature P. palustris trees 30m tall, the dominant cover type will determine the height assignment, i.e., if the 30m tall trees compose >50% of the tree cover, then the height class category for the trees will be 15-35m.

- **Density**

Density refers to the spacing of plants in the landscape. It represents the total coverage based on the percentage of crown or canopy cover. This figure is a qualitative estimate based on the aerial photography. Two methods are used to determine densities from aerial photographs, Absolute and Relative (Continual) Density. Absolute density refers to the sum total of the visible plant and non-vegetative cover within a given mapping unit. The total density cover for all visible over-, mid-, and understory vegetated and non-vegetated surfaces must equal 100% present. The unvegetated areas are not delineated unless they meet the minimum mapping unit size. Vegetation not visible on the aerial photograph is not considered part of the total plant density. For example, in a closed canopy forest the understory grasses and shrubs are not visible, therefore only the tree overstory is visible and the density class is based on the total tree cover present.

Relative density is used when the aerial photography allows the interpreter to see the understory vegetation. This is due to the environmental conditions at the time of the photography, or when detailed field notes are available. When mapping relative density, it is possible to arrive at total vegetation cover percentages well over 100%. For example, using winter photography to capture leaf-off conditions, a closed-canopy deciduous forest (over 60% crown cover) is visible along with the shrub and grass understories. In addition to the 60-100% tree cover, shrub and grass understory may make up an additional 60-100% understory cover, totaling at least 120% vegetation cover for that mapping unit.

Absolute crown density is normally the most accurate way of estimating plant coverage and will be used to determine the percentage of vegetation cover within a polygon unless noted otherwise in the park specific mapping criteria. In certain park specific situations where understory needs to be mapped, relative density estimates will be addressed if there is sufficient data. At the very least, aerial photography showing leaf-off conditions is necessary when mapping relative crown density.

For Rock Creek Park density describes average absolute crown density of the life form of the specific alliance/community association unit. If there are significant density differences within an alliance/community association unit, then the unit can be subdivided to reflect those differences, provided they meet the minimum mapping unit (mmu) resolution.

- Density Categories

  Closed/Continuous >60% = Canopies overlapping, touching or nearly touching in most of the mapping unit.

  Discontinuous 40%-60% = Canopies rarely touching, however spacing is fairly minimal, especially when plants are not evenly distributed throughout the polygon.

  Dispersed 25%-40% = An open or parkland situation where large spaces occur between trees and shrubs, or where grasses are fairly sparse throughout the mapping unit.

  Sparse 10%-25% = Trees or shrubs are widely spaced, scattered throughout the polygon, or are clumped in very small areas making up a small percentage of the entire vegetative cover.

  Rare 2%-10% = Trees or shrubs occur only occasionally and usually do not make up enough percentage to be considered evenly dispersed. Grass coverage at this level is hard to detect on small scale aerial photography.

  Not Applicable = Density does not apply.

Density Mapping Criteria

To determine the absolute density, assign percentages to the life form (trees, shrubs, or herbaceous) pertaining to that particular PI signature type or TNC community for the polygon delineated. Densities should not exceed 100%.

Consider the coverage pattern of the life form before assigning a density code to the polygon. Estimating densities is more straightforward when plants occupying a particular strata are evenly distributed throughout the mapping unit. However when polygons contain populations of plants that are clumped or occurring only in portions of the polygon, the photointerpreter must consider the area that is not occupied by plant cover when determining coverage density. To ensure consistency, it is helpful to count the plants in polygons with clumped and unevenly distributed vegetation and then compare them to similar sized polygons with an even distribution of plant cover.

Vegetation stature type and scale of the aerial photography will determine the visibility of individual plants. Trees are usually visible as individuals and with larger scale photography so are shrubs. However, grasses are rarely seen as individual plants, regardless of the scale of the photography.

In the case of trees and shrubs, the percent cover at a density break is adjusted downward. If the percent cover is at about 25%, the polygon is assigned a density code of sparse (10-25%) instead of dispersed (25-40%).

Dry grasses tend to be less dense than they appear on the aerial photographs. To accurately depict the densities, the percent cover for dry grasses should be adjusted downward. This means that if the percent cover falls at the lower end of a density category, the polygon should be assigned the next density class down. For example, if the percent cover = 25%, the polygon should be assigned a density category of sparse (10-25%) instead of dispersed (25-40%). If the percent cover falls within the middle of a density category, the polygon should be assigned that density class, i.e., if the percent cover = 35%, then the polygon is assigned to the density category dispersed (25-40%).

The date of the aerial photography will also influence the densities assigned to vegetation types, especially herbaceous species. Subsequent field verification must take into consideration the following factors that can cause apparent discrepancies between the densities evident on the photo and those visible in the field:

Seasonality - the density of most herbaceous plants is variable due to their annual growth cycle. Depending on the season the aerial photography was taken, a mapped unit could show a different density on the aerial photographs than is observed during an on-site visit at a different time of the year. Another effect of seasonality is leaf on/off conditions. Photos of forest or woodland areas with leaf on conditions obscure the understory. Photos of leaf off conditions would allow photointerpretation of the understory.

Old Photography - the environmental conditions at the time the photography was flown (wet vs. drought years, flooding, etc.) may affect the densities seen during the on-site field visits.

- **Pattern**

Pattern describes the general distribution of vegetation types across the landscape. Pattern of vegetation can be a reflection of the landform, soil, geology, climatic gradients, and/or elevation gradients.

- Pattern Categories

  Evenly dispersed = Pattern of vegetation is an even or almost even distribution of individuals, clumps, or groups.

  Clumped/Bunched = Unevenly dispersed clumps of individuals or groups.

  Gradational/Transitional = A gradual thinning of the individuals or clumps as one moves from one area to another.

  Alternating = The vegetation occurs in a regular repeating pattern.

  Not applicable = Pattern does not apply.

- Pattern Mapping Criteria

  For Rock Creek Park pattern was mapped after the final alliance / community association map was created. A plot of the alliance/community association polygons was made and the vegetation was compared back to the aerial photography. The vegetation distribution was coded with the appropriate pattern code. If a polygon contained more than one pattern type, the polygon was subdivided as needed.

Alliance / Community Associations

The assignment of alliance and community association to the vegetation is based on criteria formulated by TNC. In the case of Rock Creek Park, TNC provided AIS with a tentative community classification in February 1998. A final vegetation classification, key, and descriptions of each alliance and community, was provided in March 1998. In addition, TNC provided AIS with diagrams showing the results of the TWINSPAN analysis on the *Fagus grandifolia - Quercus alba / Podophyllum peltatum* Forest.

Park Specific Mapping Criteria

Due to its proximity to urban development, the park must contend with a serious threat from aggressive and invasive exotics that threaten the existing areas of mature deciduous forest. Of the approximately 650 plant species in the park, over 30% are introduced and eradication programs have been implemented on four particularly aggressive species. Of these four species, (*Ampelopsis brevipedunculata, Celastrus orbiculatus, Lonicera japonica* and *Ranucules ficaria*), three are especially numerous in the forest canopy openings and along the park edges. One species, *(Ranucules ficaria*), is especially common in the flood plain near the riparian zone. It was determined that the minimum-mapping unit (MMU) will be ignored where detection of canopy gaps is possible on the aerial photography. Numerous exotics, especially the vine species, are invading these openings, and their location will prove a useful management tool for eradication efforts.

Park interest in the cost of maintaining existing lawns and parkways was noted at the initial meeting. These areas were given a unique PI signature value so they can be selected in the GIS and acreage counts extracted.

Working Photo Signature Key

A photo signature key is an important tool for maintaining consistency in interpretation. It correlates the physical descriptions of the photo signature with the appropriate vegetation community. A key may also describe other useful information that would be helpful in the interpretation.

For Rock Creek Park, a preliminary or working photo signature key was developed after the initial field reconnaissance trip and before the draft linework commenced. Field data collected during the reconnaissance effort were analyzed and compared with the aerial photos and consistent correlations between the photo signatures and vegetation types were noted. Each photo signature was given a unique value. This signature key was later modified to accommodate the final classification and further knowledge gained on the field verification trip.

The final signature key is in a table format, and contains the photo signature name, photo signature characteristics, geographic settings, specific park example locations and the associated TNC community type.

TNC Classification, Key, and Descriptions

In March 1998, TNC delivered to AIS a detailed description of the vegetation of Rock Creek Park using the National Vegetation Classification System developed in conjunction with the Federal Geographic Data Committee and the Ecological Society of American Vegetation Subcommittee. The Nature Conservancy, in partnership with the network of Natural Heritage Programs, developed this classification of vegetation of the United States as the national vegetation classification standard.

The vegetation descriptions, keys, plot data, and TWINSPAN diagrams generated for Rock Creek Park along with the working photo signature key enable the photointerpreters to delineate, refine and label the vegetation units interpreted from the aerial photography at Rock Creek Park.

Project Set-Up

One complete set of aerial photography was provided for the project, including both a set of prints and diapositives. The specifications for the aerial photography are listed below:

Color infrared photography (CIR)
Flown October 29, 1996 - (height of the leaf change)
Nominal scale - 1:6,000 (Nominal refers to the photo scale variability within each aerial photo and across flight lines. In this case the photo scale ranged from approximately 1:5,800 to 1:6,200)
Approximate photo size - 9" x 9"
Overlap between photos and across flight paths met the standards for photo interpretation using a mirror stereo scope. (Approximately 60% between photos and 10% - 20% between the flight lines)

Upon receipt of the project materials, it was determined that the current version of the park boundary did not meet the accuracy requirements for this mapping effort. Therefore, delineation onto the aerial photographs extended approximately 11/4" to assure that all portions of the park were interpreted. It was also determined, that the park boundary, as depicted on the Park Systems & Environs map (USGS - Falls Church Branch) was to be used as a temporary base reference since it appeared to represent the park boundary fairly accurately in relation to the aerial photographs.

A flight line index showing the relationship of the aerial photos to the preliminary study boundary was created. After comparing the index, the Park Systems map and the aerial photographs to each other, it was determined that small portions of the park, mainly in the vicinity of Fort Reno lacked CIR coverage. These small areas would be later interpreted off the digital orthophotography (see Figure 4 - Rock Creek Park Photo Coverage).

Preliminary Photo Signature Delineations

A total of 50 photos were needed to provide full photo coverage of the study area. Because of adequate control and sufficient overlap between flight lines and photos, it was determined that interpretation would be done on every other photograph.

Each photo was prepared with a 9" x 9" frosted mylar overlay for the photo signature delineations. Photo overlays were then pin-registered to the photos; project labels were affixed to each photo identifying the photo number, status of work (Initial PI, QC), and photo interpreters responsible for that task. Study area boundaries were drafted onto each photo overlay, defining the area within the photograph to be interpreted. The study area boundaries were edge matched to adjacent photos to ensure complete coverage.

Using a mirror stereoscope, with a 3X0 lens, photo signature units were delineated onto the mylar overlays. These initial photo delineations were based on a number of signature characteristics including color, tone, texture, relative height and density. The signature units were then edge matched to the adjoining photograph.

Initial attribute codes (signature codes, height and density) were assigned to the polygons after the field reconnaissance, and the development of the initial signature key.

Field Reconnaissance Effort

A three day photointerpretation field reconnaissance effort was conducted in May 1997 (see section III) to tie the photo signatures delineated on the aerial photographs with units evident on the ground. The field crew consisted of Eden Crane and Sue Salmons (park biologists), Virginia Crouch (Heritage biologist), Julie Lundgen (TNC ecologist) and John Menke (AIS photointerpreter).

Prior to the field reconnaissance effort, several in-house preparations were performed in order to facilitate a more organized trip. Each photo was prepared with a separate field overlay. Locational features (roads, buildings, etc) were drafted onto the overlays. Each photo was reviewed and field transect sites were chosen representing different signatures types, geographic variables (% slope, aspect, shape of the slope, elevation), and other abiotic variables noted on the photography. These sites were drafted onto the field overlays with notations to each site as needed. Multiple sites were chosen to provide alternatives if one or more sites proved inaccessible.

The field crew conducted on-site investigations over the three-day period. During the field visit, the photointerpreter worked with the field biologists to identify the plant species, preliminary vegetation communities, and their associated photo signatures throughout the park. Field site numbers were annotated directly onto the photo field overlay, thereby correlating the field site to a specific location and photo signature. A field notebook was used to record pertinent information (canopy dominance, understory species present, abiotic features, disturbance history) for each site visited. Several ground photos were taken at selected locations that were later tied back to the aerial photographs and the field sites. Sites not previously identified on the photos were also visited. These sites included areas between initially selected sites, areas of noteworthy or unusual significance as determined by park personnel, and areas the photointerpreter deemed important in transit from site to site.

Photointerpretation of Vegetation

Photointerpretation is the process of identifying map units based on their photo signature. All land cover features have a photo signature. These signatures are defined by the color, texture, tone and pattern they represent on the aerial photography. By observing the context and extent of the photo signatures associated with specific vegetation types, the photointerpreter is able to identify and delineate the boundaries between plant communities or signature units. Additional collateral sources (existing vegetation maps, supplemental photography, soil data, etc.) can be of great utility to the photointerpreter. Understanding the relationship between the vegetation and the context in which they appear is useful in the interpretation process. Familiarity with regional differences also aids interpretation by establishing a context for a specific area.

Initial photointerpretation of vegetation normally takes place after an interim classification has been developed. After the draft linework in complete, a second field effort is undertaken in order to verify the accuracy of the preliminary linework and to verify initial PI signature calls. Since no plot data existed at the time for Rock Creek Park, a rudimentary classification was not in place at the time the photointerpretation was to start. In order to meet contract schedule, draft linework was delineated prior to the field visit. Initial descriptions of the units based on field reconnaissance findings were formulated into a working interim signature key to be used in labeling the polygons. Copies of the photo overlays with their first cut delineations and signature calls were sent to park biologists to aid in selecting field sample sites. Sampling and development of the classification took place in the late summer and early fall of 1997.

A working classification was completed in February 1998, several months prior to the field verification. Each polygon was then labeled with a preliminary community code. Questionable areas or types were flagged for investigation during the field verification trip. Photo overlays were again edge matched to assure consistency of linework and labels across photo boundaries.

Photointerpretation Field Verification

A two-day photointerpretation field verification was held in May 1998 (see section III). The effort focused primarily on verifying and/or refining photo signature units and substantiating the associations attached to each polygon.

Preparation for the field verification involved three steps: 1) Locating the park sample plots on the photo overlays, 2) Choosing representative areas for each community type to review in the field and 3) Compiling photo interpretation question forms in order to plan a strategy for the two-day effort. Although AIS chose specific areas of focus, all portions of the park were checked for both line and label accuracy.

For the most part, the correlation between the photo interpretation calls and plots were excellent. A few plots were of questionable location and could not reliably be tied to the PI signature polygons. Several other plots were questioned because of their very close proximity to each other. There were several plots that underwent type changes during the verification effort. Most of these changes were within variants of the Fagus grandifolia-Quercus alba / Podophyllum peltatum Forest association. These variants were added by TNC in order to facilitate differences within the communities which were of park interest. Two of the variants are separable using the aerial photography in conjunction with abiotic variables, including slope, aspect, and landform. Establishing a reliable PI signature for one of the variants however was not possible. The following variants have been described by TNC within the above mentioned association: Fagus grandifolia - Quercus alba / Podophyllum peltatum Forest (Classic type) and Fagus grandifolia - Quercus alba / Podophyllum peltatum Forest (Mixed oak / beech variant)

In addition to the above variants, an additional component of the Classic type was noted on both the photo signatures and field. This type was called Fagus grandifolia - Quercus alba / Podophyllum peltatum Forest (Classic type) - noted with a beech - tulip component.

A third variant that was defined by TNC as a mesic floodplain related type was not visible on the aerial photography. These areas were generally lumped into the Classic type containing a beech - tulip component.

While in the field, notes were taken directly onto the PI overlays using a red Pentel. This helped in establishing which polygons were visited during field verification and assisted in refinements of the codes and line-work back at the office.

It was noted that the photo interpretation signature codes are an important supplement to the TNC association, and could prove valuable to park management decisions in the future. Therefore, all mapped units will contain a PI signature code to be maintained in a separate field in the database.

Final Photointerpretation

After the field verification trip in May, AIS proceeded with the final revisions to the photointerpretation linework and community calls. Each polygon was reviewed in conjunction with the notes taken during the field reconnaissance effort.

In addition to the community descriptions, TNC keys and TWINSPAN diagrams assisted the photointerpreter in defining boundaries between the more difficult variants within the Fagus grandifolia - Quercus alba / Podophyllum peltatum Forest.

Park plot descriptions and locations were also reviewed and correlated with the attributes on the photo overlays. Revisions to some of the plot data (community type) were also noted in the final photointerpretation effort.

Photo overlays were then edge matched to the adjacent photo to ensure a seamless coverage in the database. Delineations and codes were compared and discrepancies between photos were resolved and corrected on mylar overlays. Any uncertain interpretations were flagged on the mylar overlays for review during the quality control task.

Quality Control of the Photointerpretation

A separate quality control step was performed for each photo upon completion of the photointerpretation. A senior photointerpreter on staff reviewed each photo for linework accuracy and accuracy regarding PI signature, height, density and TNC community coding. The photo overlays were checked for completeness, consistency, and adherence to the mapping criteria and guidelines. For those polygons flagged by the photointerpreter, the quality control reviewer either assigned the appropriate vegetation code, or contacted park biologists for assistance in determining the appropriate vegetation class.

V. DATA CONVERSION

Converting the vegetation delineations to a digital format involved several steps that fall within four main procedures:

Geo-referencing (rectifying) photo overlay linework to the orthophotography.
Creating manuscript (digital quality) overlays and related attribute files.
Input of spatial data into digital format (scanning).
Linking the spatial data with the fields from the attribute files.

Basemap Production

In order to begin the data conversion process, a hardcopy version of the base was needed. The designated base was the USGS digital orthophoto quarter quads (DOQQ's) series for the Washington East and Washington West 7.5 minute quadrangles.

Creation of the DOQQ's required having the image plotted onto clear mylar at the mapping input scale, approximately 1:6,000. To facilitate the geo referencing of the polygons, it was determined that the average (nominal) scale of the aerial photography was actually 1:5,860. Six base plots were generated on mylar to cover the entire park and its environs.

Manual Rectification

Manual rectification was conducted by attaching a new mylar overlay to the base. The photo signature delineation units were transferred to the overlay through local registration of the photos with the attached photo signature delineation overlay. Existing orthophotography for Rock Creek Park was created from photos flown in leaf off conditions. Although this allowed greater ease for viewing features such as roads in forest canopies, it proved difficult to register vegetation from leaf on photography to the early spring leaf off orthophotography. A small area of the photo was registered to the base at a time. By matching photo image to orthophoto image, the delineations were transferred to the base overlay. Because the parallax of the photo differs from that of the orthophoto base, care was required in transfer. Inconsistent stretching or shortening of the images was common from the photo to the base. When one area was completed, the photo was shifted to register to another small area. The process continued until the manual rectification and transfer of polygons was complete. The codes for PI signature type, height, density, and community type were transferred from the corresponding photo overlays.

A quality control step was performed by a senior interpreter in order to assure accuracy of the rectification and delineation, and transfer of the codes.

Manuscript Map Preparation

A manuscript map, suitable for automation, was created to input the spatial component of the vegetation mapping units. The manuscript was produced by pin-registering a clean sheet of mylar to the rectification overlay and the mylar base. The vegetation delineations from the manually rectified overlay were transferred to the new overlay in ink. The manuscript maps were carefully edited to ensure completeness and correctness. The editing included comparing the manuscript with the original delineations on the aerial photos.

Quality Assurance of the Manuscript Map

The final manuscript maps underwent a quality assurance review. Each manuscript map was compared to its manual rectification overlay to ensure that all line-work had been transferred correctly. Particular attention was given to the quality of the line delineations with respect to gaps and other irregularities.

Sequence Number Assignment

A sequential identification number overlay was produced for each manuscript map. A clean sheet of mylar was pin-registered to the manuscript, and each polygon was labeled with a unique sequence number. These sequence numbers were used to tie the spatial file to the keypunched attribute file.

Polygon Attribute Encoding

To expedite the encoding of the vegetation attributes for each polygon, a Quattro Pro spreadsheet file was created for each map sheet. A separate field was created for the map sheet number, polygon sequence number, PI signature code, community association code, height code, density code, and land use code attributes. The manuscript map, sequence number overlay and attribute overlays were pin-registered together on a light table. The coder, following the numbers on the sequence number overlay, entered the vegetation attributes for each polygon. During this task, the coder verified the accuracy of the sequence number labels. Any errors found on the sequence number overlay were corrected to ensure that each polygon had a unique identifier.

Spatial Data Input/Scanning

The manuscript maps were scanned and converted into an ARC/INFO coverage at ESRI. Prior to any production scanning, test scans of small areas of the data map were conducted to determine the optimum raster to vector conversion settings. The critical settings that determine the output resolution and completeness are the TOLERANCE and THRESHOLD. The TOLERANCE, which governs the output resolution and is comparable to fuzzy tolerance, would be set to .01 inches (10 feet at 1:12,000 scale). The THRESHOLD is a reflectance measure, it is dependent on the physical characteristics of the data maps and their contents and is determined through testing. Once the THRESHOLD was derived, production scanning of manuscript maps began.

Assigning Polygon Identifiers

In an earlier step, the vegetation polygons were assigned a unique identifier. The numbers were sequenced 1 through "n" (4-digit item width) and were noted on the sequence number overlay. Each manuscript map and the associated sequence number overlay were registered together on the digitizing board. The polygon identifiers were sequentially input as label points. To ensure that all labels points were entered, the processor marked off each label as it was digitized.

Creation of Topology

Topology is the mathematical procedure for explicitly defining spatial relationships. In the case of maps, topology defines connections between features, identifies adjacent polygons, and can define one feature such as an area, as a set of other feature types (i.e., lines). A topological database has several advantages: efficient data storage, faster processing, and the ability to perform analysis, such as modeling transportation networks or overlaying geographic features on one another.

Once the manuscript map's polygon boundaries and label points had been input into the computer, the ARC/INFO software CLEAN command was used to create the "coverage topology." The CLEAN fuzzy tolerance was set to .002 inches to preserve the required data resolution. When other coordinate edits were made to a coverage after the CLEAN command was run, topology was recreated utilizing the BUILD command.

Label Entry Error Processing

Label errors were identified by using the LABELERRORS command in ARC. Using ARCEDIT, any label errors identified were corrected by entering the missing label number and placing it within the correct polygon. Once all the errors were corrected, the coverage was ready for the digital rectification process.

Joining of Attribute and Spatial Data

The Quattro Pro code file was converted into an INFO file. Once converted it was related to the feature attribute table by the sequence number found in both files. An INFO item, named "SEQNO" was added to the feature attribute table. The sequence number for each polygon was calculated to equal its coverage I.D. number. The ARC/INFO command JOINITEM was used to join the code file to the feature attribute table. The spreadsheet file was joined with its corresponding coverage. Each variable interpreted from the aerial photography was assigned a unique item (field).

Code Verification and Edit Plot Quality Assurance

Code verification involved running each coverage attribute file through a series of ARC/INFO commands that checked for invalid codes. These commands produced listings that aided in identifying abnormal codes. The errors were checked against the vegetation delineation and attribute overlays. Corrections were made to the listings and input into the database.

ESRI produced a plot of the converted spatial data and sequence numbers (label I.D.s) for each manuscript. The plots were checked by AIS for cartographic quality of the arcs defining the polygon features and the accuracy of the label I.D. assignments. Each plot was overlaid to the associated manuscript map to verify that the scanned data was not distorted beyond .02 map inches. Other problems were noted on the plots, including line overshoots and undershoots, missing lines, premature convergence of polygon boundary lines that intersected arcs at acute angles, and incorrect sequence number assignments.

ESRI also produced code verification plots of the PI signature codes, community association codes, height and density codes, and land use code attributes. The plots were checked by AIS for coding errors that may have occurred during the polygon attribute encoding step. The plots were overlaid on the corresponding manual rectification code attribute overlay. Code changes were noted on the plots. The edited plots were delivered back to ESRI for correction of the attribute files. Processors conducted interactive ARCEDIT sessions to make the necessary corrections to the coverages. The final coverages for the six map sheets were mapjoined to create a single coverage for Rock Creek Park.

Georeferencing and Digital Registration of Data

The georeferencing and digital registration of the data was a simple process. The data had to be transformed into real world coordinates and the data had to be adjusted to fit the orthophoto image. These steps were all performed digitally using ARCEDIT.

- Conversion to "Real-World" Coordinates

  This task involved the transformation of the database from "digitizer inches" into "real world" coordinates. The initial vector file contained coordinates stored as digitizer inches. This format does not allow the data to be used in conjunction with other spatial overlays. To utilize geographic data, it must be converted into a common coordinate system. The coordinate system used was the Maryland State Plane coordinate system (zone 4126).

  The first step was the creation of a master tic file, linking features on the orthophoto to the same features in the polygon coverages. Wherever possible, easily identified points were chosen to ensure a more accurate transformation. Four to six points were chosen per coverage and labeled with a tic number I.D. The points were then transformed into real world coordinates, x and y values only (the orthophotos did not have a z value).

- Compare Transformed Delineation Coverages to Digital Image

  The transformed coverage was then compared to the digital orthophotos. Manual rectification had been chosen instead of digital rectification because it was assumed that a minimal amount of adjustment would need to be performed once the coverages were transformed. This was based on the photointerpretations being created from entirely different images as the digital orthophotos. Also, parallax differences between the photos and the orthophotos would not be consistent. Human observations and decisions were more likely to produce a better rectified product, thus minimizing any subsequent digital rectification.

Upon comparison of the transformed coverage to the orthophoto, it was apparent that the data did indeed fit the image well in most places. Interactive ARCEDIT sessions were conducted to improve the registration of the data to the digital image. The data was compared to the orthophoto image on a polygon by polygon basis. Special attention was given to obvious feature boundaries such as land use/vegetation and land/water interfaces. If necessary, a specific adjust was performed. The vertices of the line segments were modified (moved, added, or deleted) until the linework conformed to the orthophoto image. In some instances, entire line segments were deleted and re-digitized on-screen. This process was repeated until all of the coverages were completed.

Final Quality Assurance of the Vegetation Map

Once the transformed coverage had been completely rectified to the digital orthophotos, a final community association plot was created. The plot was compared back to the original CIR photos and photo overlays and reviewed for accuracy and consistency of community association class assignments. Corrections to the community association assignments were then made to the database. The final coverage of the vegetation database was delivered to ESRI for input into the final project database structure

Pattern

The pattern attribute was mapped by interpreting the spatial arrangement of the corresponding life form (tree/shrub/herbaceous) of each alliance/community association polygon. The units were drafted onto a mylar overlay registered to a final TNC community plot. The pattern attribute was then input by keypunching the unique sequence number and corresponding pattern attribute code into an Excel file. The Excel file was converted into and joined to the existing INFO file. An edit plot was created for review, and any corrections or changes noted, then corrected into the file.

Data Dictionary - Rock Creek Park

I. Data Format Outline:

Variable

Coverage related variables:

Area	8	18	F
Perimeter	8	18	F
Veg#	4	5	B
Veg-id	4	5	B

Defined variables:

Seqno	3	3	I
Mod	4	4	C
PI	2	2	I
Height	1	1	I
Density	1	1	I
TNC	3	3	C
Landuse	4	4	C
Pattern	1	1	I

II. Data Dictionary:

MOD (Defines the modules corresponding to the DOQQ file name. 6 total - roughly corresponding to the six individual plots)

WE4
WW1
WW2
WW3
WW3E
WW4

PI (Defines the PI signature type)

Non Forest Types:

01 = **code not used**
02 = Managed grass/lawns
03 = Meadow grasslands (native component)
04 = Shrub areas (forest edges)
05 = Canopy openings (shrubs, vines, some trees)
06 = Water
99 = Urban/disturbed (see detailed Urban codes in Land Use field)

Forest Types:

10 = Floodplain areas
11 = Ash swamps
12 = Oak/beech
13 = Mesic oak
14 = Dry mesic oak

15	=	Tulip/oak
16	=	Tulip
17	=	Pine/oak
18	=	Tulip/oak/beech
19	=	Tulip floodplain
20	=	Exotic/planted trees with managed grass/lawn

HEIGHT

1	=	< 0.5 meters		
2	=	0.5	-	2 meters
3	=	2	-	5 meters
4	=	5	-	15 meters
5	=	15	-	35 meters
6	=	35	-	50 meters
7	=	> 50 meters		
9	=	Not Applicable		

DENSITY

1	=	Closed/Continuous			>60%
2	=	Discontinuous	40%	-	60%
3	=	Dispersed	25%	-	40%
4	=	Sparse	10%	-	25%
5	=	Rare	2%	-	10%
9	=	Not Applicable			

TNC (Defines TNC communities and variants)

01	=	Forest canopy gap
02	=	Loblolly pine - mixed oak forest *Pinus taeda - Quercus (alba, falcata, stellata)* Forest [Provisional]
03	=	Virginia pine - oak forest *Pinus virginiana - Quercus (alba, stellata, falcata, velutina)* Forest Association
04	=	Sycamore - green ash forest (floodplain forest) *Platanus occidentalis - Fraxinus pennsylvanica* Forest
05	=	Tulip poplar forest *Liriodendron tulipifera* Forest [Provisional]
06	=	Chestnut oak forest *Quercus (prinus, velutina) / Gaylussacia baccata* Forest
07	=	**code not used**
08	=	MIXED OAK/BEECH VARIANT of Beech - white oak / mayapple forest *Fagus grandifolia - Quercus alba / Podophyllum peltatum* Forest
09	=	**code not used**
10	=	Beech - white oak / mayapple forest (CLASSIC TYPE) *Fagus grandifolia - Quercus alba / Podophyllum peltatum* Forest
10B	=	Beech - white oak / mayapple forest (CLASSIC TYPE) beech/tulip component *Fagus grandifolia - Quercus alba / Podophyllum peltatum* Forest
11	=	Shrub areas

- 12 = Managed grass/lawns
- 13 = Meadow grasslands
- 14 = Managed grass/lawns with trees
- 98 = Water

LANDUSE

- 1000 = Urban
    - 1900 = Residential
    - 1910 = Commercial and Services
        - 1911 = Nature center and planetarium
        - 1912 = Horse center; maintenance yard
        - 1913 = Park headquarters
        - 1914 = Park police
        - 1915 = Amphitheater
        - 1916 = Mixed park facilities
        - 1917 = Center for Urban Ecology
        - 1918 = Fort Stevens
        - 1919 = Fort Reno Park
    - 1920 = Industrial
    - 1930 = Transportation, Communications, and Utilities
        - 1931 = Road
        - 1932 = Parking Area
    - 1940 = Industrial and Commercial Complexes
    - 1950 = Mixed Urban or Built-up Land
    - 1960 = Other Urban or Built-up Land
        - 1961 = Community gardens
        - 1962 = Golf course
        - 1963 = Ball fields
        - 1964 = Tennis stadium and/or courts
        - 1965 = Tennis courts and gardens
        - 1966 = Swim center
        - 1967 = Area Under Construction
        - 1968 = Cemetery
- 2000 = Agriculture
- 3000 = Natural Vegetation
- 8000 = Water

PATTERN

1 = Evenly Dispersed
2 = Clumped / Bunched
3 = Gradational / Transitional
4 = Alternating
9 = Not Applicable

FILE SPECIFICATIONS:

Coordinate system: NAD83 - Maryland State Plane (zone 4126)

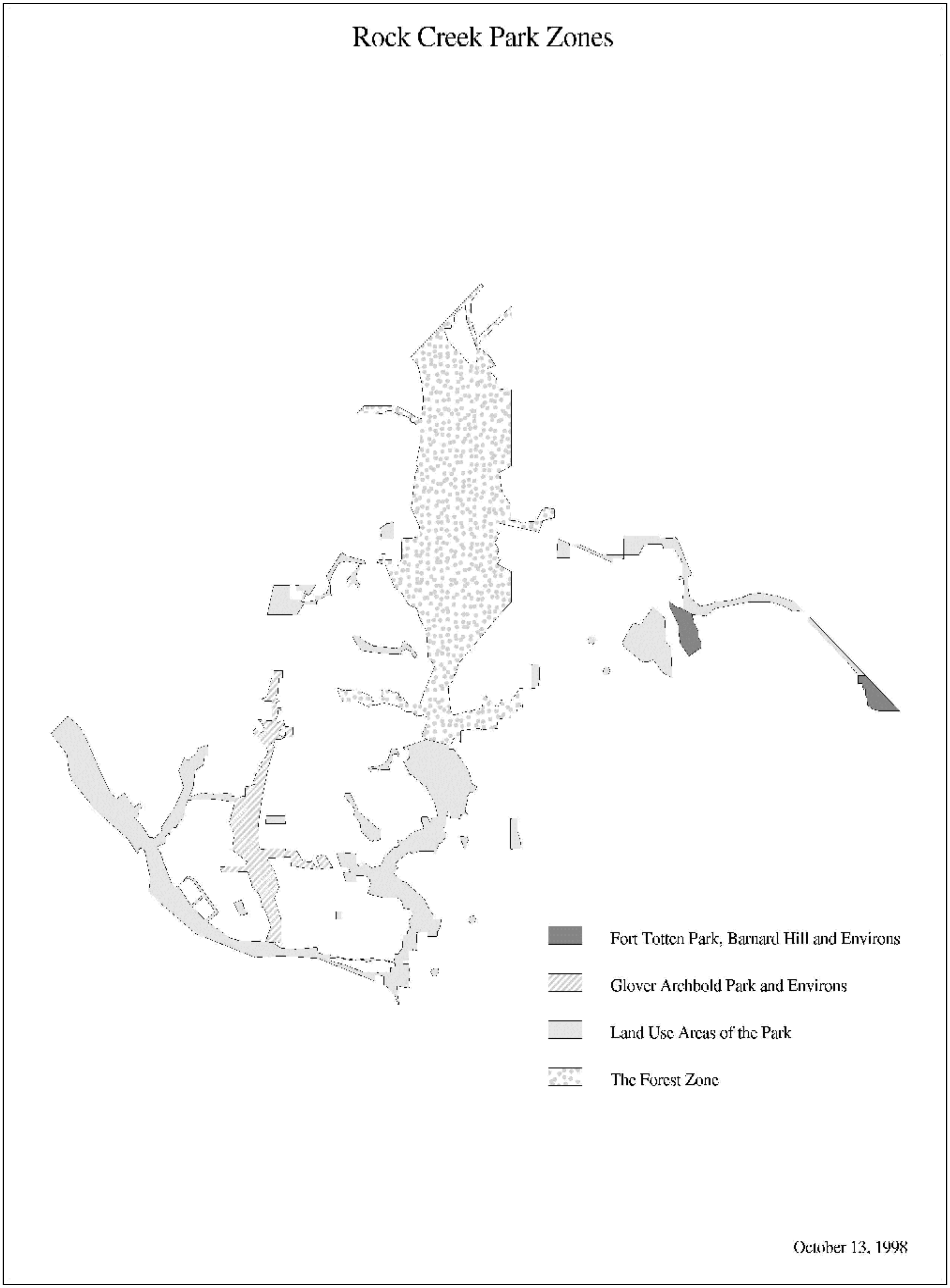
Rock Creek Park
Photo Interpretation Report
Appendices

Rock Creek Park Boundary

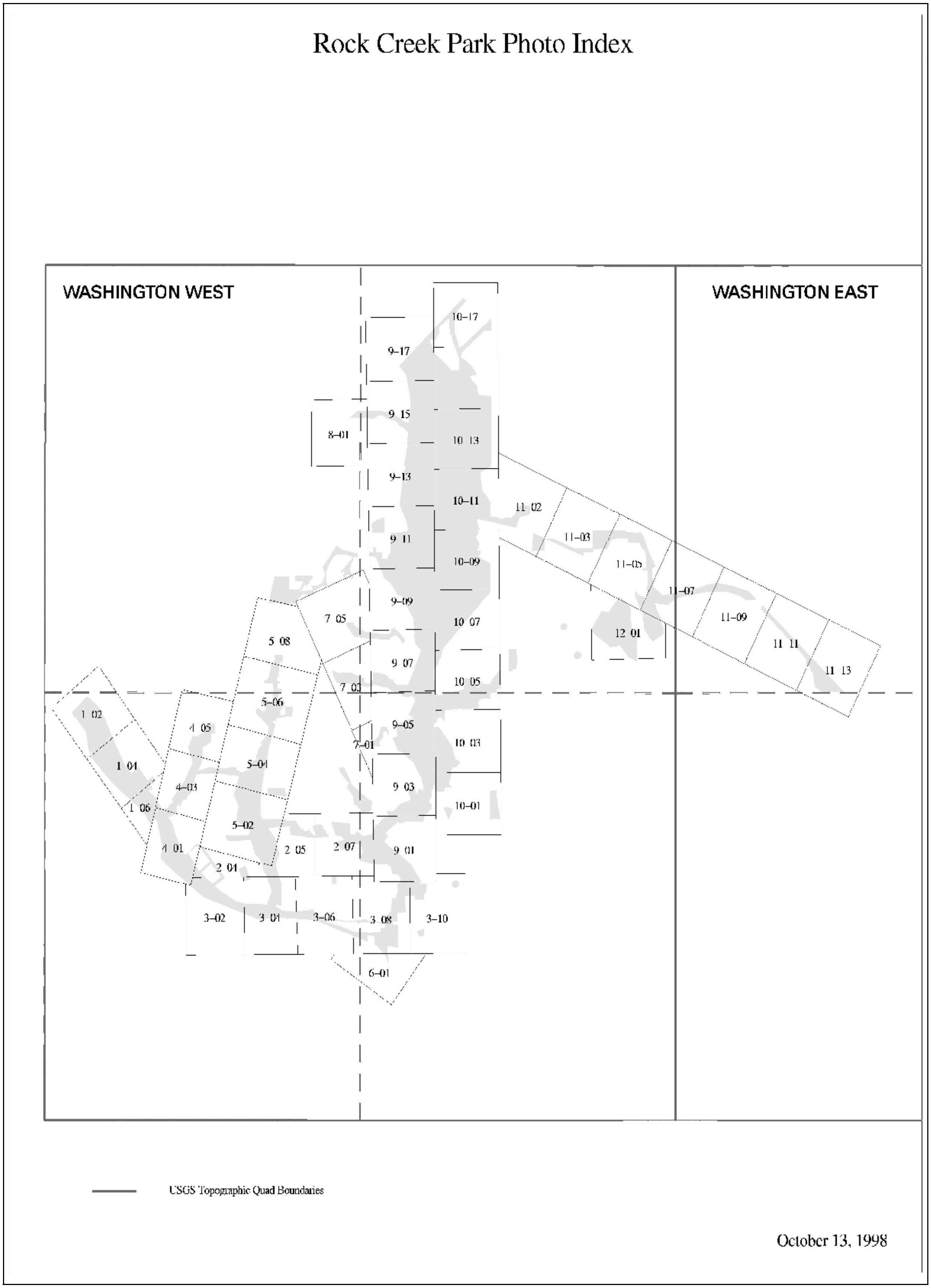
Source: NPS Center for Urban Ecology

October 13, 1998

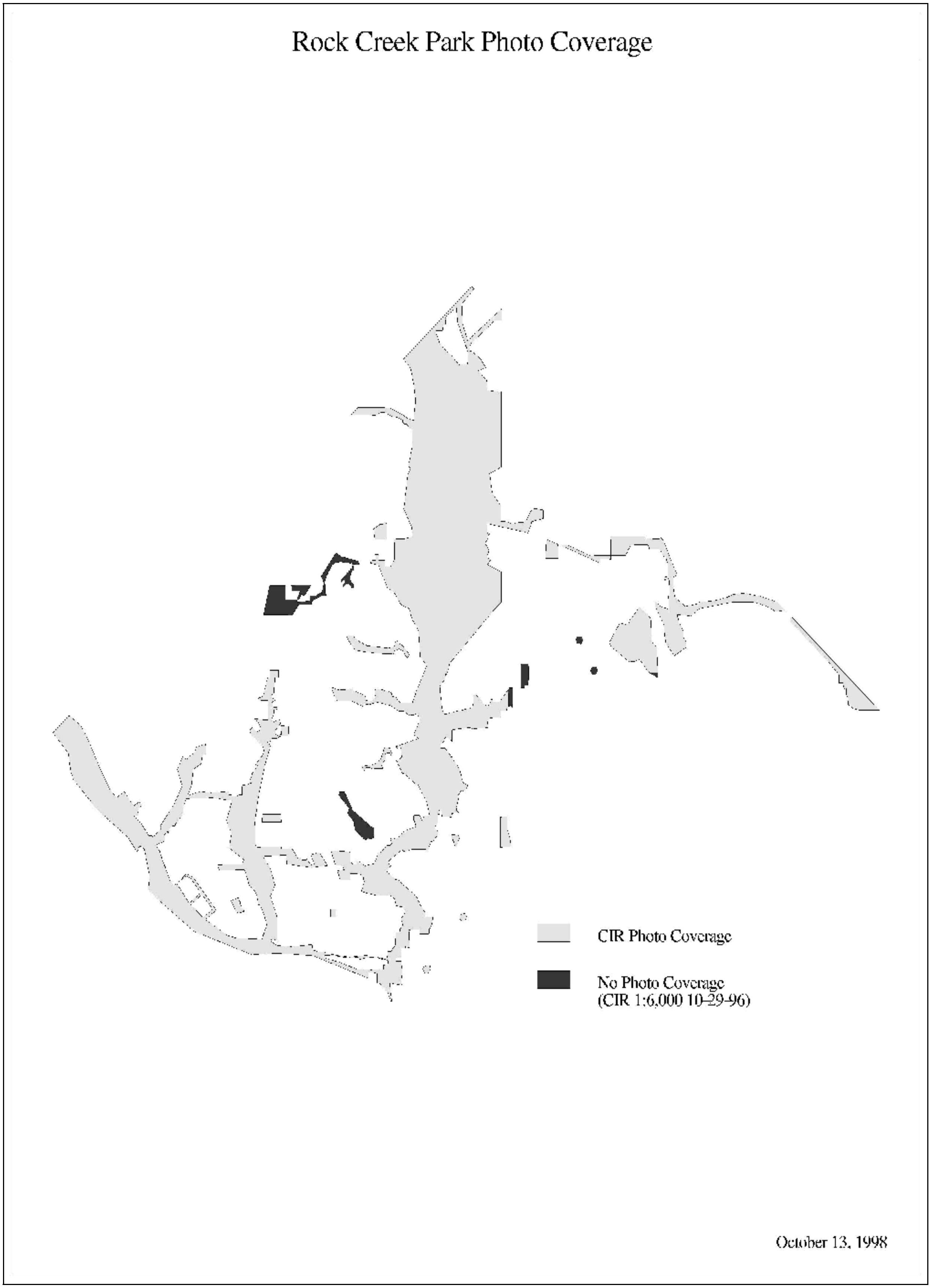
Appendix A: Figure 1



Appendix B: Figure 2



Appendix C: Figure 3



Appendix D: Figure 4