Report to the National Parks Service
Inventory and Monitoring of Mammals in the National Capital Parks
September 2000

Richard W. Thorington, Jr.
Curator of Mammals
Smithsonian Institution

General:

In reviewing the mammal lists, I have found the following publications to be most useful. (All citations are given in full at the end of this report.)

Bailey, V. 1923. Mammals of the District of Columbia.
Handley, C.O., Jr. and C.P. Patton. 19 47. Wild mammals of Virginia.
Linzey D. W. 1998. The Mammals of Virginia.
Paradiso J. L. 1969. Mammals of Maryland.
Webster W. D. , Parnell J. F., Biggs W. C. 1985 Mammals of the Carolinas, Virginia and Maryland.

My review of the documentation for the purported distributions of mammals in this area – literature and specimens in the Smithsonian collections -- leads me to the conclusion that we are distressingly ignorant of these distributions for many species. Maps are based on very few records, many of which date from the first half of the 20th century. This is particularly true for Maryland. The accounts for Sorex hoyi and Synaptomys cooperi in Virginia given by Handley (1991) and Linzey (1998) demonstrate that a species formerly considered "rare" may prove to be relatively common.

For the most part, the scientific names in the following lists follow the authorities in Wilson, D.and D.Reeder. 1993. Mammal species of the world. However, in some cases, names have changed since that book was published, so **I recommend that NPS follow the scientific names given in**
Wilson D. E. and Ruff S. 1999 The Smithsonian Book of North American Mammals.
I recommend that you also use the common names given in this publication. They represent a current attempt to standardize the common names of all North American mammals, and they are part of Wilson's attempt to standardize the common names of all Recent mammals (Wilson, D.E.and F.R.Cole. 1999. Common names of mammals of the world.) It would obviously be useful for NPS to adopt a standard nomenclature of common and scientific names throughout the whole system of National Parks, and I recommend that Wilson and Ruff (1999) be used for this purpose.

In considering the inventory and monitoring of mammalian species in the parks, you will find it useful to refer to
Wilson D. E., Cole F. R., Nichols J. D., Rudran R., and Foster M. S. 1996 Measuring and Monitoring Biological Diversity Standard Methods for Mammals.

Species Lists

Charges given in italics:
1. For each park, review the list of mammal species. Indicate whether each species is native or non-native, identify any errors in scientific and common names, and list any other sources of data that exist for the group (including historical information).

I consider only two species to be non-native. These are the Norway rat, Rattus norvegicus, and the house mouse, Mus musculus. Other non-native mammals occur nearby, but they are unlikely to be found in any of these 11 parks: e.g. Sika deer, nutria, black-tailed jackrabbit. I recommend that you avoid the intractable problem of natural and artificial reintroductions, such as beaver, white-tailed deer, etc. I consider all of these to be native species.

Recent changes in the scientific names of Maryland and Virginia mammals include the following. I provide a brief description of the reason for the name change for your information.
1. Sorex hoyi: The genus Microsorex is now considered a subgenus of Sorex.
2. Microtus pinetorum: The genus Pytimys is not recognized as distinct from Microtus.
3. Myotis septentrionalis: The former species, Myotis keenii, is now considered to be two species and Myotis septentrionalis is the Eastern species. The name, Myotis keenii, is now restricted to a West Coast form.
4. Neotoma magister: The former species, Neotoma floridana, is now divided into two species. The species occurring in these eleven parks is Neotoma magister. Neotoma floridana is a more southern and western species.
5. Lontra canadensis: The New World otters are now treated as the genus Lontra, set off from the Old World otters of the genus Lutra.

I have taken the common names from The Smithsonian Book of North American Mammals. I am not enthusiastic about some of these names, such as "Cinereus Shrew" instead of "Masked Shrew", but if you use these names you will have a single reference for them all, and if these names are adopted by NPS, you will not be using the same common name for two different species in different parts of the country.

Additional information is available in museum collections. **I recommend that you conduct a survey of the Maryland, Virginia, and District of Columbia specimens already in museum collections, in a search for material that documents the present or past occurrence of species within or adjacent to the 11 National Parks.** I append a species list of the mammals in the Smithsonian collection from Maryland and Virginia, totaling approximately 15000 specimens. I have been able to check actual locality records for only a small number of these while preparing this report.

Additional historical information on extinct species can be found in

Bailey, V. 1923. Mammals of the District of Columbia.
Handley, C.O., Jr. and C.P. Patton. 19 47. Wild mammals of Virginia.
Linzey D. W. 1998. The Mammals of Virginia.
Mansueti, R. 1950. Extinct and vanishing mammals of Maryland and District of Columbia.

Paradiso J. L. 1969. Mammals of Maryland.

2. Examine our preliminary (incomplete) list of species that could potentially occur in each park and make additions or deletions based upon species' range and habitat requirements. This list will be used by the parks to determine whether the goal of 90% documentation has been reached.

This information is provided in an appended list. I have revised the Word document and the Excel spreadsheet for the parks. If there is any remaining discrepancy between the two, assume that the Word document is correct.

There is a conflict between the first and second sentences of charge number 2. I am providing you with a list of the species that potentially occur in each park. This includes a number of species that are rare, migratory, or otherwise difficult to document. There are many insectivores, bats, and carnivores which could be found anywhere in either state, and hence could occur in any of the parks. Most of the parks are connected to other natural areas by woodland or stream corridors along which terrestrial mammals could travel, so species will occur within parks even when they are not permanent residents. Only Monocacy and Wolf Trap look moderately isolated. Bats will not be affected by isolation, of course.

By providing a list of species that could potentially occur, I am making it difficult for you to obtain 90% documentation. I recommend that you deal with this conflict later, after you have the opportunity to assess the magnitude of the problem.

3. For each park, determine where gaps exist in the species list which need to be filled with additional field investigations to reach the goal of 90% of the mammal species documented for each park.

4. For each data gap, recommend and describe appropriate sampling strategies and methods to document the existence of 90% of the mammal species present that the park could apply, taking into account both spatial and temporal factors. Provide recommendations on the sampling frame for each survey, and how sample sites should be selected. Describe any recommended specialized searches for rare species or habitats, and describe the specific methods that should be used during field surveys, providing references if available. Methods that are compatible with other well-established local, regional, or national inventory and monitoring efforts are preferred. All proposed inventory techniques should be statistically-appropriate and yield GIS-compatible deliverables.

I recommend that field investigations be conducted in every park to document the mammal species which actually occur there. It is unclear to me what documentation currently exists for the occurrence of mammal species in the National Parks. The information provided suggests that the documentation does not meet the standards of scientific credibility that NPS has set for itself. I present my recommendations on documentation below.

Inventory Documentation: Documentation of the existence of mammal species in the parks is a multifaceted problem. For small mammals, specifically insectivores, bats, and most

rodents, the principal solution will be to collect and prepare voucher specimens and to deposit them in appropriate collections. Identifications of many of these species are just too subject to doubt and challenge, unless supported by the evidence of specimens. **Therefore, specimen-based documentation of the inventory is essential to the scientific credibility of this program.** This will require a program of mammal collecting, involving pit traps for shrews, live traps and snap traps for rodents, ultrasonic detection and mist nets for bats, and other techniques for some species. Opportunistic collecting from owl pellets may provide additional records. Traps and pitfalls can be arranged as transects or in grids. The former is more efficient for inventory work and the latter is better for estimating population densities. One hundred traps set out in a transect will commonly cover more area and more habitats than 100 traps set out in a grid. The efficiency and effectiveness of both will depend on a number of factors, such as the distance between stations, wise placement of the traps, type of bait, etc.

For medium-sized mammals, particularly carnivores, a variety of techniques must be used to document the presence of species in the Parks. These include kill trapping, live trapping with photographic documentation, remote photography, scent stations with automatic photography, photographic records of tracks, hair-sampling stations (see email note at end of report, but note the need to work with someone who can identify hair samples), etc., all of which can be combined with opportunistic collection of specimens from road kills, if the park staff are alerted to the importance of these. The ultimate unequivocal documentation is a museum specimen, and this is particularly important for weasels.

For large mammals, probably the best solution is to obtain photographs of the animals in the park and maintain these photographs in an archival file. All significant sight records, including photographs, should be recorded with date, place, and person making the observation. Identification of the observer (e.g. Park Naturalist) will be important for persons reviewing the record in the future. Whenever possible, photographic documentation should be superseded by specimen documentation. This will be particularly important for coyotes, because of the difficulty of distinguishing them from some feral dogs. Each park should take advantage of opportunistic collecting and documentation, e.g. road kills.

Specimens should be deposited in a museum collection accredited by the American Society of Mammalogists. This will provide reasonable assurance that the specimens will be preserved, and that future workers will be able to verify or correct the identifications, decades or centuries from now. It may be desirable for the Parks to purchase museum cases and to maintain small collections for identification and demonstration purposes, but these specimens will not provide adequate long-term documentation. According to United States Code, dated 1993 (copy appended), specimens collected with federal funds should be deposited in the National Museum (Smithsonian Institution). Herein lies a problem. The Smithsonian will accept specimens only if ownership is transferred, and the institution can not accept any restrictions or requirements for reports on the usage of the specimens. We house millions of specimens submitted by hundreds of thousands of persons and agencies, and these specimens are used by thousands of investigators every year. The restrictions and requirements posed by the NPS are unworkable and unacceptable, and they have caused us to refuse specimens in the past and will force us to do so in the future. Every other museum faces the same problems, although to a lesser extent, and would be foolish to accept specimens under the conditions posed by the NPS. Therefore these restrictions endanger your proposed plan of "*collecting data in a scientifically credible*

manner so that they can be used to address current and future management issues". **I recommend that you discuss this problem further with Dr. Alfred Gardner (USGS), curator in charge of North American Mammals at the Smithsonian Institution, and that you attempt to resolve these issues within the NPS.**

Procedures: The National Parks Service can adopt either or both of two procedures for inventorying the parks. You can contract with mammalogists to conduct the studies for you or you can train your own staff to do the work. The advantage to contracting with mammalogists is that you will be hiring their expertise and experience. (I have provide some names of mammalogists who may be useful for specific problems. I can provide you with a number of other names, if you wish to pursue this approach.) Many species are not easily captured except by persons who know their habits and habitats well. The advantage to training your own staff, is that you will have persons in the parks who will be able to search and sample in all seasons and for several years. Your choice should probably be determined by your staff. I presume that your staff at historic battlefields will be less interested in collecting and preparing mammal specimens than will your staff naturalists at other parks. The ideal solution would be to contract with mammalogists to work with your staff on each of the parks, training your staff as the surveys are conducted on site, at several seasons, for several years. A less expensive solution would be to contract for survey and training of your staff at one of the parks, training employees from all of your parks at the same time. I am told that you have had such training courses before, but I do not know the format or the results of these courses.

Sampling: Each park should be gridded, presumably in a study of the vegetation. The mammal survey should be conducted based on knowledge of the available habitats and the frequencies of their occurrence within each grid. The survey should be designed to include every habitat type. Do not select survey sites randomly–it is too inefficient and ineffective. Instead, sample rare habitats disproportionately and adjust your results according to the area of each habitat.

5. For species of special concern for which relative abundance data are required, recommend and describe appropriate sampling strategies and methods to address the distribution and abundance of the species and/or groups of concern. Consult "Guidance for the design of sampling schemes for inventory and monitoring of biological resources in national parks" for recommendations on sampling designs. All proposed inventory techniques should be statistically-appropriate and yield GIS-compatible deliverables.

Monitoring: Mammal populations fluctuate in size in a variety of ways. Most fluctuate seasonally and annually. Population levels will likely be high in the autumn and low in the early spring. Many mammal populations will fluctuate with the mast crop: large crops of acorns will support large over-wintering cohorts of mice and carnivores, as may good crops of grass. Crop failures may result in very low densities of small mammal populations. These fluctuations must be taken into account in assessing Park health, and the monitoring of mammalian populations will best be undertaken in a broader program which assesses the distribution and productivity of the vegetation. In view of the effort and cost, I recommend that you carefully consider the objectives

of any monitoring program, to determine that the program will result in useful management data.

The subject of monitoring is too broad to cover in this report. There are obvious ways to link initial inventory work with subsequent monitoring, as recommended in the "Guidance..." report, such as maintaining accurate records of locations of transects and frequencies of success–captures per trap-night, visitation rates per scent station– or by using grids instead of transects. I strongly recommend review of Chapter 10 in Wilson D. E.Cole F. R. Nichols J. D. Rudran R. Foster M. S. 1996. I provide some general comments on monitoring of specific species, below.

The most obvious need for management is the monitoring of the **deer populations**. This is not treated in this report, because it is being treated elsewhere by others. However, I strongly suspect that over-population by deer has a large, though undocumented, negative effect on many other mammal species, because of the reduction of undergrowth.

There is probably a connection between population density of **raccoons** and survival of Allegheny woodrats (Balcom, B.J. and Yahner, R.H. 1996). The evidence now suggest that a common parasite of raccoons is lethal to the woodrats (LoGuidice, 2000), and that woodrat populations decrease when raccoon populations increase (Balcom, B.J. and Yahner, R.H. 1996). Thus there may be two reasons for monitoring raccoon populations: endemic rabies being the other. Raccoon census work has been conducted in Rock Creek Park by NPS employees, so I do not need to advise you on this. There is a large literature on raccoon management. I would merely note that in some situations with high population densities, monitoring data can be acquired very easily with visual surveys at night using a head lamp and a standard protocol. In other situations, with low population densities, it may be preferable to use scent stations, as described below.

Woodrat populations can be monitored by a program of live-trapping and marking individuals, or more easily by surveys of active woodrat dens. I recommend that you contract with a mammalogist who is actively studying the problem of woodrat population demise, to conduct a survey of woodrat dens in collaboration with park personnel in the Chesapeake and Ohio Canal National Park. Your personnel can then revisit these sites and assess the changes in numbers of active den sites. See Balcom, B.J. and Yahner, R.H. 1996.

I do not know of any ways to monitor populations of the **Eastern Small-footed Myotis.** It is reported to be caught in mist nets at the entrance to caves at higher frequencies than it is detected within the caves (Handley,C.O., Jr. 1991). From descriptions of its flight and foraging pattern, it seems likely that its vocalizations differ from those of other Myotis, and it may be possible to monitor its presence and abundance with ultrasonic bat detectors (see note on Brock Fenton at the end of the report). However, I do not know of any documentation of this. At present, the best management practice would be the location and protection of all caves used by bats for hibernation and day-time retreats. Bat detectors can be used for locating concentrations of bats in the early evening when they are emerging from their roosts.

There is a standard procedure, using **scent stations**, to monitor the abundance of small carnivores like foxes (Wood, J.E. 1959). This consists of raking a small area so that footprints

will show, and placing a scent in the middle. The percentage of scent stations visited is taken as a measure of relative abundance (Linhart, S.B. and Knowlton, F.F. 1975; Johnson, K.G. and Pelton, M.R. 1981). Unfortunately, it has recently been shown that the technique does not provide a good measure of relative abundance (Sargeant, G.A., Johnson, D.H., and Berg, W.E. 1998). It is also a method which requires a great amount of effort and data, if it is going to yield good estimates of relative abundance. However, combined with remote photography, it will provide good documentation of the presence of red and gray foxes in different parts of the park, and it could enable the monitoring of individuals. I can picture it being useful for management purposes to know where in the park there are foci of fox activity, and scent stations could provide such data.

There are a number of ways to monitor populations of **flying squirrels**: from occupancy of nest boxes, from live-trapping, marking, and recapturing individuals, or by live-trapping with the use of radio collars so that the individuals can be followed. These are progressively more expensive and time consuming. The use of nest boxes may change the very parameter that you wish to measure, but it may also provide the management technique you need to compensate for removing dead trees along trails. A study by Fridell, R.A. and Litvaitis, J.A. (1991), using radio collars, provides an excellent model that you could follow, given adequate staff and financial support. Relevant to your concerns, they measured the numbers of large dead trees within the home range of each of their flying squirrels and found that females select areas with more dead trees than do males. A less expensive way to determine the effect of dead tree removal on flying squirrel populations is to assess the use made of these trees before they are cut. If the dead trees are marked before cutting, a NPS employee could visit them repeatedly, pound each with a stick, and check to see if any flying squirrels emerge. Because den usage may vary seasonally, it would be desirable to establish an experimental protocol for study at all seasons and to study the usage of dead trees from the time of death until they collapse. (These need not be trees along trails.) Detecting flying squirrel den trees with a baseball bat will be less expensive than other techniques, so that it could be carried out with a large sample of trees over a long period of time, to yield good statistical data. With relatively little effort, the NPS staff at Rock Creek would be able to obtain a rough assessment of the effect of tree cutting on flying squirrels.

I do not know of any ways to monitor populations of **Star-nosed Moles.** I would map good mole habitat, wet meadows, woods, and marshes, and I would repeatedly inspect them for signs of mole tunnels. In good mole habitat, I would attempt to estimate population density by trapping, marking, and re-trapping individuals. Gould has been very successful at capturing live moles (Gould, E., McShea, W., and Grand, T. 1993) and might be available to assist with monitoring this species (Edwin Gould, 6505 Carlinda Av., Columbia, MD 2106-1019; E-Mail:edez18@erols.com). For other references, see Hartman, G.D. (1999) and Petersen, K.E., and Yates, T.L. (1980).

Other species that may be important to monitor include Norway rats, House mice, feral dogs, and feral cats. How these are monitored will depend largely on the situation and the management objectives, within each park. Because these species can have deleterious effects on native fauna and flora, they should not be ignored, although they can be very difficult to manage.

Literature cited

Bailey, V. 1923. Mammals of the District of Columbia. Proceedings of the Biological Society of Washington 36:103-138.

Balcom, B.J. and Yahner, R.H. 1996. Microhabitat and landscape characteristics associated with the threatened Allegheny woodrat. Conservation Biology, 10(2): 515-525.

Fridell, R.A. and Litvaitis, J.A. 1991. Influence of resource distribution and abundance on home-range characteristics of southern flying squirrels. Canadian Journal of Zoology, 69(10): 2589-2593.

Gould, E., McShea, W., and Grand, T. 1993. Function of the star in the Star-nosed Mole, *Condylura cristata*. Journal of Mammalogy, 74(1): 108-116.

Handley,C.O., Jr. 1991. Mammals pp. 539-616. In Terwilliger, K.coordinator. Virginia's Endangered Species. Blacksburg, Virginia: The McDonald and Woodward Publishing Co.

Handley, C.O., Jr. and C.P. Patton. 19 47. Wild mammals of Virginia. Commonwealth of Virginia Commission of Game and Inland Fisheries, Richmond. 220 pp.

Hartman, G.D. 1999. Star-nosed mole, *Condylura cristata*. The Smithsonian Book of North American Mammals.

Johnson, K.G. and Pelton, M.R. 1981. A survey of procedures to determine relative abundance of furbearers in the southeastern United States. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies, 35: 261-272.

Kirkland, Jr., G.L. and Krim, P.M. 1990. Survey of the statuses of the mammals of Pennsylvania. Journal of the Pennsylvania Academy of Science, 64(1): 33-45.

Linhart, S.B. and Knowlton, F.F. 1975. Determining the relative abundance of coyotes by scent station lines. Wildlife Society Bulletin, 41: 394-403.

Linzey D. W. 1998. The Mammals of Virginia. The McDonald & Woodward Publishing Co. Blacksburg VA 459 pages

LoGuidice, K. 2000. The effects of the raccoon parasite, *Baylisacaris procyonis*, on introduced populations of the imperiled Allegheny Woodrat (*Neotoma magister*). Page 2, Abstracts from the 80th Annual Meeting, American Society of Mammalogists.

Mansueti, R. 1950. Extinct and vanishing mammals of Maryland and District of Columbia. Maryland Naturalist, 20:1-48. Winter-Spring.

Pagels, J.F. and Handley, C.O., Jr. 1989. Distribution of the southeastern shrew *Sorex*

longirostris Bachman, in western Virginia. Brimleyana, 15:123-131.

Pagels, J.F., Jones, C.S., and Handley, C.O., Jr. 1982. Northern limits of the southeastern shrew, *Sorex longirostris* Bachman (Insectivora: Soricidae), on the Atlantic coast of the United States. Brimleyana, 8:51-59.

Paradiso J. L. 1969. Mammals of Maryland, North American Fauna # 66 United States Department of the Interior. Washington DC. 193 pages

Petersen, K.E., and Yates, T.L. 1980. *Condylura cristata*. Mammalian Species, No. 129: 1-4.

Sargeant, G.A., Johnson, D.H., and Berg, W.E. 1998. Interpreting carnivore scent-station surveys. Journal of Wildlife Management, 62(4): 1235-1245.

Webster W. D. , Parnell J. F., Biggs W. C. 1985 Mammals of the Carolinas, Virginia and Maryland. The University of North Carolina Press, Chapel Hill. 255 pages

Wilson, D.E.and F.R.Cole. 2000. Common names of mammals of the world. Smithsonian Institution Press. Washington DC

Wilson D. E.Cole F. R. Nichols J. D. Rudran R. Foster M. S. 1996 Measuring and Monitoring Biological Diversity Standard Methods for Mammals. Smithsonian Institution Press. Washington D. C. 409 pages

Wilson D. E. and Ruff S. 1999 The Smithsonian Book of North American Mammals. Smithsonian Institution Press. Washington DC 750 pages

Wilson, D.and D.Reeder. 1993. Mammal species of the world. Smithsonian Institution Press. Washington D. C. 1207 pages.

Wood, J.E. 1959. Relative estimates of fox population levels. Journal of Wildlife Management, 23(1): 53-63.

Other Notes of Use.

Hair-Sampling Station.
Email communication 8/07/00 on Mammal-l.
Stephen,
We have been using hair tubes adapted from designs used in Australia to survey for endangered San Joaquin kit foxes for over a year. Our kit fox-sized hair tubes are 2 ft. lengths of 6" diameter PVC pipe. We use grey-colored pipe so that they are less visible to passers-by. In the middle of tube, we drill two small holes in the center of the pipe (dorsal side) through which the ends of a piece of string that secures a bait (piece of meat, whatever) can be tied together. We have tried various

types of two-sided tape to snag hairs with mixed success. We believe that doubled-over duct tape works quite well and does not dry out or get covered with dust the way the other types of tape do. (Yet another great use for duct tape!) We also drill holes in the lower lips of the pipe openings; this way the pipe can be secured by hammering a 6" nail or tent peg through the hole and into the ground. We are satisfied with the performance of this design; picks up hair from kit foxes, skunks, etc. We are working to publish our design and preliminary findings in the coming months.

Patrick Kelly

Shrew specialist: John Pagels, who has worked extensively in Virginia (see references), could be very helpful in your surveys for shrews and small rodents. He has used pitfalls very effectively in his studies of shrew distributions in Virginia. John Pagels, Dept. of Biology, Virginia Commonwealth University, Box 842012, Richmond, VA 23284-2012. E-Mail: jpagels@saturn.vcu.edu

Bat specialist: Brock Fenton, who is excellent at identifying bats from their vocalizations, using ultrasonic techniques, could be very useful in setting up bat surveys and monitoring.

Also, Bat Conservation International could be very useful in assisting with bat surveys on the parks:
Bat Conservation International, P.O. Box 162603, Austin, TX 78716
http://www.batcon.org

Automatic cameras are advertised by Forestry Suppliers, Inc. (www.Forestry-suppliers.com).