

National Park Service
U.S. Department of the Interior

Great Smoky Mountains National Park
Tennessee, North Carolina



Annual Administrative Report and Work Plan for Inventories & Vital Signs Monitoring FY 2008 - FY 2009



View of declining eastern hemlock (*Tsuga canadensis*) from Alum Cave in Great Smoky Mountains National Park. Massive losses have recently occurred due to the introduced hemlock woolly adelgid (*Adelges tsugae*). (See Public Interest Highlights section)

Great Smoky Mountains National Park Approval Signatures

Dale Ditmanson, Superintendent Great Smoky Mountains National Park	Date
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Larry West, Regional Inventory & Monitoring Coordinator Southeast Region	Date
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Sherri Fields, Chief, Science & Natural Resources Division Southeast Region	Date
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Paul Hartwig, Associate Regional Director, Natural & Cultural Resources, Partnerships & Interpretation Southeast Region	Date
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David Vela, Regional Director Southeast Region	Date
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Table 1. AARWP Checklist

	<u>Budget program (MS Access, aarwp_budget.mdb)</u>
Y	The income amounts entered for Biological Inventories, Vital Signs Monitoring, Prototype \$\$ - Annual Transfer, Water Quality Monitoring and other sources matches the dollar amounts from the memos sent to the regions/networks by WASO (have you used the correct income amounts?).
Y	In the Add/Edit Budget Records form, the amount shown for Total Expenses matches that for Total Income. (If it doesn't, enter a record under Expenses in the 7_Other category to make it balance; use an entry such as 'Unexpended funds' or 'Overspent Funds' in the Description column to explain the amount.)
Y	For all Expense records, the Description field includes the name of the university, agency, company, or other vendor to help us document our outsourcing efforts. (If this expense involved a contract, cooperative agreement, interagency agreement, or other partnership, is it clear where the money went?)
Y	For all Expense records, the correct item from the picklist for 'Where \$\$ Went' has been entered. [Think about who the check was written to; e.g., enter 'Other Non-Federal' for funding that went directly to the private sector, such as for purchases (computers, supplies, etc.), travel (airlines, rental cars, hotels).]
Y	On the Status of Biological Inventories form, there is one record for each inventory that is described in the text section of the AARWP or in the budget program. Be sure to list each park that was involved in the particular inventory.
Y	Each year's budget has been exported as an .rtf file (one for FY 2008 and one for FY 2009), and both files have been inserted into MS Word at the end of the AARWP document.
Y	The file aarwp_budget.mdb has been renamed to include the 4-character network alpha code and the years, as shown in this example: NCCN_FY0809_aarwp.mdb
	<u>Annual Report and Work Plan (MS Word)</u>
Y	I have carefully read the guidance for the AARWP and followed it.
Y	A header or footer with the date that the aarwp was last revised has been included.
Y	I gave special attention to the 'Summary of Major Accomplishments' and 'Public Interest Highlights' sections of the report, following this years' guidance and example. (We need good examples of the successes, applications, and highlights of the program to help us obtain funding for all 32 networks! Your 'Summary of Major Accomplishments' section at the beginning of your annual report is what we'll use for the I&M Program's annual Report to Congress to justify the funding spent by your network.)
N/A	In the 'Status of Park Vital Signs Monitoring' table, all entries are equal to or greater than the entries in last year's report.
N/A	Photographs that might be included in one of the reports to Congress, brochures, websites, or other materials that help the program have been submitted by the network. (See the photo database and guidelines for submitting photographs.)
Y	The aarwp file has been renamed using the network's 4-character alpha code and the years (FY0809) as in the example NCCN_FY0809_aarwp.doc.
Y	The annual report has been approved by the appropriate individuals, per my region's procedures. (If you cannot get electronic signatures, it is okay to submit a hard copy with signatures after November 4.)
Y	I have followed my region's procedures for submitting the two files (e.g., NCCN_FY0809_aarwp.doc and NCCN_FY0809_aarwp.mdb). (Most regions require you to submit the files through the regional office. The files may be zipped into a zip file if desired, and then submitted to Steven Fancy via either email or ftp).
	<u>Review of FY 2009 Work Plan by WASO</u>
N/A	[Enter Yes or No]: Has the FY 2009 work plan been approved by the network Board of Directors, and therefore ready for the full WASO review? (If you enter No, the WASO I&M and WRD offices will only briefly review the work plan for 'red flags'.

EXECUTIVE SUMMARY

Great Smoky Mountains National Park Prototype 2008 Annual Administrative Report

Great Smoky Mountains National Park (GRSM) was established in the 1930's and protects 220,000 hectares (~810 square miles) of some of the highest peaks in the Southern Appalachian mountains. The Park has about equal acreage in North Carolina and Tennessee, and is known for its complex geology, high peaks, remnant uncut forests and one of the most species-rich temperate ecosystems in the world. Some of the best wildlife and scenery viewing opportunities in the eastern U.S. are in the Park, which gets about 9 million visitors annually.

The prototype monitoring program for the Park was established in 1993, and went through a 2-year development period under the auspices of the U.S. Geological Survey – Biological Resources Discipline. Some of the components included in the monitoring program were Park projects that pre-dated the program. The Park's monitoring program has provided data that have been used to address key points in Park land management decisions, in nationwide decisions by the U.S. Forest Service, and even in imposing restrictions on the international export of rare species by the U.S. Fish & Wildlife Service. But early on, the Park decided that it had an inadequate base of information for being such an epicenter of biodiversity. In 1998, with concurrence of the Washington Office of the NPS, GRSM embarked upon a project, with a lead non-profit partner, to inventory all life in the Park. This precedent setting project is called the All Taxa Biodiversity Inventory, or ATBI. The Smokies program therefore emphasizes both natural resources inventories and long-term monitoring.

The ATBI is funded primarily through the Smokies' Friends group and cooperating association. An ONPS base increase was received in 2005 to further support the ATBI. The monitoring program was funded by an ONPS increase to the Park base in 1995.

PROGRAM ACCOMPLISHMENTS

Inventories

- The USDA-NRCS Soils map has been completed and is on-line for the use of the NPS and the public at: <http://soildatamart.nrcs.gov/survey>. The data and metadata for over 90 soil associations and phases mapped throughout the Park are available at the site. The final report is still being reviewed by NRCS and NPS. These data are already being used for testing a modeling software application (MaxEnt).
- A temperature model for the entire 2,200 square kilometer extent of the Smokies was received from a research collaborator at Syracuse University - Dr. Jason Fridley. Dr. Fridley's GIS model is derived from ~160 "I-Button" remote sensors deployed across a variety of elevations and aspects in the Park. These small instruments record temperature every hour for six months before the data is downloaded and analyzed. The model is also linked to the Park's six long-term

climate stations that began collecting data in the 1930's. Dr. Fridley is now working on the ability to forecast and "back-cast" temperatures and climatic change across the Park, and to investigate impacts on Park species.

- The Science Committee of Discover Life in America (DLIA), our ATBI partner, funded eight mini-grants in December 2007. These small grants are meant to leverage other monies to conduct activities related directly to the ATBI. Full details are at www.dlia.org. Included in this years grants were awards to: Mississippi State University for molecular versus cultural determinations of fungal microflora associated with three declining tree species (hemlock, Fraser fir, and American beech); University of Delaware for organization of all data on plant and leafhoppers (Hemiptera) and web development; Florida State Collection of Arthropods for continued research on flies; University of Tennessee for continued research on ants; Warren Wilson College for research on tardigrades; University of Tennessee for identification of Hymenoptera and processing of backlog samples; University of Arkansas and Agriculture Canada for research on water mites; and Great Smoky Mountains Institute at Tremont for support of teacher workshops.

In addition to the above, funding was conveyed from the Park to organize previous research and/or finish specimen determinations for: 1,000 species of algae (John Carroll University); micro-Hymenoptera (University of Tennessee); an ecological cross-taxa analysis of ATBI data (University of Tennessee); sampling and identification of aquatic true-bugs (Illinois Natural History Survey), and the first work on microsporidian parasites of bees (Louisiana State University). This last study included sampling from ATBI specimens of bumblebees now thought to be extirpated from the Park.

- Dr. Andy Royle, a USGS Research Bio-Statistician at the Patuxent Wildlife Research Center in MD, has been working on recommendations for a refined protocol for structured sampling in the All Taxa Biodiversity Inventory. His work has several phases, none of which are yet complete, but preliminary findings indicate that sampling much more extensively spatially and less intensively temporally would be more efficient in assessing biodiversity.
- During FY 2008, nine NPS units received funding for ATBI's and BioBlitzes as part of the new Centennial Challenge from the Washington Office. The Smokies participated in two workshops at the Fort Collins, CO Natural Resources Program Center and shared its experiences.
- At the close of FY2008, 6,129 new Park species records have been discovered and an additional 890 species thought by taxonomic authorities to be new to science have been found. This brings the total number of species documented in the Park to 16,570. The Park is working with taxonomic authorities to identify which species are rare or vulnerable and of management concern to the Park. To determine this, a variety of factors are considered, including; the number of

records known to science, the number of previous records from the Park, whether a species is known to be endemic, or whether a species has state or federal listing status.

- The U.S. Senate Sub-Committee on National Parks conducted a field hearing on the ATBI in Asheville, NC on July 21. While the report from the hearing has not yet been released, there were four witnesses invited to testify: Dale Ditmanson, GRSM Superintendent, Dr. Peter White, Director of the North Carolina Botanical Garden and a recent Chair of Discover Life in America, Inc., Mr. Glenn Bogart, principal of Pi Beta Phi elementary school, a long-time education partner of the Park, and Dr. Tim Watkins, Program Officer, National Geographic Society, who has been involved in planning national bio-blitzes. All agreed as to the merits of an ATBI.
- Four new vascular plants were discovered during FY2008. *Pilularia americana*, or pillwort, is a type of aquatic fern which is rare and represents a new family for the Park, a new county record, and is listed as a Special Concern species in Tennessee. Also discovered during 2008 is *Croton capitatus*, or hogwort, which is also a new county record, and is at the eastern edge of its range in the Park. Several specimens of *Vaccinium simulatum*, or upland highbush blueberry, were found at high elevations. This species is at the southern edge of its range in the Park. *Thermopsis fraxinifolia*, or ash-leaved bush pea, which is listed by North Carolina and Tennessee, was discovered during an impact survey for a new backcountry site.

Vital Signs Monitoring

- Hemlock woolly adelgid (*Adelges tsugae*) accelerated infestation and mortality of eastern hemlocks (*Tsuga canadensis*) in the Park. Several treatments are being compared, but most untreated hemlocks in the Park are now dying. Initial analysis of monitoring data and observations show that hemlocks benefit significantly from Imidacloprid treatments, probably for several years. Treatment accomplishments include; over 350,000 bio-control beetles released, 100,000 individual systemic treatments of trees, and 44 hemlock conservation areas established containing 1,633 acres. Monitoring of treated versus untreated trees began in 2005 – see Public Highlights section below for additional details.
- A cooperative agreement with Clemson University to process backlogged aquatic macroinvertebrate samples was completed in July 2008. These samples were from previous years' long-term monitoring. The data has now been entered into a database and will be analyzed with all past long-term data. To date, all 27 sites have had very good to excellent site indices. Most sites are located at mid to low elevations.
- Assistance was provided to a USGS scientist determining the effects of hemlock decline on aquatic macroinvertebrates. This involved locating the most

appropriate sites within healthy hemlock stands and within declining or dead hemlock stands, and collecting aquatic macroinvertebrates according to the Park's existing long-term monitoring protocol. This was the first year of a two-year project. Loss of streamside hemlocks could change stream temperature and/or quality. This project will help assess the impact.

- Monitoring data for annual bait station surveys for black bears indicated over 75% visitation, slightly lower than reported in 2007 (77%), but still suggesting a high density of bears. The hard mast surveys (oak acorns) showed an abundance of red oak acorns in higher elevations, but low abundance of most species in the lower elevations. Due to a high density of bears and spotty acorn abundance, some bears were not finding adequate food in late summer and fall, resulting in a significant increase in nuisance bear activity. In addition, because the abundant red oak mast appears to be concentrated in the less accessible higher elevations, Park wildlife personnel anticipate wild hogs will also be located in these areas during winter, making their control efforts much more logistically challenging.
- White-tailed deer monitoring in Cades Cove continues with distance sampling and herd health checks. Results from the FY07 herd health checks (abomasal parasite count) were received from the Southeastern Cooperative Wildlife Disease Study. The results indicated a good probability that the Cades Cove deer herd is below nutritional carrying capacity. A review/synthesis of the Park's deer distance sampling data is needed, particularly since some deer researchers have expressed concern regarding the validity of this technique to monitor deer population densities. Park staff will continue to try to secure a student and possible funding for the analysis and synthesis.
- Beech stands have been devastated by beech bark disease in many areas of the Park. Ten monitoring plots were established in 1994 and are measured biennially for survivorship, density of scale and *Nectria* fungus presence, branch dieback, defoliation, and woody species regeneration. All ten monitoring plots were measured in 2008. Data is still being analyzed. Monitoring has shown high mortality of mature beech in the plots followed in some cases by dense growth of blackberry (*Rubus* spp.) due to the newly open forest canopy. Root sprout reproduction, a trait common in beech gaps as the result of root injury, is now abundant in some locations. Natural resistance to the disease is thought to be low, and no treatment for the disease is known. Some of GRSM's monitoring plots have individual mature beech still in healthy condition above a thick understory of beech sprouts. In many beech gaps, overstory trees are dead but dense understory root sprouts are growing vigorously and will likely become infested by beech scale, followed by the fungal infection.
- Butternut (*Juglans cinerea*), a relative of black walnut, is affected by butternut canker (*Sirococcus clavigignenti - juglandacearum*), a fungal disease that causes lens-shaped bark wounds and lesions visible on nuts and branches. Health monitoring of butternuts in GRSM began in 1987 with 75 trees at locations

throughout the tree's range in the Park. In 2008, 47 monitor butternuts were evaluated, four of which had died since 2005. While the number of monitored trees has declined due to both the disease and mechanical damage from storms, some characteristics of survivors are becoming evident. Trees that are mature and receive full sun to their leaves have less branch dieback, and cankers that have been evident in the past are often tightly healed and now difficult to distinguish as cankers. Smaller trees receiving less sun are in poor condition, have open cankers with decay, and are susceptible to breakage due to structural weakness. Reproduction is restricted to areas where light is abundant and this is increasingly limited to road edges. Cyclical nut production occurred in 2008. Purdue University forest geneticist Keith Woeste has applied for a research permit to collect butternuts as part of a genetic diversity project in collaboration with the USDA Forest Service.

- Non-native balsam woolly adelgid (*Adelges piceae*) densities on Fraser fir trees were nearly 10 times higher at all four mountaintop monitoring sites in 2008 compared to 2007. The insect has killed an estimated 90% of mature firs since 1962. Firs at one site continue to decline and die due to high adelgid densities at the site over several years. Insecticidal soap treatments are conducted annually at the site if densities warrant it, and 2008 was no exception. Abundant cone crops also were produced at all sites. Cones were collected from five fir areas for a cooperative study; results are forthcoming. Small stands of unaffected firs are documented in the Park but the exact mechanism of resistance is not known.
- During 2008, data collection and analysis continued for the experimental elk release program, which will assist with determining the long-term viability of the herd. No additional elk were released in 2008. Fifty-two elk were originally released in Cataloochee Valley in 2001 and 2002. The resident elk population is now about 95 animals, most of which remain within the Park or the areas immediately surrounding it. Four adult elk died in 2008. The birth of 17 calves was confirmed, 14 of which are still alive; this is one of the highest calf survival rates to date. Predator management efforts continued during the peak calving season to improve calf survival rates. The experimental phase of the elk project will end this year, and the data will be re-analyzed by University of Tennessee researchers and presented to the Park. A long-term elk management plan is forthcoming.
- Brook trout populations in 11 streams were sampled in 2008. Field observations indicate that the extreme drought has altered the population size structure. The adult fish (> 160 mm) portion of the population appears to have been significantly reduced by the last two years of drought. As a result, reproductive success has been impacted because of the reduced number of reproductively mature adults. The extent of this impact has not yet been determined.
- Several years of macroinvertebrate samples from Noland Divide Watershed will be processed during FY09. A cooperative agreement was initiated with Western

Carolina University to complete this project. Macroinvertebrate data from this site will provide valuable information as to the effects of acid deposition at this high elevation stream site.

Water Quality Monitoring

- Noland Divide Watershed is a high elevation catchment that is instrumented for air and water quality research and monitoring. It has been monitored since 1991. The importance of these long-term studies is to be able to develop predictive water quality models to estimate the critical loads of atmospheric acid pollutants entering GRSM. In general, over the 16-year period, sulfate concentrations have not changed in NDW; however, inorganic nitrogen, mostly nitrate, has declined in concentration. The combined observations for acidic deposition and stream water quality concentrations suggest pollutant retention in the soils play a major role in the sulfate mobility in the watershed, and nitrification and biological retention possibly from vegetative growth. (See Public Interest Highlights section for details)
- The Park-wide stream survey dataset for 2007 included water samples from 32 sites collected during six stream surveys (January, March, May, July, September, and November), and 11 samples collected from the Hazel Creek watershed in March and October of 2007. Prior to 2004, the Park-wide survey included a larger number of sample sites, but was reduced to these 43 sites to optimize characterization of baseflow water quality in GRSM. A summary of the 2007 water quality data showed that pH for 2007 was 0.86% higher than the long-term average (1993-2006), ANC was 2.17% lower, sulfate was 1.47% lower, and nitrate was 28.27% higher. The large nitrate increase in 2007 over previous years remains unexplained, although one could speculate that changes in forest dynamics could cause this nitrate increase, among other possibilities. Nitrate concentrations will be carefully examined in the 2008 dataset. Although sulfate was somewhat lower in 2007 overall, there is some evidence of it increasing at some mid-elevation sites (Robinson et al. 2008).

Air Quality

- The most recent 10-year air quality assessment (1996-2005) shows that air quality at the Park is improving (visibility, fine particles, sulfate deposition, and nitrate deposition) or remaining stable (ozone concentrations and ammonium deposition). Even though air quality has shown some improvements, air quality problems continue, including; non-attainment areas of the public health standards for ozone and particulate matter, regional haze, acid deposition, and mercury. Optimism that air quality will improve in the near future due to several recent air quality regulations and other related actions is waning. Recent court decisions have vacated the EPA's Clean Air Mercury Rule (CAMR) and the Clean Air Interstate Rule (CAIR), and the implications and ramifications are uncertain as to

the effects of these rulings on the Park's future air quality and on a number of other EPA rules and programs, including the 8-hour ozone and fine particulate matter implementation rules and the regional haze rule. The elimination of CAIR is a setback for the environment and the Park's ability to ever meet public health standards and restore air quality-related values.

EPA ozone standards tightened for 2008. To compare between 2007 and 2008: there were 19 exceedances in the Park under the old standard in 2007, and four in 2008. Under the new regulations, there would have been 43 in 2007, and 18 in 2008. Over all, ozone exceedance days in 2008 were at 42% of the number in 2007, which was the best year in terms of ozone exposure since 2004.

PUBLIC INTEREST HIGHLIGHTS

Abrams Creek Aquatic Species Baseline

The Tallassee Fund, which was established through a settlement agreement approved by FERC (Federal Energy Regulatory Commission) in its relicensing order for Alcoa Power Generating, Inc., provides financing for natural resource stewardship activities. This fund has supported numerous projects in the region, including projects in the Abrams Creek watershed, one of the largest watersheds in GRSM (19,771 hectares). The objectives of one such project is to augment I&M baseline efforts by establishing new baseline locations for aquatic macroinvertebrates and to delineate and monitor populations of rare aquatic plants. There are concerns in this area of the Park associated with outside development affecting Park aquatic resources. Three federally listed fish, one federally listed plant, and a number of state listed species are present in this stream. The potential for siltation and pollutants to enter Abrams Creek may be increasing; therefore, gathering baseline data now will allow for future monitoring to assess impacts.

Aquatic invertebrate sampling was conducted in Abrams Creek, both above and below two tributaries, and in the tributaries as well. Sampling was conducted in June-July 2008. Diversity levels in one of the tributaries qualitatively appeared to be lower than a typical Smokies stream, but complete analysis will be required before this can be stated for certain. The stream bed was coated with a fine layer of sediment in many places. During the course of collecting, a large growth of algae was observed in Abrams Creek. Water samples were collected and analyzed by the University of Tennessee to help determine potential chemical causes for this overgrowth. Results are pending.

Baseline data were collected in August 2008 for a Tennessee endangered aquatic plant (*Potamogeton amplifolius*, or large-leaf pondweed) in Abrams Creek, the only location for this rare species in the Park. Over 100 GPS points were collected and will be considered for all future delimiting surveys where precision is required. Locating the extent of the population required searching 6.2 kilometers of difficult terrain in a gorge through which the creek flows. Colonies of the Federally Threatened shrub, *Spiraea virginiana*, or Virginia spiraea, were also relocated in the gorge from surveys in the 1990's and appear to be stable. With input from the USFWS, novel approaches to quantitatively monitoring this clonal shrub are under discussion for summer 2009.

Wild Hog Disease Monitoring

From 2005 to 2007, 16 wild hogs have been confirmed positive for Pseudorabies (PRV). A recent analysis of these data revealed that the disease is found primarily in the southwest portion of the Park (Figure 1), although it appears to be expanding north and east (Figure 2). Pseudorabies is a serious infectious disease for the commercial pork industry since it produces abortions and piglet deaths. Pseudorabies does not affect humans, but has been implicated as an infrequent cause of mortality for various wildlife

species. The disease produces a fatal infection of the central nervous system marked by itching, convulsions, excessive salivation, and other rabies-like symptoms (hence the name pseudorabies). Wild hog disease monitoring is conducted cooperatively with the North Carolina Department of Agriculture and Consumer Services, the USDA Animal and Plant Health Inspection Service, Veterinary Services, and the Tennessee Department of Agriculture. During 2008, an additional 131 blood samples were collected and will be tested and added to the disease surveillance database.

Park staff are also working with researchers from Clemson University on a pilot study to examine social factors related to the illegal release of feral hogs near the Park boundary, which is likely the cause of the PRV outbreak. Further, they are also working with researchers from the University of Tennessee to fund a project that would elucidate the potential spread of PRV in other areas of the Park and to evaluate the risk of disease transmission to domestic livestock.

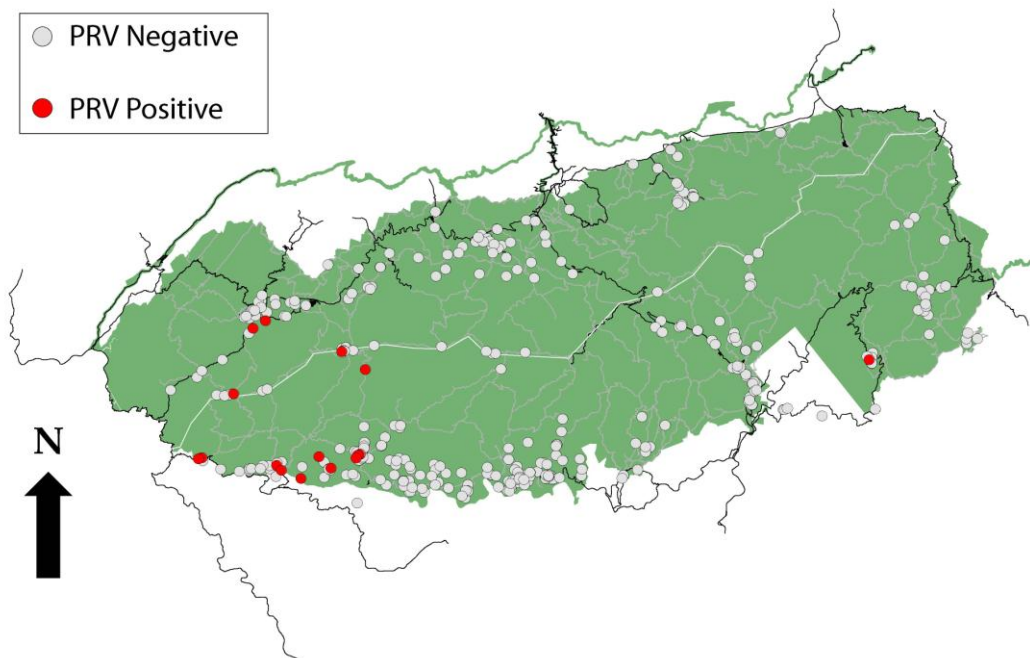


Figure 1. Great Smoky Mountains National Park showing locations of European wild hogs removed and tested for diseases during 2001-2007. White circles represent sera that were negative for pseudorabies (PRV) and red circles indicate a positive result for PRV. The black lines are major roads in and near the Park, the light grey lines are trails, and the white line is the state line between Tennessee and North Carolina.

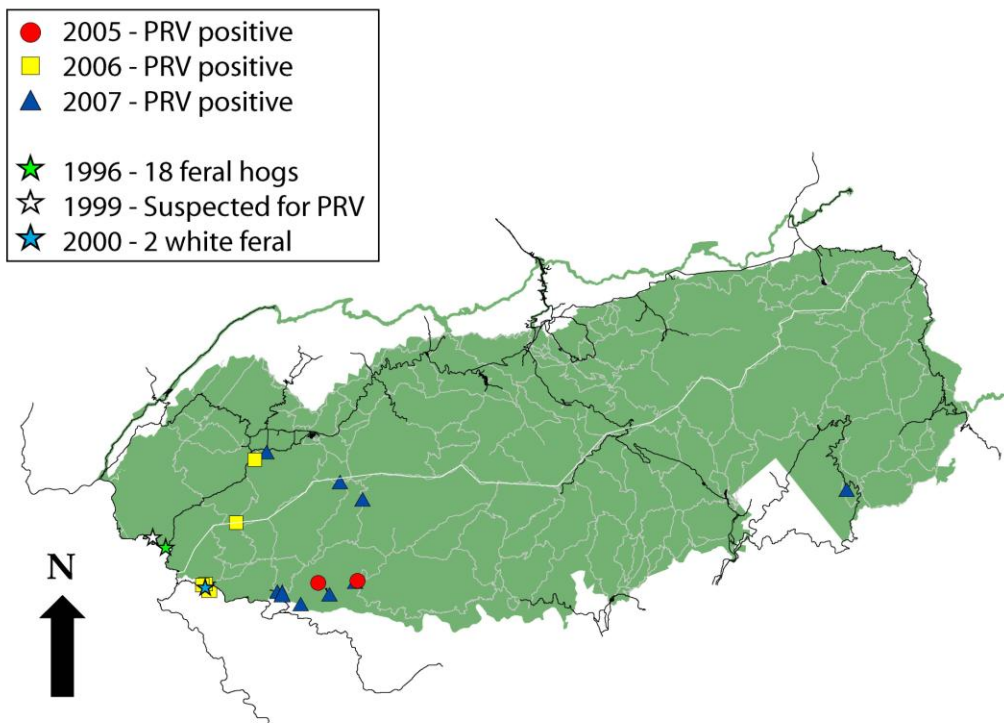


Figure 2. Great Smoky Mountains National Park showing locations of European wild hogs that tested positive for pseudorabies (PRV) in 2005 (red circles), 2006 (yellow squares), and 2007 (blue triangles). Star symbols indicate locations of hogs thought to be illegally released (green and blue stars) and of a hog suspected to be positive for PRV (white star) in a previous study.

Black Bear Monitoring

Monitoring data in the annual bait station surveys for bears indicated 75% visitation, slightly lower than 2007 (Figure 3). However, the visitation rate is still very high, suggesting a high density of bears. Additionally, although the annual hard mast survey indicated an abundance of red oak acorns in higher elevations (above 3,000 feet), abundance of most species in the lower elevations were low. Due to a high density of bears and spotty acorn abundance, some bears were not finding adequate food in late summer and fall, resulting in a significant increase in nuisance bear activity. In fact, from early August to mid October, there were two attacks on humans and multiple incidences of property damage from bears.

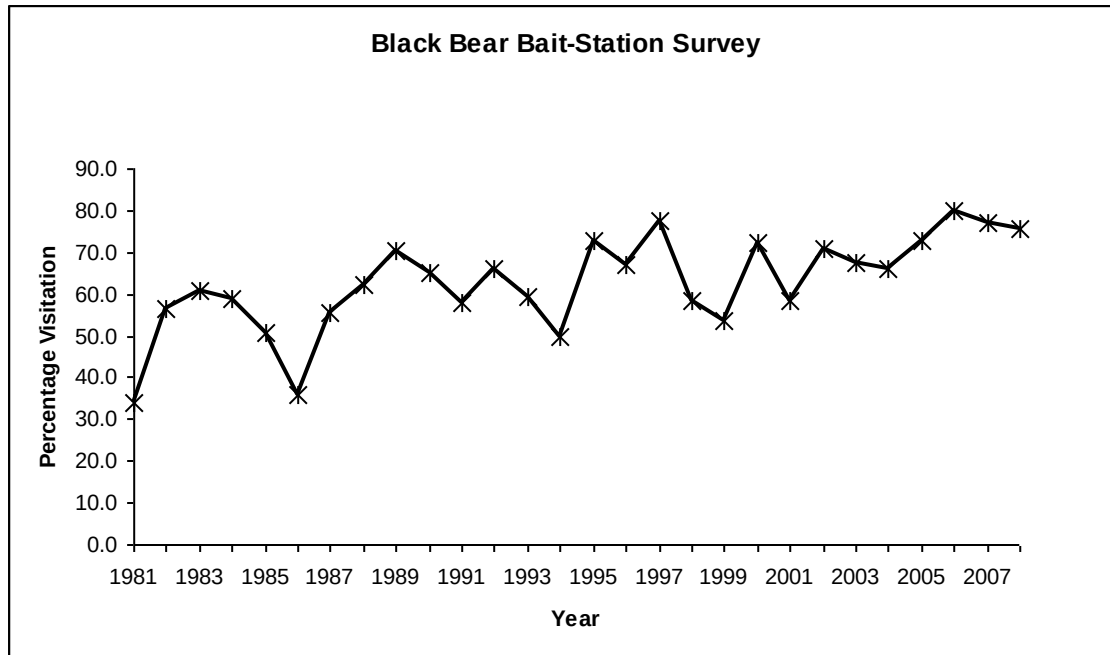


Figure 3. Black bear bait-station survey for Great Smoky Mountains National Park, 1981-2008.

Eastern Hemlock

First noticed in GRSM in 2002, hemlock woolly adelgid (*Adelges tsugae*), or HWA, has infested eastern hemlocks (*Tsuga canadensis*) throughout the Park. Feeding at the base of needles, HWA can directly kill trees in just a few years or weaken trees so that secondary pests, such as the hemlock borer (*Melanophila fulvoguttata*), eventually kill the tree. Treatment options are systemic chemical control, foliar spray of insecticidal soap or oil (restricted to developed areas and roadsides), and biological control; all have been implemented aggressively in the Park. Most untreated hemlocks are now dying.

Treatment accomplishments include; over 350,000 bio-control beetles released, 100,000 individual systemic treatments, and 44 hemlock conservation areas established containing 1,633 acres. Monitoring of treated versus untreated trees began in 2005. Analysis of monitoring data and observations show that hemlocks benefit significantly from systemic treatments, probably for several years. Adequate soil moisture is essential for soil systemic treatment uptake, and drought conditions in 2007 and 2008 have affected recent systemically treated trees response to treatment. Foliar treatments are effective but short-lived (six months) and are limited to smaller trees. Results of bio-control treatments are still in their infancy and have been mixed. Some locations show hemlocks are holding on while trees in other locations have declined severely or died. Survival may be the result of site, microclimate, or other factors. Long-term monitoring will reveal a clearer trend.

New Science Center Dedicated

On November 20, 2007, the Twin Creeks Science and Education Center was dedicated by dignitaries, including U.S. Senator Lamar Alexander. The new 14,000 square foot center is located at Twin Creeks near Gatlinburg TN, on the north slope of Mt. LeConte. It houses the Park's natural history collections, a chemical use laboratory, a biology laboratory, a large multiple use room designed for cooperative research permittees, work space, and a 1,000 square foot education/conference room. Offices for I&M, Air Quality, and Vegetation Management staff are also housed in the building in order to optimize collaborations between "outside" scientists and Park staff. The building uses natural light, and sustainable design, and is expected to achieve a LEEDS certification.



Noland Divide Watershed: Long-term Monitoring of Acid Pollutants

The Noland Divide Watershed (NDW) has been monitored since 1991, with measurements being taken on water volumes over time and chemical analysis of precipitation, throughfall, soil, and stream waters. This valuable and nationally unique dataset provides essential information to understand long-term water quality (WQ) trends, and the watershed processes that store or release acid pollutants. In 2007, the annual rainfall amount collected at the NDW site was 166 cm, which was 60 cm below the 16-year average for this site. Precipitation pH averaged 4.90 for 2007, which was above the 16-year average of 4.65. Throughfall pH averaged 4.19 for 2007, which was approximately the same as the 16-year average reported as 4.17. Rainwater not

influenced by acid pollutants would typically have a pH above 5.6, so the NDW is likely being impacted by acid deposition.

In 2007, wet deposition of sulfate and inorganic nitrogen (ammonia and nitrate) were measured as 536.7 equivalents per hectare per year (eq/ha/yr) and 482.2 eq/ha/yr, respectively. Dry deposition of sulfate and inorganic nitrogen from airborne particles settling during non-rain days was measured as 1,377.6 eq/ha/yr and 1,012.7 eq/ha/yr, respectively. Because precipitation events occurred less often in 2007 than previous years, wet deposition of sulfate and inorganic nitrogen was below the 16-year average; however, throughfall deposition of sulfate and inorganic nitrogen was above the 16-year average (Figure 4).

In 2007, the acid neutralizing capacity (ANC), a critical measurement to assess stream acidification, was indicative of a low-alkalinity stream impacted by acid deposition. Other ion constituents measured from stream samples included chloride, calcium, magnesium, aluminum, iron, potassium, sodium, manganese, copper, zinc, and silicon, which are important in computing ion balances for WQ analyses. Sulfates have contributed more acid deposition than inorganic nitrogen, although both significantly contribute to acidification of the Park's streams. In general over the 16-year period, stream water sulfate concentrations have not changed in NDW, however inorganic nitrogen, mostly nitrate, has declined in concentration.

The combined observations for acidic deposition and stream WQ concentrations suggest pollutant retention in the soils play a major role in the sulfate mobility in the watershed, and nitrification and biological retention possibly from vegetative growth.

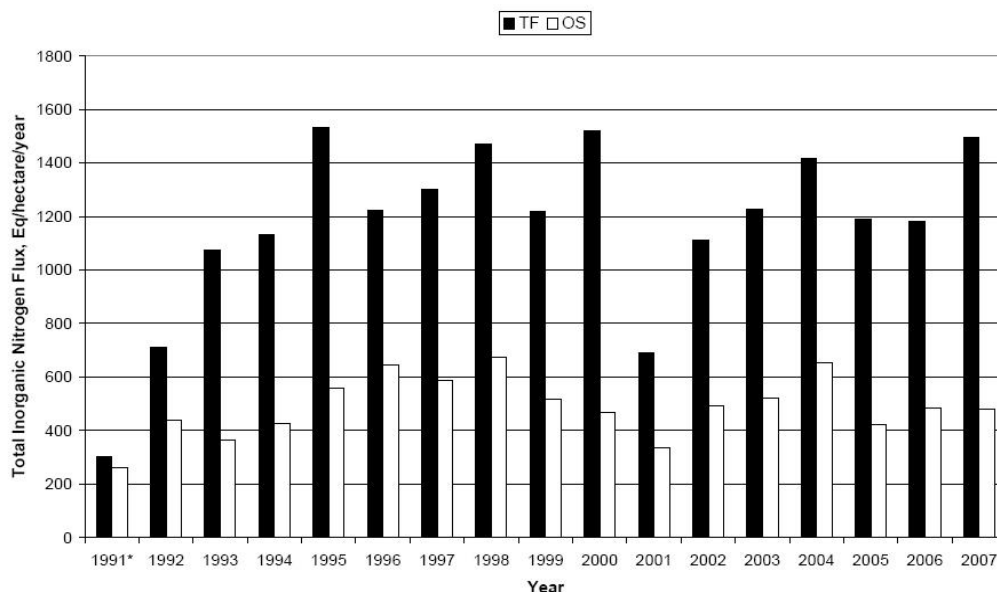


Figure 4. Total annual inorganic nitrogen deposition entering the NDW as wet-only (OS) and throughfall (TF) precipitation.

Monitoring Night Skies and Natural Soundscapes

Dark night skies are a diminishing resource in many park units due to “light pollution” from nearby and regional human activities. The Smokies received its first scientific measurements of night skies in fall 2007, through the WASO Dark Skies Initiative. These measurements were taken from Clingmans Dome, which is near the middle of the Park and is one of the highest points in eastern North America (Figure 5). Substantial amounts of light from surrounding areas were identified.

Natural soundscapes are important resources in wildlands like the Great Smokies. Data on sounds measurement, including natural sounds, have been collected in the Park by the Volpe Center, a U.S. Department of Transportation research facility. Data and reports have not yet been received from the Volpe team.

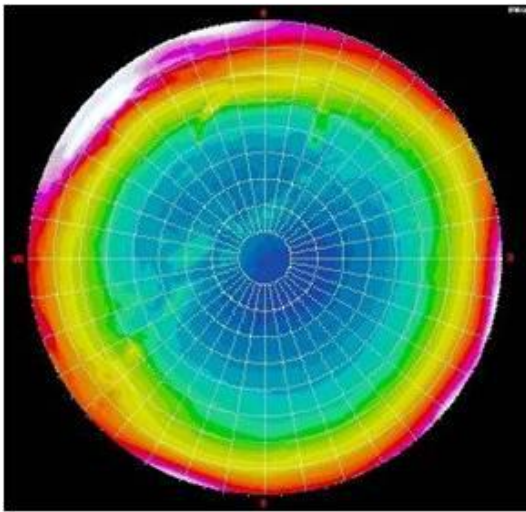


Figure 5. An example of night sky brightness from cameras at Clingmans Dome, GRSM, 2007. The darkest area is in the center of the graphic; the night sky brightens as the colors change from blue to green, yellow, red, and white. (Note: the Tennessee Valley is in top-left section as white, and the Milky Way is identifiable as a light-green arch from lower left to upper right.)

I. Overview and Objectives

Park Description – Great Smoky Mountains National Park was established in the mid 1930's from private lands bought by the states of Tennessee and North Carolina, and donated to the U.S. Department of the Interior for the creation of the Park. It is about 2,200 square kilometers (810 square miles) in size, with about equal amounts of land in each state.

Ecological Setting – The Park contains one of the most complex geologies in the eastern U.S., with bedrock spanning the geochemical spectrum from extremely acid-bearing and radioactive to karst areas, including one of the deepest caves in the east. Elevations range from 274 meters (~888 feet) above sea level, to 2,044 meters (6,643 feet) above sea level. Soils mapping and classification is complete; many new soil types have been described. Although this is an unglaciated region, extinct peri-glacial features have been described at higher elevations.

The vegetation of the Park is known to be one of the most complex in North America, and varies from dry pine-oak forests at low elevations, to highly diverse broadleaf deciduous mid-elevation forests, to dry peat shrub-heaths, to spruce-fir forests at the highest elevations. NatureServe has classified nearly 70 different associations which occur in 40,000 polygons. There are many unusual/globally rare vegetation associations.

It is apparent that the Park is a major center of species richness because of this vast array of vegetative communities and unique geological formations. A number of taxa, including salamanders, vascular plants, fungi, lichens, bees and wasps, land mollusks, aquatic insects in several orders, eumycetozoans, spiders, and other groups are being characterized relative to these systems.

Ecological Issues – Exotic invasive organisms, including forest insects and fungal diseases, plants, fish, and feral hogs are major biological problems. Air pollution, including ozone and acidification, are major chemical pollution problems. Increased fragmentation of natural areas in the immediate region of the Park represents another substantial issue. Poaching occurs for a variety of typical game species, but also for plants and even invertebrates.

Program Overview - The Smokies was selected as one of the first four prototype parks in the NPS's Inventory & Monitoring program. It identified maintenance of biodiversity as the primary natural resource related goal of Park management. The Park developed its monitoring plan in 1993 for detecting and assessing changes in biota, and identification and assessment of environmental impacts, which threaten the Park's biotic systems.

USGS developed the GRSM plan over a two-year period, which included the transfer of NPS personnel to NBS and the subsequent re-transfer of most personnel back to NPS in 1995. Some of the monitoring components in the program pre-date the I & M program, but were subsequently funded by it. Other components are new. Some initial components (e.g., cave biota, T & E fish) were dropped early on due to lack of funds.

The Smokies has assisted other parks in the Southeast region with monitoring issues and was the principal author of the inventory plan (Nichols et al., 2001) for the Cumberland-Piedmont and Appalachian Highlands networks, when they were becoming established. The GRSM monitoring program has provided data that have been used to address key points in Park land management decisions, nationwide decisions by other agencies, and even in restricting export of certain rare species protected under international treaty (CITES).

As a prototype Inventory & Monitoring Park, we have decided to emphasize both natural resource inventories and monitoring. The Park is one of the most species-rich areas of its size in temperate zones of the world. After scientific conferences and consultation with WASO, Park management in 1998 decided to undertake a project to discover and document all life in the Park. This is called an All Taxa Biodiversity Inventory (ATBI), and is funded principally through monies from local non-profits closely associated with the Park and in-kind funds are provided from other matched sources, including competitive science funding from the National Science Foundation. This project is in partnership with Discover Life in America, Inc. (DLIA), which has the operational lead in the project. It has not been funded from the original I & M program, or subsequent Natural Resource Challenge programs, but funding became available from a new increase earmarked for the ATBI in FY 2005.

Objectives for Biological Inventories:

- 1) Complete Phase 1 inventories for vascular plants and vertebrates; certify lists in NPSpecies. (complete)
- 2) Complete Phase 1 inventories for other categories (i.e., geology, soils, vegetation); portray and integrate data into GIS for use. (complete)
- 3) Accelerate comprehensive inventories of all other species in GRSM through partnership with DLIA. This includes development of an advanced data management system for the documentation and portrayal of all resource elements.
- 4) Assist other NPS units and reserves of other agencies/organizations in their efforts to begin comprehensive biodiversity inventories.

Objectives for Prototype Monitoring:

- 5) Vital Signs: Monitor trends in selected populations, communities, and abiotic components that are relevant to Park management.
- 6) Update/transition from original 1993 prototype monitoring program to revised program that reflects new knowledge and new fiscal realities.
- 7) Monitor other biological and abiotic elements in the Park, through a mixture of collaborations and partnerships.
- 8) Provide all monitoring data (and eventually all data) to all park managers and the public on a regular basis.
- 9) Test/compare new monitoring techniques and evaluate new protocols. Share all of our experiences with other parks in surrounding networks.

II. Accomplishments and Scheduled Activities:

A. BIOLOGICAL INVENTORIES:					
Objective/Task	Description	FY 2008 Goals	FY 2008 Accomplishments	FY 2009 Goals	Task Lead
1) Complete Phase 1 biological inventories and certify lists:					
1.1 Amphibians	Dr. Ken Dodd, USGS-BRD, Gainesville, FL, has conducted Park-wide amphibian inventories as part of ARMI, a USGS program.	Obtain USGS amphibian data and enter into ATBI database.	Data obtained from USGS in Gainesville. Glitches being addressed by USGS.	Get data added to database/GIS and effect pilot modeling of distributions.	USGS, GRSM
1.2 Reptiles	Dr. Ben Cash, Maryville College, has conducted reptile inventories as part of the NRPP Vertebrate Study.	Complete entering data into ATBI database.	Some data received, but still need researcher involvement.	Get data added to database and GIS; effect modeling of all species distributions.	DLIA, GRSM
1.3 Small Mammals	Dr. Don Linzey, Wytheville Community College, and Dr. Ed Pivorun, Clemson University, have conducted small mammal inventories as part of the NRPP Vertebrate Study.	Update distribution maps on web pages. Continue to investigate new modeling techniques. Enter data into ATBI database.	Small mammals are in queue for entry into database	Complete entry of small mammal data into database.	DLIA, GRSM
1.4 Fish	Patrick Rakes and J. R. Shute, Conservation Fisheries, Inc., have been conducting species distribution surveys. Additional inventories	Model distribution of all fish species.	DLIA collaborator (Rakes) received postponement for work funded. Awaiting new data before modeling effort.	Receive new data from DLIA collaborator (Rakes). Get at least rarest fish species modeled as first iteration.	DLIA, GRSM

	and web page development for the ATBI have been completed by Dr. David Etnier, University of Tennessee, and Liz Etnier.				
1.5 Birds	Dr. Ted Simons and Dr. Susan Shriner, North Carolina State University, have completed bird inventories in the Park. Appalachian Highlands Science Learning Center has augmented data by coordinating new bird data, mist netting, and parasite studies.	Staff begins testing species distribution modeling.	Bird records are in ATBI database. Investigated National Geographic Maps software for modeling distributions (Meta Lens), and found it not as comprehensive as we require. Instead piloted MaxEnt and found it quite capable, even for species with few point records.	Begin using MaxEnt for general distribution mapping.	GRSM
1.6 Vascular Plants	Dr. Patricia Cox, Tennessee Valley Authority, is the Taxonomic Working Group (TWIG) leader. Illinois Natural History Survey (INHS), independent volunteers, and NPS staff have done many surveys over the years in the Park.	Update certified vascular plant list. Continue developing fern web pages. Continue work on modeling distributions.	Four new native plants for Park reported in FY08; all uncommon to rare in Park, and two with state listing. New plant checklist published. Fern Forays (includes acquisition of other plant data) continued.	Begin using MaxEnt for distribution modeling of selected tree species.	DLIA, GRSM
2) Complete other Phase 1 inventories:					
2.1 Soil Mapping	USDA-NRCS offices in TN and NC have conducted the first comprehensive soil survey of GRSM.	Complete population of project database. Produce final product for Sept. 30, 2007 delivery. Conduct "final acre"	All field work now complete. Deadline for database population of soils polygons met at beginning of FY08, but	Continue working with NPS National Soils Coordinator (P. Biggam) to receive the best final report and ancillary	USDA-NRCS, WASO-I&M (Biggam), GRSM

		ceremony.	report returned with many review comments.	products that are possible.	
2.2 Geology Mapping	USGS-Reston has led this project in GRSM.	Integrate geology data into Park's GIS.	Done. Bedrock data has been peer-reviewed by USGS, and is in Park's GIS.	If time allows, will add geomorphology data, primarily boulder deposits to GIS.	GRSM
2.3 Vegetation Mapping	Center for Remote Sensing and Mapping Science, University of Georgia, has led the mapping project in GRSM. Classification of vegetation associations by NatureServe.	Work with GIS staff to prepare final version of vegetation map based upon accuracy assessment.	Full vegetation map attributes are now available to Park.	Pending selection of new forest ecologist, a request will be submitted to do selective updating of evergreen forest classes via remote sensing. Data on xeric pines and hemlocks need revision due to insect induced mortality.	GRSM
3) Accelerate additional biological inventories:					
3.1 Traditional ATBI Sampling	Taxonomists, volunteers, etc. are organized into ~20 loose Taxonomic Working Groups (TWIG's) and are collecting field data. These data inform us as to efficiency of structured sampling (see below).	Discover Life in America (DLIA), our partner in conducting the ATBI, issues RFP, and awards competitive "mini grants" for selected groups of organisms.	Eight mini grants were awarded by the science committee of DLIA. Ten reports were received from 2007, plus NSF funded work continued on several projects (see www.dlia.org). Genetic bar-coding allowed for mtDNA analysis of dead whip-poor-will gut contents; the process identified four invertebrate species that were ingested by this declining bird species.	New director for DLIA (Todd Witcher) was hired 12/07. Will support new mini-grant awardees and continue to require use of best management practices in data acquisition.	DLIA, assisted by GRSM

3.2 Structured Sampling in ATBI	USGS and NPS designing protocol to sample maximum biodiversity using protocol with: least impact, least cost, and most efficiency. Traditional sampling and structured sampling are designed to be mutually informative.	Work with Dr. Andy Royle, USGS PWRC, to gain recommendations for developing modified structured sampling protocol.	Royle has been delayed, but has delivered preliminary advice to make structured sampling more geographically expansive, rather than temporally extensive.	Receive Royle's recommendations, and begin planning implementation.	USGS, GRSM
4) Assist other NPS units, other reserves in planning/design of comprehensive inventories:					
4.1 Assist with consultations for other ATBI start-ups, and participate in formation of ATBI Alliance	Help develop national Alliance of ATBI projects inside and outside of NPS, so that these projects can cooperate in planning, design, data management, and funding.	Host some parks at December 2007 DLIA meeting. Participate in WASO-NPS workshops in Ft. Collins, CO in FY08.	Hosted December 2007 DLIA meeting. GRSM participated in two WASO-NPS workshops in Ft. Collins, CO in FY08.	Continue to assist in development of ATBI's at other parks and reserves as requested and available. Staff from other parks will likely attend DLIA conference in December, 2008.	DLIA, GRSM

B. VITAL SIGNS AND OTHER MONITORING:					
Objective/Task	Description	Date Initiated	Protocol Status (I&M components only)	FY08 Accomplishments	FY09 Plans
5) Vital Signs: Monitor trends in selected populations, communities, and abiotic components that are					

relevant to Park management:					
5.1 Aquatic macroinvertebrates	Program tracks changes in species diversity and abundance as an indicator of aquatic ecosystem health.	1992	Protocols have been revised to meet new I&M national standards. Revisions include a more comprehensive reference listing and better documentation of metadata.	No long-term stream sites were monitored in FY08. New sites were established on Abrams Creek and at eight hemlock-dominated stream sections; these were research/project funded samples.	With current budget projections, it is unclear what sites will be sampled in FY09, beyond Abrams Creek. However, several years of macroinvertebrate samples from Noland Divide Watershed will be processed and data entered in FY09. Data analysis section of protocols will be updated.
5.2 Bear bait station surveys	Percent of bait sites visited by bears is used to determine relative densities and to monitor population trends.	1981	Protocols currently in use are being revised to meet new I&M national standards.	Monitoring completed in FY08 recorded the fourth highest visitation in 28 years of annual sampling and slightly lower than recorded in FY07.	Modification of monitoring is under consideration for FY09.
5.3 Brook trout distribution	This component tracks changes in the distribution of brook trout in high elevation streams.	1986	Protocol is in old format. New format in draft form; expected to be final in FY09.	Much progress was made in modernizing the database that includes brook trout monitoring data.	Inactive.
5.4 Cades Cove deer population	The deer population in Cades Cove is monitored by estimating density using distance sampling, and determining physical condition by using herd health checks.	1971	New distance sampling monitoring protocol was used in FY08, but not written in new format.	Received results from FY07 herd health checks which indicated a good probability that the herd is below nutritional carrying capacity. Distance sampling continued in the winter. Review and synthesis of the protocol by a university student	Herd health checks and distance sampling to continue; however, a review/synthesis is needed. Continue to search for graduate student with interest in the project.

				was not completed as expected.	
5.5 Fish communities in large streams	This program tracks changes in fish species composition through time. Selected biotic and abiotic variables are also measured.	1986	Protocol is in old format. New format in draft form; expected to be final in FY09.	Two sites completed on Cataloochee Creek.	Sites will be sampled as personnel availability allows.
5.6 Forest insects and disease	Three insects or pathogens and their impact on host species are monitored on a rotational basis. These include the balsam woolly adelgid, beech scale, and butternut canker.	1993	Protocols follow techniques outlined in the USDA FS Forest Health Monitoring protocols. Protocols for the balsam woolly adelgid and beech bark disease have been revised to meet new I&M national standards.	Balsam woolly adelgid was at population levels 10 times higher than in 2007; this was also a cone production year for this rare conifer, which produces cones synchronously only about every three years. Beech were re-surveyed for mortality due to bark disease but results are not yet available. Ten percent mortality was noted in butternut since the 2005 survey.	Balsam woolly adelgid and hemlock woolly adelgid plots will be monitored and new data will be analyzed for trends.
5.7 Hard mast surveys	Percent of crown with acorns is estimated from selected trees along the same segments of trails each year. From these data, an index of mast quantity is calculated.	1977	Methods have been changed to sample the same trees each year, to sample more trees per site, and to calculate an index to measure mast quantity. This technique is used across the southern Appalachians and was developed by USDA FS researchers to provide more efficiency and objectivity.	Mast surveys were completed in FY08, and showed abundant red oak acorn production in higher elevations but low abundance of most species in the lower elevations.	Mast surveys will continue, and new methods will be drafted into the protocol following the inter-agency regional methodology. Results offered to other staff, public.

5.8 Rare plants	Program tracks changes in 60 plant populations from 38 species. A subset of approximately 20 populations is selected for monitoring each year.	1989	New protocol for the 37 vascular plants written in 2007. Most data now transferred to new database. The monitoring protocol for <i>Gymnoderma lineare</i> (rock gnome lichen) and other non-vascular plants has been updated to meet new I&M standards, except for the data management section.	Twenty eight rare plant populations were visited from May-September. Nine received quantitative data collection, and one new population (<i>Trientalis borealis</i>) was added to the monitoring program. Verified six locations of the Federally listed <i>Gymnoderma lineare</i> to assist USFWS in 5-year review. Six hundred fifty seven ginseng roots were aged and weighed in FY08. Many roots were relatively old, which indicates poachers may be penetrating deeper into the backcountry.	Unclear that more than a few populations will be monitored in FY09, but a new delineation technique using digital imaging will be evaluated for inclusion into the rare plant protocol.
5.9 Vegetation communities	Program uses permanent plots to track changes in the composition and structure of vegetation communities through time.	1998	Protocol has been updated to meet new I&M national standards. Currently, the database is being redesigned and metadata are being developed for program and legacy data.	Thirty-five permanent vegetation monitoring plots were re-surveyed in FY08. These were the same plots installed in 2003, in hemlock dominated areas, to serve as a baseline after infestation by hemlock woolly adelgid.	More than 10 new plots are predicted to be selected, set-up and "read" in FY08. New plot selection protocol modification developed in 2007 will be used.
5.10 Rare species databases	This project aims to organize all rare species data into one database to accomplish several Park priorities, including: use	2008, but some quantitative data go back to 1970's	Protocol written for field work with new generation GPS units and precision delineations. Still developing database -	Botanist (J. Rock) is working with the Park data manager (M. Kunze) and GIS specialist (B. Zank) to create this	Complete finalization during fall/winter CY2008, and begin systematic population and portrayal of data for

	of the information in NEPA projects, modeling rare species and natural communities across the Park, and informal monitoring of hundreds of rare species that are not otherwise covered in formal monitoring protocols. The focus is on a database – GIS interface that is standardized, and simple, but will capture tabular, notational, and spatial delineations of populations for assessment of future trends/impacts.		GIS portion of protocol.	database consisting of spatial and tabular data using Access and ArcMap. Based on a prototype developed for Cades Cove in 2007, this database is populated with historic and current data.	management use.
5.11 Water quality	Sample sites were selected to cover a gradient of elevation, vegetation, and geology. Some sites are co-located with fish and aquatic macroinvertebrate monitoring sites. A total of 43 sites is sampled regularly.	1993	Most of the protocols used by University of Tennessee cooperators are USEPA standard techniques. Low-ionic strength protocols have been developed for the Smokies.	Sampling was completed at 43 sites.	Anticipate maintaining current level of water quality monitoring in FY09. Several ancillary projects being worked on by cooperator.
5.12 Water quality - Noland Divide	Intensive sampling is being conducted at this small, high-elevation watershed. Data collected includes sulfate and nitrate deposition, total nitrogen, and base cations.	1993	Project protocols are USEPA standard methods.	Sampling continued. Nitrogen showed slight increase from FY07, but is still near 15 year mean. Sulfate showed slight decrease, but still above mean.	Noland Divide sampling will continue in FY09, and if macroinvertebrate data becomes available, co-analyses will begin.
6) Update/transition from original 1993 prototype monitoring program to revised program that reflects					

new knowledge and new fiscal realities:					
6.1 Revised Monitoring plan	Revise current, out-dated plan.	2006	N/A	New plan in draft, but has not received internal review yet, which will be followed by network and outside reviews.	Finalize plan, including reviews at various levels, and begin implementation.
7) Monitor other biological and abiotic elements in the Park, through a mixture of collaborations and partnerships:					
7.1 Air quality	This is the largest air quality monitoring program in the NPS. Four categories of data are collected: (1) ozone and trace gases, (2) deposition, (3) particulates/visibility, (4) meteorology/climate.	1980	Program uses standard protocols that are used nationally by multiple agencies.	Monitoring continues. See program accomplishments for more detail.	Monitoring will continue in FY09.
7.2 Fire effects	Program monitors the effects of prescribed fire on vegetation composition and structure in NPS units throughout the Southeast. Monitoring plots have been established in six parks, including GRSM. Plots are sampled prior to burning, immediately after, one year after, two years after, and five years after.	1997	Program uses a nationwide NPS protocol.	FY08 was largely concentrated on post-burn data collection. Staff conducted 28 plot “reads” in pine and oak vegetation types from six different prescribed burn sites, and installed four new plots (three oak, one pine) in three future burn sites. To date, the program counts 26 pine forest and 18 oak forest plots, in addition to 69 total plots at five other NPS units in the Southeast Region. Overall increase in yellow pine seedlings is	Monitoring will continue in FY09, in GRSM and in several other parks. Data generated from fire effects monitoring at GRSM have been presented at a variety of international and regional scientific conferences, featured in one publication and are currently in preparation for another publication.

				significant, but restricted to two of the most severely burned sites.	
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Monitoring by Outside Cooperators:				
Objective/Task	Cooperator	Description	Length of study	Status
7.3 Vernal pool amphibians	University of North Carolina - Asheville	GRSM is part of this multi-park project that has resulted in multiple publications.	Since 1991.	Project completed by initial PI's, but continued by Great Smoky Mountains Institute at Tremont in 2008.
7.4 Terrestrial salamanders	University of North Carolina - Chapel Hill	Data have been collected for 30 years; protocols were revised 12 years ago to make study more quantitative.	Over 30 years	In 2008 this project was turned over to Western Carolina University from UNC - Chapel Hill. There is a need to publish findings from this project in order to assess its usefulness. Contacting Dr. Haven Wiley (University of North Carolina - retired) regarding publication of data
7.5 Black bear population dynamics	University of Tennessee	This project is one of the longest bear population studies in the world. Only bears in the northwest quarter of the Park are tracked.	Over 30 years	Continuation of project is dependent upon funding availability.
7.6 Bats	U.S. Fish & Wildlife Service	Bi-annual survey of the	Over 30 years	Ongoing. Cave was last

		winter colony of Federally endangered Indiana bats in Blowhole Cave.		surveyed in FY07. Survey planned for FY09.
7.7 Northern flying squirrel	North Carolina Wildlife Resources Commission	Uses nest boxes to determine the distribution of flying squirrel populations and monitor.	10 years	Conducted on the North Carolina side of the Park. Nest boxes last checked in FY06. No surveys were conducted in FY07 or FY08. Need survey on TN side.
7.8 Breeding birds survey; Monitoring Avian Productivity and Survivorship (MAPS)	International effort	Two MAPS stations are in the Park, Tremont and Purchase Knob.	Over 5 years	This was the final year for the station at Purchase Knob.
7.9 High elevation breeding birds	Purdue University	Elevation transects in the Park are compared to transects in Costa Rica. Data from before and after Fraser fir loss is also collected.	Over 20 years	Ongoing periodically, but no surveys were done in FY08; perhaps genetic work in 2009.
7.10 Moth populations	Great Smoky Mountains Institute at Tremont and others	Light trapping has been conducted every two weeks to monitor moth population response to season, weather, and annual changes. Over 600 species have been documented at Tremont alone. A second site (Purchase) was added in 2003.	7 years	Sampling not conducted regularly in FY07; expected to be irregular in FY08.
7.11 Monarch butterfly migratory populations	Part of national protocol; Great Smoky Mountains Institute at Tremont has lead.	Butterflies have been monitored feeding on milkweed plants in Cades Cove as part of a nationwide study that examines temporal and spatial variations in migratory populations.	Over 7 years	Monitoring done in early FY08.

7.12 Gypsy moth populations	USFS, in cooperation with GRSM Vegetation Management staff	Pheromone traps are used to attract adult males. Trapping is done annually along roadsides and in developed zones.	Over 25 years	Ongoing
7.13 Old-growth forests	Oregon State University and Wright State University (Ohio)	These two projects track changes in selected old-growth forests. The OSU study consists of several 1 ha plots that are measured periodically. The WSU study measures transects that extend across gaps in old-growth forests. Both of these studies have been very influential and produced numerous publications.	Over 25 years	These enormous plots are not measured every year; no measurements taken in FY08 and none expected in FY09.
7.14 Fraser fir forests	In the past, TVA and others have conducted monitoring	Data have been collected to track post-adelgid changes. DBH and basic stand characteristics are measured. Sixty-six plots are measured every 10 years.	Over 20 years	Plots re-measured in FY00-FY01; scheduled for next survey in FY10-FY11.
7.15 Forest Inventory and Assessment (FIA) plots	USFS FIA program is a national program across all private and public lands. It uses different protocols from NPS.	Approximately 90 plots have been sampled throughout the Park on a 3-mile grid. Four plots are also forest health plots where trees are evaluated for condition, diseases, and pests.	Over 8 years	Interagency agreement signed, and permit issued in FY07. Sub-samples of sites are visited annually.
7.16 Exotic worm delineation and experimental control	University of Georgia	This MS project involves determining the extent of an exotic worm invasion along the southwest border of the Park. Experimental burning	2 years	Mapping of the infestation has been completed, although it fluctuates seasonally depending on soil moisture levels. Life history

		will be conducted by the Park in cooperation with UGA to determine if this may be a potential control strategy.		information has been determined with laboratory studies. Experimental burning should occur in FY09.
8) All monitoring data (and eventually all inventory data) to be made available to all Park managers and the public on a regular basis:				
8.1 Develop relational database.	GRSM staff	All monitoring data is to be accessible to all RM&S employees who need it, and the public. This requires standardization.	Data management plan completed and being implemented.	Complete transition to new data management plan work procedures. All final data to be posted on U:drive by end of CY08.
9) Test/compare new monitoring techniques and evaluate new protocols. Share all of our experiences with other parks in the surrounding networks:				
9.1 Participate in Network or national I&M meetings.	GRSM staff	Several meetings	N/A	All long-term monitoring protocols checked for completion. Ancillary monitoring projects evaluated for protocol need. Shared with outside park partners as available.

III. Inventory and Monitoring Staff (GRSM)

- Keith Langdon, Coordinator, Inventory and Monitoring Branch
- Janet Rock, Botanist
- Becky Nichols, Ph.D., Entomologist
- Michael Kunze, Ph.D., Data Manager
- Adriean Mayor, Ph.D., Museum Curator

Other Resource Management and Science Division Staff involved directly in conducting monitoring:

Jim Renfro, Air Quality Specialist
Kristine Johnson, Supervisory Forester
Glenn Taylor, Forester
Kim Delozier, Supervisory Wildlife Biologist
Bill Stiver, Wildlife Biologist
Steve Moore, Supervisory Fisheries Biologist
Matt Kulp, Fisheries Biologist
Ben Zank, GIS Technician
Paul Super, Biologist (Appalachian Highlands Science Learning Center)

Contractors and Cooperators:

- Discover Life in America, Inc. (DLIA)
DLIA is a private non-profit organization that coordinates the ATBI in partnership with GRSM. Over 200 scientists are involved at many different universities.
- University of Tennessee, Department of Civil and Environmental Engineering
Dr. Bruce Robinson is the principal investigator for the water quality monitoring program in GRSM.
- USDA-NRCS
Anthony Khiel and Doug Thomas are the principal investigators for the soils mapping project in GRSM.
- USGS-Patuxent Wildlife Research Center
Dr. Andy Royle is a research Bio-statistician who is working with GRSM to develop an ATBI structured sampling design.
- University of North Carolina – Chapel Hill
Dr. Todd Jobe has been a consultant on GIS modeling.
- Western Carolina University
Dr. Tom Martin and graduate student Sheree Ferrell are processing backlogged aquatic macroinvertebrate samples for the Park

IV. Reports, Publications, and Presentations from FY 2008

Reports, Theses and Dissertations:

- Paysen, E.S. 2007. Diversity and abundance of ants at forest edges in the Great Smoky Mountains National Park. Ph.D. Dissertation, Clemson University. 175 pp.
- Schwartz, J.S. 2008. Great Smoky Mountains National Park 2007 Water Quality Annual Report. 43 pp.
- Snyder, B.A. 2008. Invasion by the non-native earthworm *Amyntas agrestis* (Oligochaeta: Megascolecidae): Dynamics, impacts, and competition with millipedes. Ph.D. Dissertation, University of Georgia. 150 pp.

Publications:

- Baird, R.E., C.E. Watson, and S. Woolfolk. 2007. Microfungi from bark of healthy and damaged American beech, Fraser fir, and eastern hemlock trees during an All Taxa Biodiversity Inventory in forests of the Great Smoky Mountains National Park. Southeastern Naturalist 6(Special Issue 1): 67-82.
- Bernard, E.C. 2008. Reappraisal of the *Stachia-Stachiomella-Pseudostachia* complex (Collembola: Odontellidae), redescrptions of *Stachia minuta* and *Stachiomella oxfordia*, and *Stachia tasgola*, new species. Proceedings of the Biological Society of Washington 121(1):106-116.
- Bernard, E.C. and K.L. Felderhoff. 2007. Biodiversity explosion: Collembola (springtails) of Great Smoky Mountains National Park. Southeastern Naturalist 6(Special Issue 1): 175-182.
- Carlton, C. and V. Bayless. 2007. Documenting beetle (Arthropoda: Insecta: Coleoptera) diversity in Great Smoky Mountains National Park: beyond the halfway point. Southeastern Naturalist 6(Special Issue 1): 183-192.
- Deyton, E.B., J.S. Schwartz, R.B. Robinson, K.J. Neff, S.E. Moore, and M.A. Kulp. 2008. Characterizing episodic stream acidity during stormflows in the Great Smoky Mountains National Park. Water, Air, and Soil Pollution, doi 10.1007/s11270-008-9753-5.
- Fanning, E., J.S. Ely, H.T. Lumbsch, and H.W. Keller. 2007. Vertical distribution of lichen growth forms in tree canopies of Great Smoky Mountains National Park. Southeastern Naturalist 6(Special Issue 1): 83-88.

- Fučíková, K., J.D. Hall, J.R. Johansen, and R. Lowe. 2008. Desmid flora of the Great Smoky Mountains National Park, USA. *Bibliotheca Phycologica* 113: 1-59.
- Jenkins, M.A. 2007. Vegetation communities of Great Smoky Mountains National Park. *Southeastern Naturalist* 6(Special Issue 1): 35-56.
- Johansen, J.R., R.L. Lowe, S. Carty, K. Fučíková, C.E. Olsen, M.H. Fitzpatrick, J.A. Ressa, and P.C. Furey. 2007. New algal species records for Great Smoky Mountains National Park, with an annotated checklist of all reported algal taxa for the park. *Southeastern Naturalist* 6(Special Issue 1): 99-134.
- Johansen, J.R., C.E. Olsen, R.L. Lowe, K. Fučíková, and D.A. Casamatta. 2008. *Leptolyngbya* species from selected seep walls in the Great Smoky Mountains National Park. *Algological Studies* 126: 21-36.
- Keller, H.W., J.S. Ely, H.T. Lumbsch, and S.B. Selva. 2007. Great Smoky Mountains National Park's first lichen bio-quest. *Southeastern Naturalist* 6(Special Issue 1): 89-98.
- Lessard, J-P., R.R. Dunn, C.R. Parker, and N.J. Sanders. 2007. Rarity and diversity in forest ant assemblages of Great Smoky Mountains National Park. *Southeastern Naturalist* 6(Special Issue 1): 215-228.
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Budget Summary

FY07 Admin Report

Network: Great Smoky Mtns. Prototype

Category: 1_Income

Description	\$ Amount	\$\$ Source	Where \$ Went	Comments
From Friends for Water Quality	\$110,300.00	Other Partners		
From WASO, 1996, plus Park Base	\$789,200.00	Prototype \$\$ - Park Base		
ATBI Base	\$155,000.00	Prototype \$\$ - Park Base		
Subtotal	\$1,054,500.00			

Category: 2_Personnel

Description	\$ Amount	\$\$ Source	Where \$ Went	Comments
Aquatic Entomologist(Nichols)	\$92,799.10	Prototype \$\$ - Park Base	NPS	
Data/IT Specialist (Kunze)	\$97,536.17	Prototype \$\$ - Park Base	NPS	
Computer Operator/Office Mgr. (Powell)	\$44,049.40	Prototype \$\$ - Park Base	NPS	
I&M Coord. (Langdon)	\$106,957.48	Prototype \$\$ - Park Base	NPS	
Museum Curator (Mayor)	\$73,139.93	Prototype \$\$ - Park Base	NPS	
Wildlife Biologist(Stiver)	\$52,600.00	Prototype \$\$ - Park Base	NPS	
Forester (Taylor)	\$45,500.00	Prototype \$\$ - Park Base	NPS	
GIS Specialist (Zank)	\$13,074.28	Prototype \$\$ - Park Base	NPS	
Botanist (Rock)	\$92,613.67	Prototype \$\$ - Park Base	NPS	
Temp. Biotech	\$13,200.00	Prototype \$\$ - Park Base	NPS	
Other Salaries	\$26,146.37	Prototype \$\$ - Park Base	NPS	
Forest Ecologist (Jenkins)	\$96,501.60	Prototype \$\$ - Park Base	NPS	
Subtotal	\$754,118.00			

Category: 3_Coop. Agreements

Description	\$ Amount	\$\$ Source	Where \$ Went	Comments
Mod. to DLIA for ATBI	\$62,000.00	Prototype \$\$ - Park Base	Other non-Federal	ATBI
Peer-review of Structured Sampling Plan	\$36,900.00	Prototype \$\$ - Park Base	USGS	
Aquatic Invertebrate Sample Processing	\$14,382.00	Prototype \$\$ - Park Base	University-CESU	
Water Quality monitoring	\$110,300.00	Other Partners	Univ_Non-CESU	
Subtotal	\$223,582.00			

Category: 4_Contracts

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
Taxonomic Identifications of Bees	\$15,000.00	Prototype \$\$ - Park Base	Other non-Federal	
Subtotal	\$15,000.00			

Category: 5_Operations/Equipment

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
Equipment	\$22,500.00	Prototype \$\$ - Park Base	NPS	
Subtotal	\$22,500.00			

Category: 6_Travel

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
Attendance at Professional Meetings	\$1,200.00	Prototype \$\$ - Park Base	NPS	
Subtotal	\$1,200.00			

Category: 7_Other

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
Utilities	\$2,000.00	Prototype \$\$ - Park Base	NPS	
Field/Lab/Museum/Office Supplies	\$36,100.00	Prototype \$\$ - Park Base	NPS	
Subtotal	\$38,100.00			

Budget Analysis

Analysis of Expenses by Where \$ Went

<i>Funding Source</i>	<i>Total \$\$</i>	<i>NPS</i>	<i>USGS</i>	<i>Other Federal</i>	<i>Univ.-CESU</i>	<i>Univ_Non-CESU</i>	<i>Other non-Federal</i>
Other Partners	\$110,300					\$110,300	
Prototype \$\$ - Park Base	\$944,200	\$815,918	\$36,900		\$14,382		\$77,000
Totals	\$1,054,500	\$815,918	\$36,900		\$14,382	\$110,300	\$77,000

Analysis of Expenses by Category

<i>Funding Source</i>	<i>Total \$\$</i>	<i>Personnel:</i>	<i>Coop Agree.</i>	<i>Contracts</i>	<i>Operations/Equip.</i>	<i>Travel</i>	<i>Other</i>
Other Partners	\$110,300		\$110,300				
Prototype \$\$ - Park Base	\$944,200	\$754,118	\$113,282	\$15,000	\$22,500	\$1,200	\$38,100
Totals	\$1,054,500	\$754,118	\$223,582	\$15,000	\$22,500	\$1,200	\$38,100

Expense Totals By Category

<i>Category</i>	<i>SubTotal</i>	<i>Percent</i>
2_Personnel	\$754,118	71.51%
3_Coop. Agreements	\$223,582	21.20%
4_Contracts	\$15,000	1.42%
5_Operations/Equipment	\$22,500	2.13%
6_Travel	\$1,200	0.11%
7_Other	\$38,100	3.61%
	\$1,054,500	

Budget Summary

FY08 Work Plan

Network: Great Smoky Mtns. Prototype

Category: 1_Income

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
Water Quality Monitoring from Friend	\$110,300.00	Other Partners		
Park Base including Prototype Funding	\$789,000.00	Prototype \$\$ - Park Base		
ATBI Base	\$155,000.00	Prototype \$\$ - Park Base		
Subtotal	\$1,054,300.00			

Category: 2_Personnel

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
Combined personnel costs; est.	\$845,000.00	Prototype \$\$ - Park Base	NPS	
Subtotal	\$845,000.00			

Category: 3_Coop. Agreements

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
Cooperative, Interagency Agreements; est.	\$115,000.00	Prototype \$\$ - Park Base	Other Federal	
Subtotal	\$115,000.00			

Category: 5_Operations/Equipment

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
Laboratory equipment for new facilities; est.	\$39,300.00	Prototype \$\$ - Park Base	NPS	
Subtotal	\$39,300.00			

Category: 6_Travel

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
Travel to professional meetings; est.	\$5,000.00	Prototype \$\$ - Park Base	NPS	
Subtotal	\$5,000.00			

Category: 7_Other

<i>Description</i>	<i>\$ Amount</i>	<i>\$\$ Source</i>	<i>Where \$ Went</i>	<i>Comments</i>
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Combined field/lab/office materials; est.		\$50,000.00	Prototype \$\$ - Park Base	NPS
	Subtotal	<i>\$50,000.00</i>		

Budget Analysis

Analysis of Expenses by Where \$ Went

<i>Funding Source</i>	<i>Total \$\$</i>	<i>NPS</i>	<i>USGS</i>	<i>Other Federal</i>	<i>Univ.-CESU</i>	<i>Univ_Non-CESU</i>	<i>Other non-Federal</i>
Prototype \$\$ - Park Base	\$1,054,300	\$939,300		\$115,000			
Totals	\$1,054,300	\$939,300		\$115,000			

Analysis of Expenses by Category

<i>Funding Source</i>	<i>Total \$\$</i>	<i>Personnel:</i>	<i>Coop Agree.</i>	<i>Contracts</i>	<i>Operations/Equip.</i>	<i>Travel</i>	<i>Other</i>
Prototype \$\$ - Park Base	\$1,054,300	\$845,000	\$115,000		\$39,300	\$5,000	\$50,000
Totals	\$1,054,300	\$845,000	\$115,000		\$39,300	\$5,000	\$50,000

Expense Totals By Category

<i>Category</i>	<i>SubTotal</i>	<i>Percent</i>
2_Personnel	\$845,000	80.15%
3_Coop. Agreements	\$115,000	10.91%
5_Operations/Equipment	\$39,300	3.73%
6_Travel	\$5,000	0.47%
7_Other	\$50,000	4.74%
	\$1,054,300	