

Detailed Implementation Plan

**Identify and Assess Cliff Resources and Visitor Use,  
Develop and Implement Cliff Management Planning**

Natural Resource Preservation Program FY2005-2007

PMIS 92112

January 4, 2005 (budget table corrections 3/8/05)

Park Strategic Plan Goal # 1a

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## **ABSTRACT**

The cliff and outcrop areas of Shenandoah National Park (SHEN) are some of the largest in the region and contain myriad significant vegetation communities and rare plant and animal populations. Intense use of these areas by hiking, climbing and camping enthusiasts has led to severe degradation of vegetation and soils at some cliff sites, including impacts to rare species and communities. The Park must protect cliff resources while still providing opportunities for visitor enjoyment of those resources. This project will gather information on factors such as cliff location, resource composition and visitor use impacts necessary to make decisions about cliff management. Information will be gathered through resource and recreation use assessments that will be used to develop and implement a cliff management plan to mitigate current impacts and direct the future management of fragile cliff areas.

## **INTRODUCTION**

### **Problem Statement:**

Rare species and communities at cliff and outcrop areas throughout Shenandoah National Park (SHEN) have been severely degraded by essentially unmanaged and unregulated visitor use. The SHEN Mission Goals state that, "The integrity of this portion of the Blue Ridge/Central Appalachian **biome** is protected, maintained, and restored as appropriate", yet, "Recreation and recreation opportunities are provided consistent with the purposes and significance of the Park" (Shenandoah National Park 2003). Clearly, the Park's cliff resources are to be preserved while allowing for recreational opportunities.

The project goal is to obtain information to support development and implementation of a park-wide Cliff Management Plan. Visitor access, use, and associated impacts to park cliff areas are known to be unrestrained and significant, but the full extent of rare species associated with cliff areas and subject to recreation impacts remains unknown. This project will fund natural resource survey and classification work, identification of cliff area visitor use and impacts, and the development and implementation of a Cliff Management Plan. This information is critically needed to direct visitor recreation use to minimize impacts, mitigate resource degradation associated with visitor use, preserve valuable cliff resources, and restore damaged cliff and rock outcrop areas.

## Background:

Shenandoah National Park (SHEN) encompasses 70 miles of ridge crest along the Blue Ridge mountains of Virginia, straddling habitats of both the northern and southern Appalachians and supporting a rich assemblage of flora and fauna. Rock outcrops and cliffs punctuate the otherwise forested landscape composing approximately 2% (3920 acres) of the Park's 196,000+ acre area. The cliffs of SHEN are some of the largest in the region and serve as islands of unusual habitat and species assemblages. The relatively high elevation of many rock outcrop areas in the park means that these areas provide habitat for unique communities of boreal disjunct species. For example, the bearberry (*Arctostaphylos uva-ursi*) shrub is known from one outcrop area in the park, and is disjunct over 200 miles from its southern range limit. Previous Virginia Department of Conservation and Recreation (VADCR) survey work at a few of the park's larger rock outcrop and cliff communities has documented the occurrence of 28 rare species, including the federally endangered Shenandoah Salamander (*Plethodon shenandoah*) (Ludwig et al. 1993). VADCR staff have also identified a rare plant community type, the high elevation greenstone outcrop barren, believed to be endemic to the park (Fleming et al. 2004).

The survey work that has been accomplished in SHEN is far from complete. The park-wide vegetation map scheduled to be delivered in 2005 (PMIS #72250) will not have sufficient resolution to adequately locate and classify cliff and rock outcrop areas because of their small size and often linear shape. In addition, numerous outcrop and cliff areas within the park have never been visited by survey teams, and it is suspected that many more occurrences of rare botanical and zoological resources will be found if survey work is performed in these areas. Cliff and rock outcrop areas have been identified by the VADCR, Division of Natural Heritage, as some of the most important sites for immediate conservation action in the park (Smith 2002).

Cliff and rock outcrop areas of SHEN are very popular visitor destinations for hiking, rock climbing, camping and vista enjoyment. The location of the world-famous park tour road, Skyline Drive, along the ridgeline provides exceptional access to many outcrops and cliffs throughout the park for a large number of the park's 1.7 million annual visitors. Visitation at one of the park's most accessible peaks averaged 980 people per week during the summer and fall of 2002 (Hilke 2002). This visitation occurred exclusively within an identified rare plant community. No visitation data is available for the park's most popular hike/climbing destination, Old Rag Mountain, a granitic peak rich in rare species, that is served by a 250-car parking area often filled to capacity on weekends. The popularity of the park for rock climbing and bouldering appears to have increased within the last 10 years, but that recreation use is neither monitored nor actively managed by the Park. One popular climbing guide (Watson 1998) identifies 27 separate rock climbing areas within the Park, each area described in detail with numerous climbing routes. The Park has no climbing guidelines or registration procedures, yet is a popular area for recreational climbing by park visitors, and is regularly used by nearby universities and outdoor organizations for climbing classes and activities.

Intense visitor use of cliff areas has led to widespread impacts such as soil compaction, erosion, vegetation damage and loss, informal social trail development and proliferation, illegal or poorly located campsites, and human waste disposal issues. The vegetation communities that thrive on cliffs and rock outcrops are very susceptible to human impacts from hiking and climbing activities because they support large areas of dense and delicate foliose lichen growth, and mats of vegetation growing on very thin soil or in rock crevices. Lichens take many years to grow back once destroyed, and damaged vegetation recovers very slowly because the soil needed for growth is quickly eroded by high winds. VADCR, Department of Natural Heritage, botanists have noted severe degradation of outcrop plant communities within the park over the last twenty years (Fleming 2001), but the change in conditions is not well documented. Outcrop and cliff areas that were once pristine have been virtually denuded of lichen and vegetation cover. Known rare plant populations have exhibited marked decreases in size and vigor, and campsite and social trail proliferation are occurring in one area occupied by the federally endangered Shenandoah Salamander. Old Rag Mountain had a pristine example of the high elevation acidic heath barren community on one of the mountain's two main summits. Within the last ten years the area has become increasingly popular with visitors, and is now

readily accessible by large social trails, has severe trampling damage to vegetation, and is starting to show loss of lichen cover and substantial soil erosion (Fleming 2001).

Despite the clear ecological value and imminent threats to the natural resources at cliff areas within SHEN, the park lacks sufficient information on the locations, geological and biological characteristics, and full extent of human uses and impacts to these areas. If the Park simply restricts recreation activities in areas that we currently know are being impacted, surely those activities will relocate to other areas that may be even more sensitive. The park-wide planning process funded by this project incorporates public involvement and science-based comprehensive survey and assessment work. This process will guide future management actions so that they are both adequate to protect park resources and acceptable to park user groups.

## **SPECIFIC TASKS TO BE ADDRESSED**

Year one (FY1) of the project is devoted to gathering information on the location, composition, and recreation uses of cliff resources through the implementation of four **cooperator** contracts. Year two (FY2) focuses on the completion of cooperator projects, outreach efforts, and synthesis of information into a Cliff Management Plan. Year three (FY3) includes **finalization** of the Cliff Management Plan and the completion of the NEPA and public review process, coupled with continued outreach and plan implementation activities. Specific project tasks are as follows:

- TASK 1. Identify and map locations of cliff resources through aerial photo interpretation and analysis of satellite imagery.
- TASK 2. Conduct surveys of cliff sites park-wide to assess the type and location of Botanical and Zoological resources.
- TASK 3. Classify outcrop communities based on vegetation type and assess threats to the communities.
- TASK 4. Classify geologic composition and condition of cliff resources.
- TASK 5. Conduct a recreational use survey to assess the type and extent of recreational activities and associated visitor impacts on all identified cliff sites.
- TASK 6. Develop and conduct a social science survey of day and overnight visitors at cliff sites.
- TASK 7. Create a Cliff Management Plan incorporating information from resource and visitor use/impact studies and relevant evaluative information developed by the project to address SHEN cliff management concerns.
- TASK 8. Initiate management activities to mitigate visitor use issues, and protect and restore natural resource conditions.

## Environmental Planning

Because the initial portions of the project will be limited to non-destructive data collection, surveying, mapping, study and research, a Categorical Exclusion will apply to this project (NPS-12, 3.4 E. (6)). The project will be evaluated using the process at NPS-12, 3.2, to address the potential for environmental impacts of the project. At the conclusion of that evaluation, appropriate compliance documentation will be obtained. Prior to initiating the project, **cooperators** contracted to perform resource and visitor use assessments will comply with the "NPS Guidelines for Researchers Study Proposals" and obtain a research and collecting permit.

As a Cliff Management Plan is developed in FY2-FY3, the document will be required to undergo NEPA analysis, which is anticipated to lead to an Environmental Assessment.

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## BUDGET OVERVIEW

|                        | NRPP-NRM FUNDS |           |          | IN-KIND SUPPORT |           |           | SUBTOTAL  |           |           | TOTAL     |
|------------------------|----------------|-----------|----------|-----------------|-----------|-----------|-----------|-----------|-----------|-----------|
|                        | YR1            | YR2       | YR3      | YR1             | YR2       | YR3       | YR1       | YR2       | YR3       | ALL YEARS |
| Personnel Services     | \$254,786      | \$50,455  | \$22,259 | \$142,836       | \$117,813 | \$115,628 | \$397,622 | \$168,268 | \$137,887 | \$703,777 |
| Transportation         | -              | -         | -        | -               | -         | -         | -         | -         | -         | -         |
| Travel                 | \$19,430       | \$6,230   | \$1,970  | -               | -         | -         | \$19,430  | \$6,230   | \$1,970   | \$27,630  |
| Vehicle Rental         | -              | \$3,920   | \$3,920  | -               | -         | -         | -         | \$3,920   | \$3,920   | \$7,840   |
| Supplies               | \$7,490        | \$3,490   | \$3440   | \$3,490         | -         | -         | \$10,510  | \$3,490   | \$3,440   | \$17,440  |
| Equipment              | \$10,043       | \$2,440   | \$2,450  | \$22,510        | -         | -         | \$32,553  | \$2,440   | \$2,450   | \$37,443  |
| Other Services         | \$8,020        | \$43,300  | \$19,600 | -               | -         | -         | \$8,020   | \$43,300  | \$19,600  | \$70,920  |
| Printing               | \$3,000        | \$1,470   | \$2,940  | -               | -         | -         | \$3,000   | \$1,470   | \$2,940   | \$7,410   |
| Overhead               | \$33,714       | \$3,493   | \$1,397  | -               | -         | -         | \$33,714  | \$3,493   | \$1,397   | \$38,604  |
| Other                  | -              | \$490     | \$490    | -               | -         | -         | -         | \$490     | \$490     | \$980     |
| Subtotal               | \$336,483      | \$115,248 | \$58,466 | \$168,836       | \$117,813 | \$115,628 | \$504,849 | \$233,101 | \$174,094 | \$912,044 |
| Total                  | \$510,197      |           |          | \$402,278       |           |           | \$912,044 |           |           |           |
| 2% Regional Assessment | \$6,867        | \$2,352   | \$1,194  |                 |           |           |           |           |           |           |
| Authorized funding     | \$343,350      | \$117,600 | \$59,660 |                 |           |           |           |           |           |           |
| PROJECT TOTAL          | \$520,610      |           |          |                 |           |           |           |           |           |           |

## METHODOLOGY AND BUDGET DETAILS BY TASK

### **Task 1. Identify and map locations of cliff resources through aerial photo interpretation and analysis of satellite imagery.**

#### Approach and Methods:

Rock outcrops will be mapped by the USGS, Leetown Science Center (USGS-LSC) using remote sensing, aerial image interpretation, and GIS modeling. This mapping effort will build on vegetation mapping projects currently being finalized at USGS-LSC and will exploit data sources previously compiled for Shenandoah National Park. The mapping effort will primarily involve interpretation of existing aerial and satellite imagery augmented by GIS analysis of slope conditions using a digital elevation model. Since the target of interest is simply the presence of exposed rock (both in the open and under forest canopy), this mapping effort will be much simpler than distinguishing spectral properties of vegetation.

The primary data source will be interpretation of leaf-off color infrared **orthophotography** at 1:12,000 scale (USGS). This imagery has been corrected for systematic and terrain induced errors, and is delivered as quadrangles covering one-quarter of a standard USGS 7.5' quadrangle (e.g. 3.75' coverage). Approximately 51 quadrangles will be analyzed, covering the entire park. Minimum pixel resolution for this data is 1 meter.

Rock outcrop and slide areas will be identified from imagery using semi-automated techniques. We will identify representative outcrop areas on imagery using visual inspection guided by previous field surveys and GPS locations. Boundaries of representative rock outcrops will be generated using automated "region-growing" algorithms that delineate boundaries on the basis of spectral similarity to a "seed pixel" manually identified by the image interpreter (Erdas Imagine, Leica Geosystems, Inc.). Outcrops identified in this manner will be stored to an ArcGIS (ESRI, Inc.) **shapefile** to be used as training areas for further processing. Training areas will be input to eCognition (Definiens Imaging Inc.) and/or Feature Analyst (Visual Learning Systems, Inc.) image segmentation software to classify image objects identified by segmenting imagery into polygons on the basis of spectral properties. Three basic classes of outcrops will be identified: 1) exposed outcrops, 2) forested outcrops, and 3) **talus/unconsolidated** rock slides. We estimate that the minimum mapping unit will be 0.0025 ha (25 m<sup>2</sup>).

Digital elevation models at a scale of 1:24,000 will be used to map steep slopes to assist in image interpretation. A seamless mosaic of 7.5' quadrangles covering the park is available from previous projects. The minimum pixel resolution of this data is 10 meters. A map of slope steepness will be calculated using ArcGIS and grouped into classes of 0-2%, 2-5%, 5-10%, 10-15%, and greater than 15% slope. Steep slope class polygons will be used as a guide for image interpretation of rock outcrops.

Additional **multi-** and hyper-spectral imagery will be used as a secondary source for cross validating outcrop interpretations. Typically, aerial imagery is captured using 2 visible and 1 near infrared wavelength bands (red, green, and near infrared) allowing for discrimination of vegetated and non-vegetated areas. Multispectral imagery such as Landsat has broadly defined wavelength bands that capture visible and near infrared surface reflectances in 7 wavelength band images. Hyperspectral imagery captures surface reflectances over hundreds of finely tuned wavelength bands (220 in the case of the AVIRIS sensor). While the pixel size of this satellite imagery is too coarse to adequately detect small rock outcrops (30m and 15m pixels for Landsat and AVIRIS respectively), the high *spectral* resolution of these sensors may allow for discrimination of surface materials in a manner that is not possible using traditional aerial photography. We will assess mapped rock outcrops against our satellite image archives to determine if discrimination of rock material is possible using satellite spectral data. This cross correlation of mapped rock outcrops

against spectral information from satellite imagery may help to determine the accuracy of mapped outcrops as well as to add additional information on parent geologic material.

Mapped rock outcrop polygons will be tagged with attributes of area, perimeter, slope, aspect, and probable parent geologic material using GIS overlays. All mapping will be completed in UTM, zone 17 projection using the NAD83 datum.

## TASK 1 TOTAL BUDGET TABLE

### TASK 1 USGS SUBCOMPONENT BUDGET TABLE

| TOTAL BUDGET / USGS-BRD | NRPP-NRM FUNDS  | IN-KIND SUPPORT | TOTAL           |
|-------------------------|-----------------|-----------------|-----------------|
|                         | YR1             | YR1             | ALL YEARS       |
| Personnel Services      | \$19,017        | -               | \$19,017        |
| Transportation          | -               | -               | -               |
| Travel                  | \$500           | -               | \$500           |
| Vehicle Rental          | -               | -               | -               |
| Supplies                | \$2,000         | \$3,490         | \$5,490         |
| Equipment               | \$7,000         | \$22,510        | \$29,510        |
| Other Services          | -               | -               | -               |
| Printing                | -               | -               | -               |
| Overhead (DOI, 15%)     | \$5,048         | -               | \$5,048         |
| Other                   | -               | -               | -               |
| <b>TOTAL</b>            | <b>\$33,565</b> | <b>\$26,000</b> | <b>\$59,565</b> |

### **Task 2. Conduct surveys of cliff sites park-wide to assess the type and location of Botanical and Zoological resources.**

#### **Approach and Methods:**

##### **Sub-task A. Determine survey locations and target significant biological resources**

To initiate this task, biologists from DCR-DNH will gather relevant biological information on Park outcrop sites from literature, museum specimens, NPS data bases, and past work including Ludwig *et al.* 1993. This information will be used to develop a comprehensive understanding of the outcrop communities of the Park and target lists of known and potential significant biological resources (including rare, threatened, and endangered species - see Roble, 2003 and Townsend, 2004 and significant vegetation communities - see Fleming *et al.* 2004) within and adjacent to the outcrops. Concurrently, biologists will work with USGS staff conducting Task 1 to determine the location of survey sites within the Park. Based on preliminary information, the number of sites targeted for survey is expected to be around 50. Target biological resources are expected to include at least 30 rare species and numerous community types. A species population's viability is qualitatively ranked on site

using population/occurrence viability criteria developed by **NatureServe** through its member Natural Heritage organizations. The viability is ranked A through D using these criteria.

**Note:** Specifications for most species are currently under **development**, though a few can now be found on line. See: NatureServe. 2004. NatureServe Explorer: An online encyclopedia of life [web application]. Version 4.1. NatureServe, Arlington, Virginia. Available <http://www.natureserve.org/explorer>. Biodiversity ranks (**B-ranks**) will be assigned according to the standardized VA NHP **B-rank** table available on request.

### **Sub-task B. Conduct field inventories.**

Following the development of target lists and survey sites, DCR-DNH botanists, zoologists, ecologists, and stewardship biologists will visit each of the survey sites. They will conduct extensive biological surveys to determine the status of significant biological resources and collect data on vegetation and threats needed to complete task #3. Inventory for targeted species may require repeated visits to many sites and potential habitats at different seasons. Contract limitations prohibit exhaustive surveys for each targeted animal, however, and priorities will be set based on available habitat, and the significance of the biological resource. By discipline, the following field methods will be employed:

**Botanical inventory:** All sites will be visited by botanists to determine the presence and status of rare plant species. The botanical investigation will be conducted on foot and, as with all field work for this task, biologists will work in pairs. Field data will be recorded when rare plants are found including a GPS polygon of the species' location, approximate number of individuals and/or population area and concentration, reproductive and phenological status, and species viability. Habitat factors such as moisture, light, and associated species, as well as any apparent immediate or long-term threats to the rare species population will also be noted.

**Zoological inventory:** All sites will be visited by zoologists to determine the presence and status of rare animal species. Biologists will employ a full complement of inventory and sampling methods including, but not limited to, the following:

**Bird surveys:** Surveys for avifauna will include visual survey techniques and listening for target bird species in suitable habitats during appropriate seasons.

**Hand collection and visual surveys** - Reptiles, amphibians, and some invertebrates, will be collected by hand from terrestrial habitats, where various cover objects are overturned in search of cryptic species.

**Leaf-litter sampling** - leaf-litter samples maybe collected and placed in a Berlese funnel (white light set over a funnel emptying into a jar with alcohol as the killing agent) for small invertebrate sampling.

**Sweep nets** - Lepidopterans, odonates, tiger beetles, and other flying invertebrates will be sampled in terrestrial habitats using sweep nets.

**Sugaring** - Some nocturnal insects that are not attracted to **UV-light** come to bait. The bait is a mixture of fermented beer, fruit, and sugar, which is applied to tree trunks and other structures. The moths will be hand-collected with a kill-jar and **non-lepidopterans** will be taken in alcohol.

**UV-Light Traps** - Nocturnal lepidopterans and other invertebrates will be captured using standard bucket traps equipped with a blacklight (= ultraviolet) powered by a 12-volt gel-cell battery. Ethyl acetate will be used as a killing agent. Traps will be run overnight in a variety of habitats. As an alternative, a UV-light may be used with a white sheet and the moths will be taken in a kill-jar and non-lepidopterans in alcohol.

**Note:** It is unlikely that any rare small mammals will be identified, though there may be an outside chance for the southern rock vole (*Microtus chrotorrhinus carolinensis*). If this is the case, we will be trapping using Sherman live traps.

As with botanical work, during the zoological investigation, field data will be recorded when rare animals are found. This data will include a GPS polygon of the species' location, approximate number of individuals and/or population area and concentration if available, reproductive status when it can be determined, and an estimate on species viability. Habitat factors such as moisture, light, and associated species, as well as any apparent immediate or long-term threats to the rare species population will also be noted.

**Ecological inventory:** Vegetation at selected sites will be assessed during field visits and subjectively assigned to existing U.S. National Vegetation Classification (USNVC) associations if possible. Plot data may be collected from new, uncertain, or poorly documented vegetation types, in order to ensure that vegetation at each site is properly classified and that significant communities are documented.

Plots will be sampled using the *relevé* method (sensu Peet *et al.* 1998), following standard procedures employed by DCR-DNH. As a rule, 100 m<sup>2</sup> plots with 10 x 10 m, 8 X 12.5 m, or 5 X 20 m configurations will be used to sample shrubland or herbaceous vegetation on rock outcrops. 400 m<sup>2</sup> plots will be used for woodland vegetation. Plots may be visited more than once to collect floristic data at different seasons, if appropriate.

To the extent possible, plots will be placed in homogeneous stands of vegetation. Every vascular plant taxon present will be recorded and its cover, defined as the percentage of the ground covered by the vertical projection of above-ground plant parts, will be visually estimated over the full plot area. Cover will be assigned using a nine-point scale of cover classes (Table 1).

The overall cover of mosses, lichens, and liverworts will be estimated, but the individual covers of non-vascular taxa will not be estimated. Vascular plants characteristic of the stand, but located outside the plot, will be recorded parenthetically if visible from the boundary, and assigned a cover class score of "1." The total vegetative cover in each stratum will also be estimated using the same nine-point scale of cover classes. Table 1. Cover class scores used in field sampling and data analysis are as follows:

| Cover Class: | Percent Cover Range: | Area of Coverage:                        | Cover Class Midpoint (%): |
|--------------|----------------------|------------------------------------------|---------------------------|
| (P)          | present outside plot | -                                        | 0.05                      |
| 1            | < 0.1%               | < 20 cm <sup>2</sup>                     | 0.05                      |
| 2            | 0.1% to 1%           | 20 cm <sup>2</sup> to 4 m <sup>2</sup>   | 0.55                      |
| 3            | 1 to 2%              | 4 m <sup>2</sup> to 8 m <sup>2</sup>     | 1.50                      |
| 4            | 2 to 5%              | 8 m <sup>2</sup> to 20 m <sup>2</sup>    | 3.50                      |
| 5            | 5 to 10%             | 20 m <sup>2</sup> to 40 m <sup>2</sup>   | 7.50                      |
| 6            | 10 to 25%            | 40 m <sup>2</sup> to 100 m <sup>2</sup>  | 17.50                     |
| 7            | 25 to 50%            | 100 m <sup>2</sup> to 200 m <sup>2</sup> | 37.50                     |
| 8            | 50 to 75%            | 200 m <sup>2</sup> to 300 m <sup>2</sup> | 62.50                     |
| 9            | 75 to 100%           | 300 m <sup>2</sup> to 400 m <sup>2</sup> | 87.50                     |

In addition to recording presence and cover for all species, stand structure will be quantified by measuring the size distribution and vertical stratification of woody plants. The diameter at breast height (1.4 m dbh) of each woody stem (trees, shrubs, lianas)  $\geq 2.5$  cm dbh and  $< 40$  cm dbh will be measured by size class. Classes used are 2.5-5, **5-10**, **10-15**, **15-20**, 20-25, 25-30, 30-35, and 35-40 cm. Stems  $\geq 40$  cm dbh will be measured to the nearest 1 cm (0.4 in). Moreover, the maximum canopy height will be measured using a clinometer and the cover of each woody species estimated (if present) at each of six height strata:

- a herb layer,  $< 0.5$  m
- a shrub layer, 0.5 to 6 m
- a tree layer, 6 to 10m
- a tree layer, **10 to 20 m**
- a tree layer, 20 to 35 m
- a tree layer,  $> 35$  m

A standard set of environmental data will be measured or estimated at each plot (Table 2). Slope inclination and aspect will be measured to the nearest degree from plot center. In plots with variable microtopography, slope will be measured at several points and averaged. Elevation will be determined to the nearest 10 ft ( $\sim 3$  m) using a topographic map or altimeter. The percent cover of different surface substrates will be estimated visually, with precision varying such that values sum to 100%. Topographic position, slope shape (both horizontally and vertically), soil drainage class, soil moisture regime, and inundation will be assessed using scalar values. Bedrock geology will be determined to the greatest precision possible by using existing geological maps, while the characteristics of surface rocks present in a plot will be recorded in the field.

Soil samples will be collected from the top 10 cm (4 in) of mineral soil (below the **surficial** litter and humus), if possible. Based on previous experience, it is not always possible to collect mineral soil samples from rock outcrop environments in the Park. Depth of surface duff, depth of mineral soil, soil color, and texture will be evaluated in the field and recorded on the plot forms. Soil samples will be oven-dried, sieved (2mm), and analyzed for pH, phosphorus (P), soluble sulfur (S), exchangeable cations (calcium [Ca], magnesium [Mg], potassium [K], and sodium [Na] in ppm), **extractable** micronutrients (boron [B], iron [Fe], manganese [Mn], copper [Cu], zinc [Zn], and aluminum [Al], in ppm), total exchange capacity (CEC; **m.e.q./100g**), total base saturation (**%TBS**), and percent organic matter (**%OM**). A soil scientist will not be part of the field inventory crew. Soil samples will be analyzed off-site. Chemical and textural analyses will be conducted by Brookside Laboratories, Inc. New Knoxville, Ohio. Extractions will be carried out using the Mehlich III method (Mehlich 1984) and percent organic matter determined by loss on ignition.

Evidence of any past or ongoing vegetation disturbance will be carefully recorded at each sampling site.

Standard metadata, or information regarding the implementation of the sampling protocol, will be recorded at each plot. These include plot numbers, date(s) of sampling, participants, geopolitical locality (county/city), survey site name, USGS quadrangle, plot size and configuration, photographic documentation, and a written description of the plot location. Plots will be assigned unique alphanumeric codes. A global positioning system (GPS) unit will be routinely used to record **locational** data with greater precision. The UTM (Universal Trans Mercator) coordinates of each plot location will be determined to 10 m ( $\sim 33$  ft) precision using ArcView GIS (Version 3.2; ESRI 1999), and all plot locations will be mapped as precisely as possible on USGS 7.5' quadrangle maps.

Table 2. Topographic / hydrologic environmental indices recorded at each plot-sampling site.

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><b>Topographic position:</b><br/> A - plain / level<br/> <b>B – toe</b><br/> C - lower slope<br/> D - middle slope<br/> E - upper slope<br/> F - escarpment / face<br/> G - ledge / terrace<br/> H - crest<br/> I - basin / depression<br/> <b>J - floodplain</b><br/> K - stream bottom</p> <p><b>Surface Substrate: % cover</b><br/> decaying wood<br/> bedrock<br/> boulders (&gt; 60 cm diam.)<br/> stones (&gt; 25 cm diam.)<br/> cobbles (8-25 cm rounded)<br/> <b>channery</b> (8-25 cm flattened)<br/> gravel<br/> mineral soil<br/> organic matter<br/> water<br/> other</p> <p><b>Measured Slope (degrees)</b></p> <p><b>Slope shape</b><br/> Vertical<br/> C - concave<br/> X - convex<br/> S - straight<br/> Horizontal<br/> C - concave<br/> X - convex<br/> S - straight<br/> H - hummock and hollow microtopography<br/> I - irregular <b>craggy/bouldery</b> microtopography</p> <p><b>Measured Aspect</b><br/> _____degrees<br/> F (flat)<br/> V (variable)</p> | <p><b>Soil Drainage Class:</b><br/> A - very poorly drained<br/> B - poorly drained<br/> C - somewhat poorly drained<br/> D - moderately well drained<br/> E - well drained<br/> F - rapidly drained</p> <p><b>Inundation:</b><br/> A - never<br/> B - infrequently<br/> C - regularly, for &lt; 6 mos.<br/> D - regularly, for &gt; 6 mos.<br/> E - always submerged by shallow water (&lt; 30 cm)<br/> F - always submerged by deep water (&gt; 30 cm)</p> <p><b>Soil Moisture Regime:</b><br/> A - very xeric (moist for negligible time after precipitation)<br/> B - xeric (moist for brief time)<br/> C - somewhat xeric (moist for short time)<br/> D - submesic (moist for moderately short time)<br/> E - <b>mesic</b> (moist for significant time)<br/> F - subhygric (wet for significant part of growing season; mottles at &lt; 20 cm)<br/> G - hygric (wet for most of growing season; permanent seepage / mottling)<br/> H - subhydric (water table at or near surface for most of the year)<br/> I - hydric (water table at or above surface year round)</p> <p><b>Hydrologic Regime:</b><br/> Terrestrial (<i>i.e.</i>, not a wetland)<br/> Non-Tidal<br/> A - Permanently flooded<br/> B - Semipermanently flooded<br/> C - Seasonally flooded<br/> D - Intermittently flooded<br/> E - Temporarily flooded<br/> F - Saturated</p> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

**Stewardship inventory:** All sites will be visited on foot by stewardship biologists to determine impacts to the biological resources by various threats including overuse by Park visitors and impacts from invasive species. **Indicators** of soil disturbance or loss will be recorded by our stewardship staff when we visit the outcrops. Each threat at each site will be documented with GPS locations of the disturbance and observations as to the nature and severity of the threat to the site.

**Task 3. Classify outcrop communities based on vegetation type and assess threats to the communities.**

**Approach and Methods:**

**Sub-task A. Identify and deposit plant and animal specimens**

When required, plant and animal specimens will be collected during field studies. Plants will be pressed and dried. All invertebrate specimens collected during the study will be preserved using standard methods (Martin 1977).

Identification of specimens will be conducted by staff at DCR-DNH concurrent with field work. Plant specimens will be retained in the reference collection of DCR-DNH. Pending discussions with the National Park Service regarding the disposition of collected material, most of the animal specimens may be deposited in the Virginia Museum of Natural History; some specimens may be deposited in the National Museum of Natural History and the reference collection (primarily Lepidoptera and Odonata) of DCR-DNH.

**Sub-task B. Classify outcrop communities**

The community classification will build on a broad classification and map of Shenandoah National Park vegetation under development by the USGS and DCR-DNH and due for completion in 2005. Plot data collected during field work will be combined with existing plot data and analyzed using the following method:

**Data Preparation and Transformation:** Stem diameter measurements will be used to compute density (stems/ha) and basal area ( $m^2/ha$ ) for all woody plants at each sampling site.

Prior to analysis, most environmental variables will also be transformed, either to normalize frequency distributions or to assign numeric values to categorical variables. Topographic position, slope shape in vertical and horizontal directions, and soil moisture regime will be converted to ordinal variables (Table 3). Aspect will be transformed using the cosine method of Beers *et al.* (1966), using the formula  $A' = \cos(45^\circ - A) + 1$ , where  $A'$  = transformed aspect and  $A$  = aspect in degrees. This transformation standardizes aspect to a linear variable from 0 (225°; SW, dry, solar-exposed) to 2 (45°; NE, moist, sheltered), reflecting a purported gradient in topographic moisture and solar exposure. Substrate values will be converted to decimals and arcsine transformed to normalize their distributions. Values for all soil variables with non-normal distributions will be natural log to normalize their distributions and make the values more biologically interpretable (Palmer 1993).

Table 3. Ordinal variables used in analysis for scalar topographic and soil moisture variables estimated in the field.

|                                                              |                          |
|--------------------------------------------------------------|--------------------------|
| Topographic Position                                         | Soil Moisture Regime     |
| I - basin/depression = -1                                    | A - very xeric = 1       |
| A, J, K - plain/level, <b>floodplain</b> , stream bottom = 0 | B - xeric = 2            |
| B - toe = 1                                                  | C - somewhat xeric = 3   |
| C - lower slope = 2                                          | D - submesic = 4         |
| D, G = middle slope, ledge/terrace = 3                       | E - <b>mesic</b> = 5     |
| E, F = upper slope, <b>escarpment/face</b> = 4               | F - <b>subhygric</b> = 6 |
| H = crest = 5                                                | G - hygric = 7           |
|                                                              | H - subhydric = 8        |
|                                                              | I - hydric = 9           |
| Slope Shape - Vertical and Horizontal                        |                          |
| C - concave = -1                                             |                          |
| X - convex = +1                                              |                          |
| S - straight - 0                                             |                          |

Horizontal and vertical slope shape will be also converted to a single ordinal variable (scale = 0 to 10) using a modification of Parker (1982):

| VERT.<br><u>PROFILE</u> | HORIZ.<br><u>PROFILE</u> | SLOPE SHAPE<br><u>SCALAR</u> |
|-------------------------|--------------------------|------------------------------|
| concave                 | concave                  | 10                           |
| concave                 | straight                 | 9                            |
| straight                | concave                  | 7                            |
| straight                | straight                 | 5                            |
| straight                | convex                   | 3                            |
| convex                  | straight                 | 2                            |
| convex                  | convex                   | 0                            |

A synthetic Topographic Relative Moisture Index (TRMI) will be calculated for each plot using a procedure modified from Parker (1982). Parker (1982) is a synthetic variable for assessing crude site moisture potential based on a combination of topographic position, slope inclination, slope shape, and aspect. It does not figure any soil properties into the equation. TRMI is a scalar ranging from 0 (lowest moisture potential) to 60 (highest moisture potential) and combining four topographic variables that potentially influence water runoff, evapotranspiration, and soil moisture retention:

- a Slope inclination (10-point scale; per Parker [1982])
- Slope shape (10-point scale; as above)
- a Aspect (20-point scale) = Beers-transformed aspect x 10
- a Topographic position (20-point scale) = 1-relative slope position x 20

Cluster Analysis : Hierarchical, agglomerative cluster analysis, implemented in the software program PC-ORD (version 4.17; McCune and Mefford 1999), will be employed to generate a classification from sampled plots, which will be combined in a larger dataset with rock outcrop plots previously sampled in Shenandoah National Park and elsewhere in Virginia. The Lance-Williams Flexible-Beta linkage method (Lance and Williams 1966, 1967) will be used in conjunction with the Bray-Curtis coefficient of community (Bray and Curtis 1957) to identify compositionally similar groups. The Lance-Williams method is a generalized sorting strategy, the performance of which varies with user-specified emphasis (beta) on different measures of between-group distance. In general, beta settings ranging from the default -0.25 to -0.5 produce optimal results with vegetation data, performing very similarly to minimum-variance clustering, *i.e.*, Ward's method (Ward 1963). The Bray-Curtis coefficient, also known as the Czekanowski or Sorenson coefficient, has been used with demonstrable success in a wide range of ecological studies (Beals 1984). Among available measures of ecological "distance,"

represented as a mathematical dissimilarity between samples, the Bray-Curtis **coefficient** is a balanced measure that places some emphasis on dominant (*i.e.*, high-cover) species while still giving minor (*i.e.*, low-cover) species considerable weight in the analysis (Gauch 1982).

This work complements the comprehensive classification and descriptive work already done for rock outcrops in the Park during the vegetation mapping project (now **nearing** completion) and other studies by VANHP. Based on extensive inventory and data from 69 plot samples, 9 association-level community types were fully described from these habitats in SHEN and incorporated into the U.S. National Vegetation Classification. Plot-sampling in this project will be done only for "new, uncertain, or poorly documented" vegetation types. Data from any new plots will be combined with the existing SHEN plots for re-analysis. The classification can easily be scaled up to the Ecological Systems level, which will have very limited utility at the management level. More useful information about community complexes will be provided in the site descriptions.

**Compositional Summary Statistics :** Compositional statistics will be calculated to evaluate the adequacy of groups recognized in cluster analysis and ultimately to assist in naming and describing the community types. Initially, total mean cover and total frequency across all plots will be determined for every taxon. Cover class scores will then be converted to the midpoints of their respective percent ranges, the midpoints will be averaged, and resulting values back-transformed to cover class scores. For each taxon in each group under consideration, the following summary statistics will then be calculated:

- ❑ **Frequency**
- ❑ **Mean Cover**
- **Relative Cover**
- **Constancy**
- **Fidelity**
- a **Indicator Value (IV)** (= Constancy x Fidelity / 100).
- **Indicator Value Adjusted by Cover, Scaled** (Scaled Adj IV) (= Indicator Value x Mean Cover / 9). By dividing IV by 9, the maximum possible cover value, this statistic synthesizes information about frequency, diagnostic value, and mean abundance.
- a **Indicator Value Adjusted by Cover, Unsealed** (Unsealed Adj IV) (= Indicator Value x  $2^{\text{relative cover}}$ ). An alternative, unsealed synthetic measure of adjusted IV, using relative cover as the modifier of IV. Since cover classes form a logarithmic, rather than linear scale of values, Unsealed Adjusted IV is a statistically more legitimate means of incorporating information on cover, and has the advantage of not favoring only dominant species and better identifying species that are considerably more abundant within a given type than in the data set as a whole.

Additionally, the following statistics will be generated for each group:

- **Mean Species Richness** - the average number of species present per plot (**S**); only species rooted inside plot boundaries are included in this calculation.
- a **Homoteneity** - the mean constancy of the **S** most constant species, expressed as a fraction. This value (*sensu* Curtis 1959) can be considered the constancy of the average species in a community type; higher values for homoteneity indicate greater uniformity in species composition among plots. Although homoteneity is not independent of group size, often increasing as the number of group members decreases, it can be used to evaluate whether community types have been defined at an appropriate level.

**Environmental Summary Statistics :** Mean values for continuous and ordinal environmental variables will be calculated for each group to aid in describing the units and identifying the differences between them. These calculations will be performed with raw (untransformed) values, which will be averaged across all plots representing a given group. Mean aspect will be calculated as the average position along an arc defined by the range of aspect values.

Ordination : The ordination method non-metric multidimensional scaling (NMDS; Kruskal 1964) will be used to validate the classification, detect compositional variation and trends that are obscured in cluster analysis, and aid in identifying the environmental gradients along which vegetation classes and community types are distributed. NMDS is a type of indirect gradient analysis that assigns samples to coordinates in ordination space in a way that maximizes, to the extent possible, the rank-order (*i.e.*, non-parametric) correlation between inter-sample distance in ordination space and inter-sample dissimilarity (*i.e.*, ecological distance; Minchin 1987). Pearson correlations between environmental variables and sample coordinates on each axis will be calculated, and significant correlations will be displayed through joint plot overlays.

**Sub-task C. Complete heritage field forms and enter data into the Biotics data system of DCR-DNH**

During field work, all information on the sites and the significant biological resources will be documented using standard Natural Heritage field forms and methodology. These data will then be incorporated into the DCR-DNH Biotics data system. This system serves as the central repository for collected data and will be used to produce summary information, tables, and maps for use in the report produced in task D. The DCR-DNH Biotics data will be made available to The Nature Conservancy when/if they revise their Ecoregional portfolio.

**Sub-task D. Produce report summarizing the status and threats to the significant biological resources and rock outcrop sites**

In late 2006, a report summarizing the classification of the outcrop communities as well as the status and threats to the communities and significant biological resources will be completed. This report will include a report on each outcrop site, its vegetation, its significant biological resources, and threats to the significant resources. The site reports detailing the biological resources and threats will be similar in form to those found in Ludwig et al. 1993, but they will be more detailed.

## TASKS 2 AND 3 TOTAL BUDGET TABLE

| TASK 2/3<br>TOTAL<br>BUDGET | NRPP-NRM FUNDS |          |     | IN-KIND SUPPORT |          |     | SUBTOTAL  |          |     | TOTAL        |
|-----------------------------|----------------|----------|-----|-----------------|----------|-----|-----------|----------|-----|--------------|
|                             | YR1            | YR2      | YR3 | YR1             | YR2      | YR3 | YR1       | YR2      | YR3 | ALL<br>YEARS |
| Personnel Services          | \$195,831      | \$33,207 | -   | \$89,938        | \$41,852 | -   | \$285,769 | \$75,059 | -   | \$360,828    |
| Transportation              | -              | -        | -   | -               | -        | -   | -         | -        | -   | -            |
| Travel                      | \$5,945        | \$2,000  | -   | -               | -        | -   | \$5,945   | \$2,000  | -   | \$7,945      |
| Vehicle Rental              | -              | -        | -   | -               | -        | -   | -         | -        | -   | -            |
| Supplies                    | \$1,000        | \$500    | -   | -               | -        | -   | \$1,000   | \$500    | -   | \$1,500      |
| Equipment                   | \$1,000        | -        | -   | -               | -        | -   | \$1,000   | -        | -   | \$1,000      |
| Other Services              | -              | -        | -   | -               | -        | -   | -         | -        | -   | -            |
| Printing                    | -              | -        | -   | -               | -        | -   | -         | -        | -   | -            |
| Overhead                    | \$19,909       | \$3,493  | -   | -               | -        | -   | \$19,909  | \$3,493  | -   | \$23,402     |
| Other                       | -              | -        | -   | -               | -        | -   | -         | -        | -   | -            |
| SUBTOTAL                    | \$223,685      | \$39,200 | -   | \$89,938        | \$41,852 | -   | \$313,623 | \$81,052 | -   | \$394,675    |
| TOTAL                       | \$262,885      |          |     | \$131,790       |          |     | \$394,675 |          |     |              |

### TASKS 2 AND 3 VADCR - DNH SUBCOMPONENT BUDGET TABLE

| VADCR-DNH BUDGET   | NRPP-NRM FUNDS |          | IN-KIND SUPPORT |          | SUBTOTAL  |          | TOTAL     |
|--------------------|----------------|----------|-----------------|----------|-----------|----------|-----------|
|                    | YR1            | YR2      | YR1             | YR2      | YR1       | YR2      | ALL YEARS |
| Personnel Services | \$195,831      | \$33,207 | \$31,375        | \$31,375 | \$227,206 | \$64,582 | \$291,788 |
| Transportation     | -              | -        | -               | -        | -         | -        | -         |
| Travel             | \$5,700        | \$2,000  | -               | -        | \$5,700   | \$2,000  | \$7,700   |
| Vehicle Rental     | -              | -        | -               | -        | -         | -        | -         |
| Supplies           | \$1,000        | \$500    | -               | -        | \$1,000   | \$500    | \$1,500   |
| Equipment          | \$1,000        | -        | -               | -        | \$1,000   | -        | \$1,000   |
| Other Services     | -              | -        | -               | -        | -         | -        | -         |
| Printing           | -              | -        | -               | -        | -         | -        | -         |
| Overhead           | \$19,909       | \$3,493  | -               | -        | \$19,909  | \$3,493  | \$23,402  |
| Other              | -              | -        | -               | -        | -         | -        | -         |
| SUBTOTAL           | \$223,440      | \$39,200 | \$31,375        | \$31,375 | \$254,815 | \$70,575 | \$325,390 |
| TOTAL              | \$262,640      |          | \$62,750        |          | \$325,390 |          |           |

### TASKS 2 AND 3 NPS SUBCOMPONENT BUDGET TABLE

| NPS BUDGET         | NRPP-NRM FUNDS |     | IN-KIND SUPPORT |          | SUBTOTAL |          | TOTAL     |
|--------------------|----------------|-----|-----------------|----------|----------|----------|-----------|
|                    | YR1            | YR2 | YR1             | YR2      | YR1      | YR2      | ALL YEARS |
| Personnel Services | -              | -   | \$57,676        | \$10,477 | \$58,563 | \$10,477 | \$69,040  |
| Transportation     | -              | -   | -               | -        | -        | -        | -         |
| Travel             | \$245          | -   | -               | -        | \$245    | -        | \$245     |
| Vehicle Rental     | -              | -   | -               | -        | -        | -        | -         |
| Supplies           | -              | -   | -               | -        | -        | -        | -         |
| Equipment          | -              | -   | -               | -        | -        | -        | -         |
| Other Services     | -              | -   | -               | -        | -        | -        | -         |
| Printing           | -              | -   | -               | -        | -        | -        | -         |
| Overhead           | -              | -   | -               | -        | -        | -        | -         |
| Other              | -              | -   | -               | -        | -        | -        | -         |
| SUBTOTAL           | \$245          | -   | \$57,676        | \$10,477 | \$58,808 | \$10,477 | \$68,398  |
| TOTAL              | \$245          |     | \$68,153        |          | \$68,398 |          |           |

**Task 4. Classify geologic composition and condition of cliff resources.****Approach and Methods:**

An assessment of the geological composition, condition, erosion considerations, and unique resources of cliff areas will be designed by consultation with staff from the NPS Geologic Resources Division, the USGS Geologic Division (USGS-GD), and professors from local universities. A technical assistance request to the NPS-GRD was made to assist with the location and organization of geological professionals. An initial conference call with NPS, USGS, and University participants was held on October 4, 2004. Survey plans will be refined when this same group of people gathers at SHEN for an on-site meeting in February 2005.

The majority of field survey work will be completed by an individual participating in the Geological Society of America - **Geologist-In-the-Parks Program (GSA-GIP)**. The **GSA-GIP** program participant will attend the February 2005 planning meeting and work under the supervision and instruction of USGS-GD scientists and a university professor. The two-year agreement between the NPS and GSA will cover 10 months of **GIP** support including in-park housing (\$2,800) and supplies (\$1,200). The **GIP** program participant will work alongside the Virginia Natural Heritage field crew involved in plant survey work. Funds are also provided for travel to the February 2005 and future meetings related to the geological component of the cliff management plan.

**TASK 4 TOTAL BUDGET TABLE****TASK 4 NPS SUBCOMPONENT BUDGET TABLE**

| TOTAL BUDGET /<br>NPS | NRPP-NRM FUNDS                               |                                              | IN-KIND SUPPORT |     | SUBTOTAL |          | TOTAL     |
|-----------------------|----------------------------------------------|----------------------------------------------|-----------------|-----|----------|----------|-----------|
|                       | YR1                                          | YR2                                          | YR1             | YR2 | YR1      | YR2      | ALL YEARS |
| Personnel Services    | -                                            | -                                            | \$26,775        | -   | \$26,775 | -        | \$26,775  |
| Transportation        | -                                            | -                                            | -               | -   | -        | -        | -         |
| Travel                | \$3,740                                      | \$3,740                                      | -               | -   | \$3,740  | \$3,740  | \$7,480   |
| Vehicle Rental        | -                                            | -                                            | -               | -   | -        | -        | -         |
| Supplies              | -                                            | -                                            | -               | -   | -        | -        | -         |
| Equipment             | -                                            | -                                            | -               | -   | -        | -        | -         |
| Other Services        | \$8,020-<br>GSA-GIP,<br>lodging,<br>supplies | \$9,000-<br>GSA-GIP,<br>lodging,<br>supplies | -               | -   | \$8,020  | \$9,000  | \$17,020  |
| Printing              | -                                            | -                                            | -               | -   | -        | -        | -         |
| Overhead              | -                                            | -                                            | -               | -   | -        | -        | -         |
| Other                 | -                                            | -                                            | -               | -   | -        | -        | -         |
| SUBTOTAL              | \$11,760                                     | \$12,740                                     | \$26,775        | -   | \$38,535 | \$12,740 | \$51,275  |
| TOTAL                 | \$24,500                                     |                                              | \$26,775        |     | \$51,275 |          |           |

**Task 5. Conduct a recreational use survey to assess the type and extent of recreational activities and associated visitor impacts on all identified cliff sites.**

**Approach and Methods:**

The principal resource impacts associated with recreational visitation of cliffs in Shenandoah NP will be inventoried and measured on visitor-created trails and at recreation sites. Recreation sites will include areas of vegetation and/or soil disturbance associated with visitor use - including trampling at vistas, campsites, and areas at the base and top of cliffs used by rock climbers. We do not anticipate assessing impacts on the vertical cliff face, though such work could be incorporated if identified as an important concern. The recreation specialists will discuss potential ledge / face habitats with the state biologists to assure that adequate consideration is given for the potential for rare species and nesting sites in that habitat.

Park staff do not yet know the number of cliff sites that exist in the park or the number that are visited by the public. We expect it will be most efficient to conduct field research at a random sample of cliff sites stratified by amount of use (low, moderate, and high), though a stratification by type of use (hiking, vista, picnic, rock climbing) may be necessary. Within the rock climbing areas we may further stratify our sampling by type of climbing (traditional, sport, bouldering).

With consultation and approval of park staff, we expect the trail survey methodology will employ a GPS survey of all visitor-created trails and point sampling at a standardized interval (e.g., every 300 feet) to characterize trail conditions. At these locations a transect will be temporarily established perpendicular to the trail tread and measurements of selected indicators will be taken and recorded. Indicators such as tread width, maximum tread incision, cross-sectional area, and tread composition (e.g., vegetation cover, organic litter, dry soil, wet soil, rock, and exposed roots) will be assessed and summarized. Point sampling procedures are described in Farrell and Marion (2002) and Marion and Leung (2001). Depending on management needs, vegetation sampling with line transects or quadrats may also be applied to document trampling-related changes in the cover and composition of ground vegetation. Stewardship biologists will also be evaluating the composition and extent of invasive plant species.

Resource conditions at vistas, "lunch" sites, rock climbing sites, and campsites are also of management concern and will be assessed as part of this research. Methodologies adapted from campsite impact assessment approaches (Leung and Marion 2000) will be developed and integrated. These will include condition class (Marion 1995) ratings, permanent photopoints (Magill 1989), and more intensive quantitative multi-indicator measurements (Marion 1991, 1995; Marion and Farrell 2002). The boundaries and size of each visitor use site will be determined using the variable transect method and permanent reference points (Marion 1995). Six to eight impact indicators will be assessed, including site size, area of vegetation loss and exposed soil, tree root exposure, damaged trees, and stumps. Slope and aspect will be recorded for social trail developments but not at campsites and staging areas where slope is not a significant variable. Depending on management needs, vegetation sampling with line transects or quadrats may also be applied to document trampling-related changes in the cover and composition of ground vegetation. Replicating these procedures permits the monitoring of changes in site conditions, which can be used to document trends and to evaluate the effectiveness of management actions.

Data will be input in Microsoft Excel and analyzed using the SPSSPC statistical package. Analyses will include descriptive procedures and statistical inference testing employing T-tests, ANOVA, and multiple regression. The relative influence of various use-related (e.g., type and amount of use) and environmental (e.g., vegetation and substrate type) factors will be evaluated. Fully descriptive data dictionaries will be developed for all datasets, which will be archived at Virginia Tech and transferred to Shenandoah NP staff along with copies of all field manuals and procedures.

**Task 6. Develop and conduct a social science survey of day and overnight visitors at cliff sites.**

**Approach and Methods:**

The Shenandoah National Park Cliff Area Use and User Survey will provide the National Park Service with baseline visitor information to assist with the development of a Cliff Resource Management Plan for Shenandoah National Park. Visitors to selected cliff areas in the park will be administered an on-site survey to help determine the amount and type of recreational use of cliff areas as well as visitors' trip characteristics, experiences, motivations, setting preferences, socioeconomic and cultural characteristics, and attitudes and preferences for cliff resource management alternatives. Study findings will be incorporated by the park into a Cliff Resource Management Plan.

The respondent universe will be all visitors to selected cliff areas in Shenandoah National Park during the peak use period of the 2005 visitor use season. Peak use season is determined to be April through October which includes those periods in which resources are also more sensitive to disturbance. Park staff do not yet know the number of cliff sites that exist in the park or the number that are visited by the public. We expect it will be most efficient to conduct field research at a random sample of cliff sites stratified by amount of use (low, moderate, and high), though a stratification by type of use (hiking, vista, picnic, rock climbing) may be necessary. Within the rock climbing areas we may further stratify our sampling by type of climbing (traditional, sport, bouldering). Information collected about cliff area use will constitute baseline information. It would be possible, with information from a park exit survey, to gather data that could serve as the basis for a rough estimate of future trends in use.

During each sampling day trained interviewers will be stationed at selected cliff areas in Shenandoah National Park. At the beginning of the sampling period at each sampling location, the trained interviewers will select the first visitor group exiting the cliff area and ask them to participate in the study. When the interviewer has completed the visitor contact he/she will recruit the next exiting group to participate in the study. This process will continue throughout the sampling period. A series of short breaks for the interviewers will be designed into the sampling schedule. Exiting visitors selected for the survey will be read a standard script used in social science surveys in other U.S. national parks (Lawson & Manning, 2003; Lawson & Manning, 2002).

The questionnaire will be designed to be self-administered. Trained survey administrators will be present to assist study participants if needed - for example, to provide clarification to a respondent if they do not understand a question or set of instructions. In addition, the response rate to the social science survey will be recorded for the entire sampling period. Efforts will also be made to collect information about visitors who decline to participate in the study to test for non-response bias (i.e., statistical differences in personal characteristics compared to respondents). These sources of information will provide a basis for assessing the external validity of the survey findings. All electronic data records will be checked for "out-of-range" data entries using SPSS for Windows. Furthermore, ten percent of records will be randomly selected for comparison back to field forms (i.e., completed questionnaires). The questions included in this questionnaire will be designed and reviewed by the Principal Investigators, research staff and graduate students at Virginia Tech, and park and regional staff, and are similar to questions used at several other national park areas (Manning et al., 2003; Manning & Lawson, 2002; Manning et al., 2002). The questionnaires will also be reviewed and approved by the National Park Service Social Science Program and the United States Office of Management and Budget. Thus, the questionnaires used in this study will have received extensive testing and will result in study findings that are useful for park management purposes.

All study data will be coded electronically and analyzed using Statistical Package for the Social Sciences version 12.0 for Windows XP. Descriptive statistics including means (with confidence intervals), medians, standard deviations, minimums, maximums and frequency distributions will be reported for all relevant data. Cross-tabulations will be reported for the purpose of comparisons of subgroups within the sample of respondents (e.g., first-time versus repeat visitors) on selected variables. Statistical inference testing will be conducted and may include t-tests, ANOVA, and multiple regression.

One or more graduate students from Virginia Tech will be responsible for administering questionnaires to visitors. The survey administrators will have completed an extensive review of literature on survey research methods, including types of biases associated with surveys and techniques of survey administration designed to reduce or eliminate these biases. Furthermore, the survey administrators will have completed two semesters of graduate-level coursework in statistics, including coursework related to survey research methods. In addition to rigorous academic training, the survey administrators will receive training off-site (i.e., at Virginia Tech) and on-site (i.e., at the study sites in Shenandoah National Park) from the principal investigator. This training will focus on the logistics of survey administration in national parks in general and Shenandoah National Park cliff areas in particular, including scheduling, survey station setup, methods to recruit study participants and administer intercept surveys, data storage, recording of information concerning non-response rates and non-response bias, and respondent and survey administrator safety. Furthermore, the principal investigator will be on-site to supervise and oversee survey administration during the first several days of the sampling period. Undergraduate students from Virginia Tech, NPS staff, and/or volunteers may also assist the study as survey administrators. Undergraduate students, NPS staff and volunteers serving as survey administrators would be required to complete an on-site training with the principal investigator as described above and would receive on-site supervision at all times from the principal investigator and/or the trained Virginia Tech graduate students. The principal investigator has used the techniques described above to train and supervise survey administrators with a wide variety of backgrounds (e.g., graduate students, undergraduate students, volunteers, NPS staff) to conduct visitor surveys at numerous national parks throughout the United States.

As noted in the statement of work, the social science survey will be administered as an on-site intercept survey as visitors are exiting at the end of their visit to the study site. Survey administrators will be stationed at trailhead or similar access point parking lots. Survey stations will be made apparent to visitors with the use of a sign. Survey administrators will wear National Park Service volunteer uniforms and/or hats, or Virginia Tech hats, so that visitors will know they are affiliated with the visitor survey. The survey station will be located near enough to trailheads or access points that survey administrators will be in close proximity to visitors exiting the study site, but not blocking visitor traffic or circulation. Therefore, survey administrators will simply ask randomly selected visitors (selected using procedures described in the statement of work) to participate in the study as they exit the area, walking in the vicinity of the survey station. Study participants will be provided with clipboards, pens and questionnaires. The principal investigator has applied these methods for recruiting visitor survey participants in numerous studies of national park visitors, yielding consistently adequate survey samples.

### TASKS 5 AND 6 TOTAL BUDGET TABLE

| TOTAL BUDGET       | NRPP-NRM FUNDS |         |     | IN-KIND SUPPORT |          |     | SUBTOTAL  |          |     | TOTAL     |
|--------------------|----------------|---------|-----|-----------------|----------|-----|-----------|----------|-----|-----------|
|                    | YR1            | YR2     | YR3 | YR1             | YR2      | YR3 | YR1       | YR2      | YR3 | ALL YEARS |
| Personnel Services | \$39,938       | -       | -   | \$27,010        | \$40,153 | -   | \$66,948  | -        | -   | \$107,101 |
| Transportation     | -              | -       | -   | -               | -        | -   | -         | -        | -   | -         |
| Travel             | \$9,245        | \$245   | -   | -               | -        | -   | \$9,245   | \$245    | -   | \$9,490   |
| Vehicle Rental     | -              | \$3,920 | -   | -               | -        | -   | -         | \$3,920  | -   | \$3,920   |
| Supplies           | \$4,490        | \$980   | -   | -               | -        | -   | \$4,490   | \$980    | -   | \$5,470   |
| Equipment          | \$2043         | -       | -   | -               | -        | -   | \$243     | -        | -   | \$243     |
| Other Services     | -              | -       | -   | -               | -        | -   | -         | -        | -   | -         |
| Printing           | \$3,000        | -       | -   | -               | -        | -   | \$3,000   | -        | -   | \$3,000   |
| Overhead           | \$8,757        | -       | -   | -               | -        | -   | \$8,757   | -        | -   | \$8,757   |
| Other              | -              | -       | -   | -               | -        | -   | -         | -        | -   | -         |
| SUBTOTAL           | \$67,473       | \$5,145 | -   | \$27,010        | \$40,153 | -   | \$92,683  | \$45,298 | -   | \$137,981 |
| TOTAL              | \$72,618       |         |     | \$67,163        |          |     | \$137,981 |          |     |           |

### TASKS 5 AND 6 VA- TECH SUBCOMPONENT BUDGET TABLE

| VA-TECH BUDGET     | NRPP-NRM FUNDS | IN-KIND SUPPORT | TOTAL     |
|--------------------|----------------|-----------------|-----------|
|                    | YR1            | YR1             | ALL YEARS |
| Personnel Services | \$32,000       | \$5,000         | \$37,000  |
| Transportation     | -              | -               | -         |
| Travel             | \$9,000        | -               | \$9,000   |
| Vehicle Rental     | -              | -               | -         |
| Supplies           | \$4,000        | -               | \$4,000   |
| Equipment          | \$2,043        | -               | \$2,043   |
| Other Services     | -              | -               | -         |
| Printing           | \$3,000        | -               | \$3,000   |
| Overhead           | \$8,757        | -               | \$8,757   |
| Other              | -              | -               | -         |
| TOTAL              | \$58,800       | \$5,000         | \$63,800  |

## TASKS 5 AND 6 NPS SUBCOMPONENT BUDGET TABLE

| NPS BUDGET         | NRPP-NRM FUNDS     |         | IN-KIND SUPPORT |          | SUBTOTAL |          | TOTAL     |
|--------------------|--------------------|---------|-----------------|----------|----------|----------|-----------|
|                    | YR1                | YR2     | YR1             | YR2      | YR1      | YR2      | ALL YEARS |
| Personnel Services | \$7,938-technician | -       | \$22,010        | \$40,153 | \$29,948 | \$40,153 | \$70,101  |
| Transportation     | -                  | -       | -               | -        | -        | -        | -         |
| Travel             | \$245              | \$245   | -               | -        | \$245    | \$245    | \$490     |
| Vehicle Rental     | -                  | \$3,920 | -               | -        | -        | \$3,920  | \$3,920   |
| Supplies           | \$490              | \$980   | -               | -        | \$490    | \$980    | \$1,470   |
| Equipment          | -                  | -       | -               | -        | -        | -        | -         |
| Other Services     | -                  | -       | -               | -        | -        | -        | -         |
| Printing           | -                  | -       | -               | -        | -        | -        | -         |
| Overhead           | -                  | -       | -               | -        | -        | -        | -         |
| Other              | -                  | -       | -               | -        | -        | -        | -         |
| SUBTOTAL           | \$8,673            | \$5,145 | \$22,010        | \$40,153 | \$30,683 | \$45,298 | \$75,981  |
| TOTAL              | \$13,818           |         | \$62,163        |          | \$75,981 |          |           |

**Task 7. Create a Cliff Management Plan incorporating information from resource and visitor use/impact studies and relevant evaluative information developed by the project to address SHEN cliff management concerns.**

### Approach and Methods:

Upon gathering and evaluating resource and visitor use information in FY1 and FY2, the Park, a VADCR stewardship biologist, and other partners will work with a contracted technical writer to develop a Cliff Management Plan. Using information gathered from **Tasks 1-6**, this plan will pull together information on the location, geology, ecological communities, significant biological resources, threats to the biological resources, human impacts, and recreational use of outcrop sites throughout the Park. As part of this process we will develop conceptual models of site types to drive management, restoration, and monitoring. These models will include ecosystem components and responses to natural and visitor related disturbances.

The Plan will use this information to develop a recreational carrying capacity planning framework, a rock climbing plan, and cliff site visitor use management strategies and directives. Information developed by the recreation use and impacts study, and VADCR outcrop classification system, will contribute to the development of prescriptive management objectives addressing broader resource stewardship issues for cliff sites. These objectives will include creation of indicators of change and condition standards within a Limits of Acceptable Change (LAC) or Visitor Experience and Resource Protection (VERP) planning model. As cliff management issues are better understood and clarified, climbing organizations and other recreation groups and interested individuals will be involved in plan development through a series of public meetings.

### TASK 7 TOTAL BUDGET TABLE

| TOTAL BUDGET       | NRPP-NRM FUNDS |          |          | IN-KIND SUPPORT |          |          | SUBTOTAL  |          |          | TOTAL     |
|--------------------|----------------|----------|----------|-----------------|----------|----------|-----------|----------|----------|-----------|
|                    | YR1            | YR2      | YR3      | YR1             | YR2      | YR3      | YR1       | YR2      | YR3      | ALL YEARS |
| Personnel Services | -              | \$8,624  | \$13,282 | -               | \$29,544 | \$72,809 | -         | \$38,168 | \$86,091 | \$124,259 |
| Transportation     | -              | -        | -        | -               | -        | -        | -         | -        | -        | -         |
| Travel             | -              | \$245    | \$1,970  | -               | -        | -        | -         | \$245    | \$1,970  | \$2,215   |
| Vehicle Rental     | -              | -        | \$3,920  | -               | -        | -        | -         | -        | \$3,920  | \$3,920   |
| Supplies           | -              | \$500    | \$500    | -               | -        | -        | -         | \$500    | \$500    | \$1,000   |
| Equipment          | -              | \$2,440  | -        | -               | -        | -        | -         | \$2,440  | -        | \$2,440   |
| Other Services     | -              | \$29,400 | -        | -               | -        | -        | -         | \$29,400 | -        | \$29,400  |
| Printing           | -              | \$490    | \$2,940  | -               | -        | -        | -         | \$490    | \$2,940  | \$3,430   |
| Overhead           | -              | -        | \$1,397  | -               | -        | -        | -         | -        | \$1,397  | \$1,397   |
| Other              | -              | -        | -        | -               | -        | -        | -         | -        | -        | -         |
| SUBTOTAL           | -              | \$41,699 | \$24,009 | -               | \$29,544 | \$72,809 | -         | \$71,243 | \$96,818 | \$168,061 |
| TOTAL              | \$65,708       |          |          | \$102,353       |          |          | \$168,061 |          |          |           |

### TASK 7 VADCR-DNH SUBCOMPONENT BUDGET TABLE

| VADCR-DNH BUDGET   | NRPP-NRM FUNDS | IN-KIND SUPPORT | TOTAL     |
|--------------------|----------------|-----------------|-----------|
|                    | YR3            | YR3             | ALL YEARS |
| Personnel Services | \$13,282       | -               | \$13,282  |
| Transportation     | -              | -               | -         |
| Travel             | \$500          | -               | \$500     |
| Vehicle Rental     | -              | -               | -         |
| Supplies           | \$500          | -               | \$500     |
| Equipment          | -              | -               | -         |
| Other Services     | -              | -               | -         |
| Printing           | -              | -               | -         |
| Overhead           | \$1,397        | -               | \$1,397   |
| Other              | -              | -               | -         |
| TOTAL              | \$15,679       | -               | \$15,679  |

## TASK 7 NPS SUBCOMPONENT BUDGET TABLE

| NPS BUDGET         | NRPP-NRM FUNDS              |                           | IN-KIND SUPPORT |          | SUBTOTAL  |          | TOTAL     |
|--------------------|-----------------------------|---------------------------|-----------------|----------|-----------|----------|-----------|
|                    | YR2                         | YR3                       | YR2             | YR3      | YR2       | YR3      | ALL YEARS |
| Personnel Services | \$8,624-biotech             | -                         | \$29,544        | \$72,809 | \$38,168  | \$72,809 | \$110,977 |
| Transportation     | -                           | -                         | -               | -        | -         | -        | -         |
| Travel             | \$245                       | \$1,470                   | -               | -        | \$245     | \$1,470  | \$1,715   |
| Vehicle Rental     | -                           | \$3,920                   | -               | -        | -         | \$3,920  | \$3,920   |
| Supplies           | \$500                       | -                         | -               | -        | \$500     | -        | \$500     |
| Equipment          | \$2,440-computer for writer | -                         | -               | -        | \$2,440   | -        | \$2,440   |
| Other Services     | \$29,400-technical writer   | -                         | -               | -        | \$29,400  | -        | \$29,400  |
| Printing           | \$490                       | \$2,940- final cliff plan | -               | -        | \$490     | \$2,940  | \$3,430   |
| Overhead           | -                           | -                         | -               | -        | -         | -        | -         |
| Other              | -                           | -                         | -               | -        | -         | -        | -         |
| SUBTOTAL           | \$41,699                    | \$8,330                   | \$29,544        | \$72,809 | \$71,243  | \$81,139 | \$152,382 |
| TOTAL              | \$50,029                    |                           | \$102,353       |          | \$152,382 |          |           |

### Task 8. Initiate management activities to mitigate visitor use issues, and protect and restore natural resource conditions

#### Approach and Methods:

The Cliff Management Plan will address management actions to mitigate unacceptable resource impacts, however some mitigation activities will necessarily be accomplished or initiated prior to the completion of the Plan. Visitor use management actions will likely include establishment of physical barriers and signage to confine visitor activities to protect resources, and resource restoration activities. With the potential to construct designated campsites and formal trails as a visitor use "containment strategy" to confine use and impacts at cliff sites, an archeological survey contract with James Madison University (JMU) will be necessary in FY2-FY3 to assess archeological conditions at any site with potential for soil disturbance by construction activities. Archeological survey will be accomplished in compliance with Section 106 of the National Historic Preservation Act. As appropriate, some mitigation activities, including campsite and trails issues, might be addressed within the context of the existing SHEN Backcountry and Wilderness Management Plan prior to final completion and approval of the Cliff Management Plan. Even though mitigation activities will be initiated in late FY2, it is likely that complete installation of permanent signs, exhibits, campsites, and fencing, and implementation of new regulations may extend beyond the project period.

## TASK 8 TOTAL BUDGET TABLE

### TASK 8 NPS SUBCOMPONENT BUDGET TABLE

| TOTAL<br>BUDGET- <b>NPS</b> | NRPP-NRM FUNDS |                                     |                                   | IN-KIND SUPPORT |     |          | SUBTOTAL |         |          | TOTAL        |
|-----------------------------|----------------|-------------------------------------|-----------------------------------|-----------------|-----|----------|----------|---------|----------|--------------|
|                             | YR1            | YR2                                 | YR3                               | YR1             | YR2 | YR3      | YR1      | YR2     | YR3      | ALL<br>YEARS |
| Personnel Services          | -              | -                                   | -                                 | -               | -   | \$36,304 | -        | -       | \$36,304 | \$36,304     |
| Transportation              | -              | -                                   | -                                 | -               | -   | -        | -        | -       | -        | -            |
| Travel                      | -              | -                                   | -                                 | -               | -   | -        | -        | -       | -        | -            |
| Vehicle Rental              | -              | -                                   | -                                 | -               | -   | -        | -        | -       | -        | -            |
| Supplies                    | -              | \$980<br>barriers,<br>signs         | \$2,940                           | -               | -   | -        | -        | \$980   | \$2,940  | \$3,920      |
| Equipment                   | -              | -                                   | \$2,450                           | -               | -   | -        | -        | -       | \$2,450  | \$2,450      |
| Other Services              |                | \$4,900 -<br>Archeology<br>contract | \$4,900<br>Archeology<br>contract | "               | "   | "        | "        | \$4,900 | \$4,900  | \$9,800      |
| Printing                    | -              | -                                   | -                                 | -               | -   | -        | -        | -       | -        | -            |
| Overhead                    | -              | -                                   | -                                 | -               | -   | -        | -        | -       | -        | -            |
| Other                       | -              | -                                   | -                                 | -               | -   | -        | -        | -       | -        | -            |
| SUBTOTAL                    | -              | \$5,880                             | \$10,290                          | -               | -   | \$3,6304 | -        | \$5,880 | \$46,594 | \$52,474     |
| TOTAL                       | \$16,170       |                                     |                                   | \$36,304        |     |          | \$52,474 |         |          |              |

## Interpretive Component

1. The natural resource issue to be addressed by the park in this project is to obtain information to support development and implementation of a park-wide cliff management plan. Rare species and vegetation communities at cliff and outcrop areas throughout the park have been severely degraded by essentially unmanaged and unregulated visitor use. Visitor access, use and associated impacts to park cliff areas is known to be rather unrestrained and significant, but the full extent of rare species associated with cliff areas and subject to recreation impacts remains unknown. Additional natural resource surveys and classification work, identification of cliff area visitor use and impacts, and the development and implementation of a cliff management plan is critical to direct visitor recreation use to minimize impacts, mitigate resource degradation associated with visitor use, preserve valuable cliff resources, and restore damaged cliff and rock outcrop areas.
2. The Shenandoah NP interpretive and education staff will function as the primary specialist collaborators for the interpretive component of the project. These specialists will include, but not be limited to, the Division Chief for Interpretation and Education (**I&E**), the Assistant Division Chief for **I&E**, at least one Interpretive Specialist and one Education Specialist, and a Visual Information Specialist. Other Park staff will contribute to the Interpretive Component of this project, including Ranger Activities Division staff, Natural and Cultural Resources Division staff, and Administrative staff including the Geographic Information System (**GIS**) specialist (to construct accurate maps for interpretive posters at wayside exhibits) and the Management **Assistant**/Public Affairs Officer. The NPS Harpers Ferry Center Wayside Exhibit staff will assist the park to obtain trailhead bulletin displays to contain interpretive posters created and printed in-house. Various climber organizations and individuals will be enlisted to contribute to the interpretive/education effort to help shape the public interpretive message.
3. An important aspect of development and implementation of the cliff management plan is to educate and interpret to cliff visitors public the sensitivity of cliff natural resources and to involve the public in management decision-making. Visitors will be made aware of the value and sensitivity of cliff natural resources, the potential for damage to resources that may result from human recreation activities, and techniques and practices that individuals might use in their recreation activities to help minimize or prevent unacceptable impacts. As a result of implementation of the project's interpretive component, it is anticipated that the public most affected by Park cliff site management activities will have an understanding and appreciation of management actions and will support those actions.
4. The visitors most affected by cliff protection activities and targeted by the interpretive message will be casual day hikers interested in scenic viewing opportunities at cliff areas accessed by formal trails, **backcountry** campers interested in the scenic campsite qualities offered at cliff sites and/or base camping to support rock climbing activities, and rock climbing enthusiasts. Visitor use containment strategies which might include use of minimally obtrusive physical barriers, signing, park-constructed campsites and trails, and additional regulation can be designed and employed to have minimal impact on the visitor recreation experience, but park management interaction with the rock climbing community is critical for public support to protect cliff resources. Rock climbing appears to be an increasingly popular recreational activity in the park, but the extent of this activity and its impacts to park resources is largely unknown. Regional climbing groups, individuals and organizations can contribute to the knowledge and understanding of use levels and types and frequencies of use. Several regional climbing groups or organizations are known to the park and these and other groups in particular will be targeted for the interpretive outreach program.

5. The following media and methods will be employed to communicate the cliff management message:

- (1) **Interpretive site bulletin:** A handout brochure will be professionally designed for wide public distribution, primarily focused on rock climbing activities in the Park. The site bulletin will contain a "*Leave No Trace*" message to provide information and advice to cliff recreationists to help manage their behavior and activities to minimize resource and social impacts at cliff sites. The bulletin will address any visitor containment strategies and regulations that might be developed through the climbing plan.
  - (2) **Trailhead bulletin displays:** The Park will employ the NPS Harpers Ferry Center to assist in the design, construction and placement of six or more low-maintenance permanent bulletin displays (wayside exhibits). The bulletin case of each will encase a poster (approximately 3'x4' in size) produced and printed in-house and reflect prioritized visitor information based on the site bulletin publication (described above). The bulletin displays will be placed at trailhead parking areas and any other sites identified as those providing the most active visitor access to the most sensitive cliff sites.
  - (3) **Interpretation/Education Program:** An existing base-funded temporary or STF Park Ranger position will have supplemental funding from this project to design and present cliff resource management and associated rock climbing outreach information to local and regional climbing organizations. This supported position would also serve to work with the park's Management Assistant to keep the interested public updated in the Cliff Management Plan development and implementation and will participate in developing the interpretive poster and site bulletin text and design.
  - (4) **Public Meetings:** Public involvement in the project is important to its success. This participation would be enhanced by public forum to gain public information, interest and support and to dispense accurate update information. A climbing plan has potential to be publicly controversial as no past efforts have been made by SNP to manage or restrict rock climbing activities in any form. Two or more public meetings will be accomplished as necessary and will likely be conducted by the Ranger Activities Division with support from the Park's interpretive and resources staffs.
6. Park ranger and resources staff will monitor and document cliff site resource conditions per the criteria and standards established in the Cliff Management Plan and associated Climbing Plan. The Cliff Management Plan will direct monitoring and program evaluation activities in the future. Park staff will interact with the public at cliff site areas to assess the effectiveness and success of the various interpretive communication efforts to raise public awareness of cliff protection issues. A future (post-project) visitor study of cliff users would certainly incorporate an evaluation of the effectiveness of the interpretive message and media in obtaining understanding of, compliance with and support for cliff management decisions and actions. Evaluation criteria might include examination of where and how the public receives their information about cliff natural and cultural resources, public understanding and acceptance of cliff resource protection strategies employed by the Park, and what degree of effectiveness the various interpretive media and messages are having to impact the behavior of cliff users and reduce damage to cliff resources.

### INTERPRETIVE COMPONENT TOTAL BUDGET TABLE

| TOTAL BUDGET /<br>NPS | NRPP-NRM FUNDS                 |                               | IN-KIND SUPPORT |         | SUBTOTAL |          | TOTAL     |
|-----------------------|--------------------------------|-------------------------------|-----------------|---------|----------|----------|-----------|
|                       | YR2                            | YR3                           | YR2             | YR3     | YR2      | YR3      | ALL YEARS |
| Personnel Services    | \$8,624                        | \$8,977                       | \$6,264         | \$6,515 | \$14,888 | \$15,492 | \$30,380  |
| Transportation        | -                              | -                             | -               | -       | -        | -        | -         |
| Travel                | -                              | -                             | -               | -       | -        | -        | -         |
| Vehicle Rental        | -                              | -                             | -               | -       | -        | -        | -         |
| Supplies              | \$490 – signs, office supplies | -                             | -               | -       | \$490    | -        | \$490     |
| Equipment             | -                              | -                             | -               | -       | -        | -        | -         |
| Other Services        | -                              | \$14,700 – Trailhead displays | -               | -       | -        | \$14,700 | \$14,700  |
| Printing              | \$980- Site bulletins, posters | -                             | -               | -       | \$980    | -        | \$980     |
| Overhead              | -                              | -                             | -               | -       | -        | -        | -         |
| Other                 | \$490- public meetings         | \$490- public meetings        | -               | -       | \$490    | \$490    | \$980     |
| SUBTOTAL              | \$10,584                       | \$24,167                      | \$6,264         | \$6,515 | \$16,848 | \$30,682 | \$47,530  |
| TOTAL                 | \$35,241                       |                               | \$12,779        |         | \$47,530 |          |           |

## TIME FRAME FOR ADDRESSING PROJECT TASKS

| TASK                                                                                                               | FY2005 | FY2006 | FY2007 |
|--------------------------------------------------------------------------------------------------------------------|--------|--------|--------|
| Identify and map locations of cliff resources                                                                      | x      |        |        |
| Conduct Botanical and zoological field surveys of cliff sites park-wide                                            | x      | x      |        |
| Classify geologic composition and condition of cliff resources                                                     | x      | x      |        |
| Conduct a recreational use survey to assess the type and extent of recreational activities and impacts             | x      | x      |        |
| Develop and conduct a social science survey of day and overnight visitors at cliff sites.                          | x      | x      |        |
| Create an outcrop classification system based on vegetation type and recreational impact sensitivity               |        | x      |        |
| Create a Cliff Management Plan incorporating information from resource and visitor use/impact studies              |        | x      | x      |
| Initiate management activities to mitigate visitor use issues, and protect and restore natural resource conditions |        | x      | x      |

## KEY TO DETAILED ACTIVITY SCHEDULE

### SEASONS:

FALL            OCTOBER 1 - DECEMBER 31  
WINT            JANUARY 1 - MARCH 31  
SPRI            APRIL 1 - JUNE 30  
SUMM           JULY 1 - SEPTEMBER 30

### LEAD ORGANIZATIONS AND KEY STAFF MEMBERS:

|           |                                                   |                                |
|-----------|---------------------------------------------------|--------------------------------|
| NPS-SHEN  | National Park Service -Shenandoah NP              | Wendy Cass<br>Steve Bair       |
| USGS -BRD | U.S. Geological Survey-BRD Leetown Science Center | John Young                     |
| DCR -DNH  | Virginia Dept. of Conservation and Recreation     | Alan Belden<br>Kevin Heffernan |
| VATECH    | Virginia Tech University                          | Steve Lawson<br>Jeff Marion    |
| NPS-GRD   | NPS Geologic Resources Division                   | Bob Higgins                    |
| JMU       | James Madison University                          | Carole Nash                    |
| TBD       | Geology Professor at local University             | selection underway             |

## DETAILED PROJECT ACTIVITY SCHEDULE

| TASK | SUBTASK                                                                  | Lead<br>Organization | FY05 |      |      |      | FY06 |      |      |      | FY07 |      |      |      |
|------|--------------------------------------------------------------------------|----------------------|------|------|------|------|------|------|------|------|------|------|------|------|
|      |                                                                          |                      | FALL | WINT | SPRI | SUMM | FALL | WINT | SPRI | SUMM | FALL | WINT | SPRI | SUMM |
|      | Project coordination meeting at SHEN                                     | NPS-SHEN             | X    |      |      |      | X    |      |      |      | X    |      |      | X    |
| 1    | Assemble imagery and GIS data and classify outcrops                      | USGS-BRD             | X    | X    |      |      |      |      |      |      |      |      |      |      |
|      | Cross correlate images with hyper-spectral imagery                       | USGS-BRD             |      | X    |      |      |      |      |      |      |      |      |      |      |
|      | Prepare maps for field surveys                                           | USGS-BRD             |      | X    | X    |      |      |      |      |      |      |      |      |      |
|      | Prepare interim cliff mapping report *                                   | USGS-BRD             |      |      | X    |      |      |      |      |      |      |      |      |      |
|      | Revisit mapping based on field collected data                            | USGS-BRD             |      |      |      | X    |      |      |      |      |      |      |      |      |
|      | Prepare mapping accuracy assessment report *                             | USGS-BRD             |      |      |      | X    |      |      |      |      |      |      |      |      |
|      | Prepare and submit final cliff mapping report *                          | USGS-BRD             |      |      |      | X    |      |      |      |      |      |      |      |      |
| 2    | Determine survey locations and target biological resources               | DCR-DNH              |      | X    | X    |      |      |      |      |      |      |      |      |      |
|      | NEPA compliance for field projects                                       | NPS-SHEN             |      | X    |      |      |      |      |      |      |      |      |      |      |
|      | Conduct field inventories                                                | DCR-DNH              |      |      | X    | X    | X    | X    | X    | X    | X    |      |      |      |
|      | Identify and deposit plant and animal specimens                          | DCR-DNH              |      |      | X    | X    | X    | X    | X    | X    | X    | X    |      |      |
|      | Complete field forms and enter data into the Biotics data system         | DCR-DNH              |      |      |      |      | X    | X    | X    | X    | X    | X    |      |      |
|      | Produce report summarizing status / threats to cliff sites *             | DCR-DNH              |      |      |      |      |      |      |      |      | X    | X    |      |      |
| 3    | Classify outcrop communities *                                           | DCR-DNH              |      |      |      |      |      |      |      |      | X    | X    |      |      |
| 4    | Convene meeting to discuss geologic survey variables                     | NPS-GRD              |      | X    |      |      |      |      |      |      |      |      |      |      |
|      | Train GSA-GIP Intern - collect geologic survey data                      | TBD                  |      |      | X    | X    | X    |      | X    | X    | X    |      |      |      |
|      | Summarize and report on geologic findings *                              | TBD                  |      |      |      |      | X    | X    |      |      | X    | X    |      |      |
| 5    | Describe biophysical impacts associated with recreation on cliffs        | VA-TECH              | X    | X    | X    |      |      |      |      |      |      |      |      |      |
|      | Select biophysical indicators that reflect critical recreational impacts | VA-TECH              |      | X    | X    |      |      |      |      |      |      |      |      |      |
|      | Apply monitoring protocols to evaluate recreational impacts              | VA-TECH              |      |      | X    | X    |      |      |      |      |      |      |      |      |
|      | Analyze and report findings of recreational impacts study *              | VA-TECH              |      |      |      | X    | X    | X    | X    |      |      |      |      |      |

| TASK         | SUBTASK                                                                 | Lead<br>Organization | FY05 |      |      |      | FY06 |      |      |      | FY07 |      |      |      |
|--------------|-------------------------------------------------------------------------|----------------------|------|------|------|------|------|------|------|------|------|------|------|------|
|              |                                                                         |                      | FALL | WINT | SPRI | SUMM | FALL | WINT | SPRI | SUMM | FALL | WINT | SPRI | SUMM |
| 6            | Review existing cliff resource management plans (NPS and other)         | VA-TECH              | X    | X    | X    |      |      |      |      |      |      |      |      |      |
|              | Review scientific literature on cliff resource use, users, <b>mgnt.</b> | VA-TECH              | X    | X    | X    |      |      |      |      |      |      |      |      |      |
|              | Develop recreational use and social science survey instrument           | VA-TECH              |      | X    | X    |      |      |      |      |      |      |      |      |      |
|              | Acquire NPS-SSP and OMB approval for survey instrument                  | VA-TECH              |      |      | X    | X    |      |      |      |      |      |      |      |      |
|              | Administer recreation use and social science survey                     | VA-TECH              |      |      |      | X    | X    |      | X    |      |      |      |      |      |
|              | Analyze and report findings of social science survey *                  | VA-TECH              |      |      |      |      | X    | X    | X    | X    | X    |      |      |      |
|              |                                                                         |                      |      |      |      |      |      |      |      |      |      |      |      |      |
| 7            | Environmental Assessment work                                           | NPS-SHEN             |      |      |      |      |      |      |      | X    | X    | X    | X    |      |
|              | Compile Final Project Report *                                          | NPS-SHEN             |      |      |      |      |      |      |      |      |      |      |      | X    |
|              | Write Cliff Management Plan *                                           | NPS-SHEN             |      |      |      |      |      |      |      |      |      | X    | X    | X    |
|              | DCR assistance to create a cliff management plan                        | DCR-DNH              |      |      |      |      |      |      |      |      |      | X    | X    | X    |
|              |                                                                         |                      |      |      |      |      |      |      |      |      |      |      |      |      |
| 8            | Complete <b>archeological</b> survey of rehabilitation areas            | JMU                  |      |      |      |      |      |      |      | X    | X    | X    |      |      |
|              | NEPA compliance for restoration measures                                | NPS-SHEN             |      |      |      |      |      | X    |      |      |      | X    |      | X    |
|              | Purchase and install site signing                                       | NPS-SHEN             |      |      |      |      |      | X    | X    |      |      | X    | X    |      |
|              | Purchase and construct or install site barricades                       | NPS-SHEN             |      |      |      |      |      | X    | X    |      |      | X    | X    |      |
|              |                                                                         |                      |      |      |      |      |      |      |      |      |      |      |      |      |
| Interpretive | Develop and print interpretive site bulletins                           | NPS-SHEN             |      |      |      |      | X    | X    |      |      | X    | X    |      |      |
| Component    | Develop and print trailhead bulletin posters                            | NPS-SHEN             |      |      |      |      | X    | X    |      |      | X    | X    |      |      |
|              | Purchase and install trailhead bulletin display cases                   | NPS-SHEN             |      |      |      |      |      |      |      |      | X    | X    | X    |      |
|              | Conduct interpretive/education outreach program                         | NPS-SHEN             |      |      |      |      | X    | X    | X    | X    | X    | X    | X    | X    |
|              | Conduct public meetings to design climbing plan                         | NPS-SHEN             |      |      |      |      |      | X    |      |      |      | X    |      |      |
|              |                                                                         |                      |      |      |      |      |      |      |      |      |      |      |      |      |

\*. See deliverables section for completion date

## **Deliverables**

- Investigator's annual reports for RPRS (USGS-BRD, VATECH, VADNH, Geology)
  - o March 1, 2006
  - o March 1, 2007
- Annual Accomplishment Report in PMIS (NPS)
  - o October 30, 2005
  - o October 30, 2006
  - o October 30, 2007
- SHEN annual progress report
  - o December 31, 2005
  - o December 31, 2006
- Digital / printed map(s) showing rock outcrop and cliff locations within the park (USGS-BRD)
  - o Field maps - April 2005
  - o Final maps - October 2005
- Final report for outcrop mapping effort (USGS-BRD)
  - o Draft - June 30, 2005
  - o Final - September 30, 2005
- Mapping accuracy assessment report (USGS-BRD)
  - o September 30, 2005
- Recreational Impacts Study final report (VATECH)
  - o November 30, 2007
- Social Science Survey final results report (VATECH)
  - o March 31, 2006
- Complete and Print Interpretive site bulletins (NPS)
  - o Draft - February 28, 2006
  - o Final - February 28, 2007
- A report summarizing the geologic composition and condition of cliff resources (TBD)
  - o Draft - December 31, 2006
  - o Final - December 31, 2007
- A report detailing the location, condition, and threats to rare plant and animal populations within cliff / outcrop areas (VADCR-NHP)
  - o March 31, 2007
- A vegetation and impact sensitivity classification scheme for outcrops (VADCR-NHP)
  - o March 31, 2007
- Install permanent trailhead interpretive displays (NPS)
  - o March 31, 2007
- Digital data for species and communities of conservation interest (VADCR-NPS)
  - o June 30, 2007
- A cliff management plan which includes a section on climbing management and directing visitor use (NPS)
  - o Draft - June 30, 2007
  - o Final - September 30, 2007
- A presentation of findings to park staff at the conclusion of the study (ALL)
  - o November 2007
- Final project completion report including all data (NPS)
  - o Draft - June 30, 2008
  - o Final - December 30, 2008

## Quality Assurance/Quality Control

### NPS - Project Oversight

- The Shenandoah National Park (SHEN) Botanist and **Backcountry** and Wilderness Manager will oversee the collection and interpretation of botanical, zoological, geological, and visitor use data by the cooperating agencies.
- The SHEN Botanist and Backcountry and Wilderness Manager will organize and oversee the completion of the project's Environmental Assessment with assistance from the SHEN Natural Resources Branch Chief and Cultural Resources Specialist.
- Periodic field oversight visits of cooperator's field crews will be made by the park Botanist and Backcountry and Wilderness Manager

### USGS - Rock Outcrop Mapping

- Outcrop mapping will be conducted under the supervision of a USGS Research Biologist (Landscape **Ecology/GIS**) with 15 years experience in mapping, **GIS**, and remote sensing.
- Interpretations from outcrop mapping will be subjected to internal validity checks against topographic maps and aerial and satellite imagery and will conform to National Map Accuracy Standards (USGS, 1947) for 1:12,000 scale data (e.g. 90 percent of well defined points fall within 33.3 feet of their actual position).
- Interpretations will also be subject to an accuracy assessment using the results of field sampling conducted by vegetation field crews following methods outlined in Congalton and Green (1999). If necessary, outcrop maps will be revised such that overall mapping accuracy exceeds 80%.

### NPS/TBD University – Geologic Features Survey

- Geologic variables to be examined by the survey will be determined by a group of professional geologists from the NPS-GRD, USGS-GD, and local universities in a February 2005 meeting.
- Field data collection will be performed by a **GSA-GIP** intern at the PhD candidate or higher experience level. The GSA-GIP intern will be overseen by USGS-GD and University geologist advisors.
- Geologic data will be stored and compiled in an Access database at **SHEN** for which automated anti-error procedures have been designed.
- Geologic data will be reviewed by the USGS-GD and University geologic advisors during the compilation process.

### VADNH - Botanical and Zoological Surveys

- The biological resources inventory project will be under the direction of the DCR-DNH Chief Biologist with 18 years experience in rare species inventory and applied conservation biology.
- The zoology inventory will be under the direction of the DCR-DNH Staff Zoologist with 16 years experience in rare species inventory and applied conservation biology.
- The botanical inventory will under the direction of the DCR-DNH Staff Botanist with 3 years experience in rare species inventory and applied conservation biology. Prior experience includes 6 years as herbarium curator.

- The ecological inventory will be under the direction of a DCR-DNH Staff Ecologist with 12 years experience in community inventory and sampling as well as applied conservation biology.
- DCR-DNH Zoology inventories will be performed by Field Zoologists with 9 and 11 years experience in rare species inventory and applied conservation biology.
- DCR-DNH Botanical inventories will be performed by Field Botanists with 11 and 12 years experience in rare species inventory and applied conservation biology.
- DCR-DNH Community inventories will be performed by Field Ecologists with 12 and 2 years experience in community inventory and sampling as well as applied conservation biology.
- The stewardship inventory will be conducted by DCR-DNH Stewardship biologist with 10 years experience in land management and applied conservation biology
- Selection of cliff sites will be collaborative with input from USGS and NPS personnel to ensure that all sites with significant biological resources and all sites with threatening visitor use are selected.
- In all instance when unthreatening to the resource, rare species identifications will be vouchered with a specimen to ensure accurate identification.
- Community types will be verified checked against internal plots database containing ca. 3500 vegetation plots from Virginia. All types will be cross-walked to USNVC to insure their validity and accurate labeling.

#### VATECH - Recreation Impact and Visitor Use Surveys

- The recreation impact inventory project will be under the direction of Dr. Jeff Marion, a Recreation Ecologist with 25 years experience in addressing outdoor recreation use and impacts.
- The social science inventory will be under the direction of Dr. Steve Lawson, a Recreation Ecologist with 10 years experience in addressing outdoor recreation use and impacts.
- A comprehensive field research manual will be developed for the Recreation Resource Impact component that describes all study procedures, including diagrams and photographs.
- Data collection will be performed by a small number of thoroughly trained full-time field staff.
- The field forms used will be designed to facilitate the recording and entry of data. Field data collection staff will also be responsible for office data entry.
- Ten percent of entered records will be randomly selected for comparison back to field forms. All data will be checked for “out-of-range” data entries.
- The recreation use and social science survey will utilize standard survey research methods used and refined in several previous social science surveys of national park use and users (Manning et al., 2003; Manning & Lawson, 2002; Manning et al., 2002).
- Recreation use and social science survey data will be analyzed using the SPSS statistical software package automated data screening techniques to identify data entry errors.

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