National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science

# Great Smoky Mountains National Park

## *Rare Plant Monitoring Summary 1989-2010*

Natural Resource Report NPS/GRSM/NRR—2013/643

**ON THE COVER**
*Geum radiatum* flowers
Photograph by: Nora Murdock

# Great Smoky Mountains National Park

*Rare Plant Monitoring Summary 1989-2010*

Natural Resource Report NPS/GRSM/NRR—2013/643

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April 2013

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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This report is available from the Appalachian Highlands Inventory and Monitoring Network (APHN) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/nrpm/).

Please cite this publication as:

Rock, J. 2013. Great Smoky Mountains National Park: Rare plant monitoring summary 1989-2010. Natural Resource Report NPS/GRSM/NRR—2013/643. National Park Service, Fort Collins, Colorado.

NPS 133/120296, April 2013

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# Abstract

The Rare Plant Monitoring Program formally began in 1993 as part of Great Smoky Mountains Long-term Monitoring Program. Thirty-six rare plant species have been monitored at varying levels and frequency (monitoring intensity) based on potential or documented disturbances, federal or state listing, and park rarity. Over time, monitoring intensity has been adjusted following a number of years of qualitative or quantitative data collection.

Select populations of the 36 rare plant species have been managed to ensure population survival. Prescribed fire, mechanical clearing, and removal of non-native plants by hand-pulling have all been used and were successful in maintaining, and even increasing, population sizes.

Twenty-three percent (125) of the park's rare plant species are ranked rare enough to warrant management concern. The Rare Plant Monitoring Program currently addresses only the plant species that have documented disturbances and/or are in decline.

# Introduction

## Purpose

This summary provides an overview of Great Smoky Mountains National Park's Rare Plant Monitoring Program. It also provides the status of the program since its inception. It is intended to inform managers on the progress of the program and serves as a point of reference for park Natural Resource Management staff, particularly those that may be involved in rare plant monitoring.

## Background and Objectives

### *Rationale for rare plant monitoring in GRSM*

Great Smoky Mountains National Park (GRSM) has more than 1,650 vascular plant species. A primary reason GRSM became a national park (1934) and an International Biosphere Reserve (1976) was to preserve this great diversity and abundance of plant species. GRSM is noted for its endemics, peripherals, and disjuncts and the majority of GRSM rare plant species can be placed into one of these phytogeographic categories. Because these plant populations are particularly vulnerable to reduction in numbers or extirpation by human-caused changes in the environment, they demand special attention.

### *Historical development of rare plant monitoring in GRSM*

From the time of park establishment until 1982, park staff made piecemeal attempts to identify sensitive species and their habitats. This included work in 1979 to assign special protection status to sites most vulnerable to disturbance, and the creation of site specific management specifications (Bratton 1979). However, no attempt had been made to locate the most sensitive plant populations in the field or to monitor plant populations based on management objectives. In 1982, Dr. Peter White, a research botanist for GRSM, completed a research project on rare plant populations in GRSM. His work included review of previous work by DeFoe, a park naturalist/interpreter (Peter White, pers.comm) and Bratton (1979); review of specimens at 10 herbaria; review of the Natural Heritage databases of the Tennessee Valley Authority and the states of Tennessee and North Carolina; and field surveys of rare plant populations. Rare plant species were identified and prioritized; locations of the highest priority species were verified in the field, mapped, and, in some cases, population sizes were counted or estimated with assistance and funding from Earthwatch (White 1987).

In 1988, GRSM, in cooperation with The Nature Conservancy (TNC), developed a comprehensive inventory and monitoring program for plant species of special concern. The program was undertaken to protect rare, threatened and endangered species as described in the Endangered Species Act of 1973, State acts, and NPS policy. NPS Management Policies (2006) states "…the Service will inventory other native species that are of special management concern to parks (such as rare, declining, sensitive, or unique species and their habitats) and will manage them to maintain their natural distribution and abundance."

Great Smoky Mountains Natural Heritage Data System was established in conjunction with the Long-term Monitoring Program, to maintain a systematic inventory of rare plant and animal species and locations in GRSM. For plant species, the system captured location habitat and site

descriptions, and was used to rank each species according to abundance and vulnerability to natural or human-caused disturbances. This program also served as a tool to prioritize plant species within the park based on the global, state, and park rarity, and provided the foundation for selecting the rare plant species included in the Rare Plant Monitoring Program.

The Rare Plant Monitoring Program became a part of the park's Long-term Monitoring Program in 1993. In 2001, this program was independently reviewed by two subject matter experts (Dr. Peter White at UNC-Chapel Hill and Rob Sutter, rare plant authority of The Nature Conservancy). At this time, selected plant species were re-evaluated for inclusion into the program. Some species were placed on longer visiting intervals, and some monitoring methods were revised.

***Current program status in GRSM***

GRSM contains 537 rare plant species, 125 (23%) of which are ranked rare enough to warrant management concern. These plant species have federal or state status and are often globally rare or park rare (Table 1). Thirty-six of these species have been monitored within the park's Long-term Monitoring Program since 1993 or, in some cases, since 1989 before the formal program began. Of these species, three are federally listed, and 25 are state-listed as threatened or endangered. Table 2 lists federal and state statuses and park and global ranks of the 36 species currently selected.

**Table 1**. Definitions of statuses and ranks used to guide plant species selection for monitoring.

| Statuses and Ranks | Definition |
|---|---|
| Federal Status | Species status is designated by the U.S. Fish and Wildlife Service. E.g., Endangered, Threatened, or Federal Species of Concern. |
| State Status | Species status is designated by the Tennessee Department of Conservation's Advisory Committee and/or the North Carolina Plant Conservation Program. |
| Park Rank | Park ranks are determined by the botanist and coordinator of the Inventory and Monitoring Program. The total number of individuals, the number of populations, and the threats to the populations are considered throughout the species range in the park. |
| Global Rank | Global ranks are determined by the scientific staff of NatureServe and state natural heritage programs and are the most scientifically objective rankings available. The total number of individuals, the number of populations, and the threats to the populations are considered throughout the species range. |

**Table 2**. Rare plant species monitored in Great Smoky Mountains National Park as of 2010, with federal and state statuses, and rarity ranks.

| Scientific Name | Common Name | Federal[1] Status | *State[2] Status | Park[3] Rank | Global[4] Rank |
|---|---|---|---|---|---|
| *Adlumia fungosa* | Climbing fumitory | | SR/T | P1 | G4 |
| *Betula papyrifera var. cordifolia* | Heart-leaf paper birch | | SR/E | P1 | G5 |
| *Botrychium lanceolatum* | Lance-leaf moonwort | | SR/SR | P1 | G5 |
| *Botrychium matricarifolium* | Daisy-leaf moonwort | | SR/S | P1 | G5 |
| *Calamagrostis cainii* | Cain's reed grass | FSC | E/E | P1 | G1 |
| *Campanula aparinoides* | Marsh bellflower | | SR/S | P1 | G5 |
| *Cardamine clematitis* | Small mountain bittercress | FSC | SR/T | P2 | G2G3 |
| *Cardamine flagellifera* | Blue Ridge bittercress | | /T | P1 | G3 |
| *Cardamine rotundifolia* | American watercress | | SR/S | P1 | G4 |
| *Clematis glaucophylla* | White-leaf leatherflower | | SR/E | P1 | G4? |
| *Dodecatheon meadia* | Shootingstar | | SR/ | P1 | G5 |
| *Dryopteris cristata* | Crested wood fern | | W/T | P1 | G5 |
| *Euphorbia purpurea* | Glade spurge | FSC | SR/ | P1 | G3 |
| *Frasera caroliniensis* | American columbo | | SR/ | P1 | G5 |
| *Geum radiatum* | Spreading avens | E | E/E | P1 | G1 |
| *Glyceria nubigena* | Smoky Mountain manna grass | FSC | T/E | P1 | G2 |
| *Gymnoderma lineare* | Rock gnome lichen | E | E/E | P1 | G1 |
| *Gymnomitrion laceratum* | A liverwort | | /T | P1 | G1 |
| *Helianthus glaucophyllus* | White-leaf sunflower | | W/T | P1 | G3 |
| *Huperzia appalachiana* | Appalachian club-moss | | SR/ | P1 | G4G5 |
| *Hydrastis canadensis* | Goldenseal | | E-SC/S | P1 | G4 |
| *Ilex collina* | Long-stalk holly | | T/ | P1 | G3 |
| *Liparis loeselii* | Fen orchid | | SR/E | P1 | G5 |
| *Panax quinquefolius* | American ginseng | | W/S-CE | P2 | G3G4 |
| *Philadelphus sharpianus* | Sharp's mock-orange | | | P1 | GUQ |
| *Platanthera peramoena* | Purple fringeless orchid | | SR/T | P1 | G5 |
| *Rugelia nudicaulis* | Rugel's ragwort | FSC | T/E | P3 | G3 |
| *Scutellaria saxatilis* | Rock skullcap | | SR/T | P1 | G3 |
| *Silene ovata* | Blue Ridge catchfly | FSC | SR/E | P1 | G2 |
| *Spiraea virginiana* | Virginia spiraea | T | E/E | P1 | G2 |
| *Spiranthes ochroleuca* | Yellow nodding ladies'-tresses | | SR/E | P1 | G4 |
| *Synandra hispidula* | Guyandotte-beauty | | SR/T | P1 | G4 |
| *Thermopsis mollis* | Allegheny golden-banner | | SR /S | P1 | G3G4? |
| *Trichomanes petersii* | Dwarf bristle fern | | T/T | P1 | G3 |
| *Trientalis borealis* | Starflower | | SR/ T | P1 | G5 |
| *Trillium rugelii* | Southern nodding trillium | | W/E | P1P2 | G3 |

* North Carolina/Tennessee

[1]**Federal Status**

| | |
|---|---|
| E | Endangered, a taxon "in danger of extinction throughout all or a significant portion of its range" (Endangered Species Act, Section 3). |
| T | Threatened, a taxon "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (Endangered Species Act, Section 3). |
| FSC | Federal Species of Concern, a species under consideration for listing, for which there is insufficient information to support listing at this time. |

[2]**State Status**

| | |
|---|---|
| E | Endangered, any species or higher taxon whose continued existence as a viable component of the state's flora is determined to be in jeopardy. |
| T | Threatened, any species or higher taxon which appears likely, in the foreseeable future, to become endangered throughout all or a significant portion of its range in the state. |
| S | Special Concern Species, any species or higher taxon that is uncommon in Tennessee, or has unique or highly specific habitat requirements or scientific value and therefore requires careful monitoring of its status. |
| SC | Special Concern, any species of plant in North Carolina which requires monitoring. |
| SR | Significantly rare, any species of plant which is rare in North Carolina but is not listed by the NC Plant Conservation Program as Endangered, Threatened, or Candidate. |
| CE | Commercially exploited, due to large numbers being taken from the wild. |
| W | Watch list, any other species believed to be rare and of conservation concern in the state but not warranting active monitoring at this time. |

[3]**Park Rank**

| | |
|---|---|
| P1 | Five or fewer occurrences with generally small populations: vulnerable to extirpation. |
| P2 | Six to 20 occurrences, uncommon and potentially vulnerable to extirpation. |
| P3 | Twenty-one to 100 occurrences known, uncommon. |
| P4 | Apparently secure probably with many occurrences. |
| P5 | Demonstrably secure; generally encountered or characteristic and dominant. |

[4]**Global Rank**

| | |
|---|---|
| G1 | Extremely rare and critically imperiled, generally with five or fewer occurrences in the world, or very few remaining individuals. |
| G2 | Very rare and imperiled, generally with six to twenty occurrences and less than 3000 individuals. |
| G3 | Very rare and local throughout its range or found locally in a restricted range. Generally between 21 and 100 occurrences and fewer than 10,000 individuals. |
| G4 | Apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery. |
| G5 | Demonstrably secure globally, though it might be quite rare in parts of its range, especially at the periphery. |

### *Measurable Objectives*

Rare plant monitoring in GRSM is designed to detect and measure changes in rare plant populations. There are two monitoring objectives:

1. Determine long-term trends in the distribution and abundance of selected rare plant species.
2. Determine size-class distribution for selected rare plant species to help predict population trends.

# Methods

## Rationale for addressing species by level of monitoring (selecting intensity)

Resources available for rare plant monitoring are limited and for this reason priorities have been set. GRSM priorities are based on a combination of the overall inference of monitoring data (e.g., all populations of a species within the park, a portion of a population within the park),monitoring effort, and frequency of monitoring visits (e.g., is qualitative monitoring adequate?). Monitoring intensity is determined by objectives, species priority, and resources (staff, funding, etc.) (Elzinga et al. 1998). Monitoring can be: 1) qualitative, semi-quantitative; 2) quantitative measure of abundance, qualitative assessment of vigor; or 3) quantitative estimates of abundance and vigor. Listed below are descriptions of the three levels of monitoring used during this program.

### *Level I: Qualitative, semi-quantitative*

Presence/absence, estimates of numbers, photo-points and mapping populations are examples of qualitative, semi-quantitative monitoring. There are strengths and weaknesses associated with this level of monitoring. That it is quick and inexpensive is a strength, but this level of monitoring is not very repeatable and has observer bias.

### *Level II: Quantitative measure of abundance, qualitative assessment of vigor*

Quantitative data would include number of individuals, density, percent cover, or frequency. Strengths of this level of monitoring are that one can detect changes over time, it's repeatable, and data can be analyzed. Weaknesses include no quantitative data on vigor changes or fates of individuals, reproduction and other components of life history, and one can only detect changes in number, not changes in quality.

### *Level III: Quantitative estimates of abundance and vigor*

This level of monitoring entails taking detailed measurements of individuals to determine vigor, reproduction, and seedling establishment (demographic studies) to define quantitative estimates. This level of monitoring is very sensitive to changes and one can learn much about the biology of a species or population. Consuming too many resources or collecting data on more parameters than necessary are drawbacks to this level of monitoring. Table 2 lists the rare plant species currently (2010) monitored in GRSM by monitoring level.

## Rationale for this sampling design (based on potential or documented disturbances)

Table 3 separates the selected rare plant species into monitoring levels. Since the Rare Plant Monitoring Program's inception, 36 plant species have been prioritized for assessment. Many of these species' populations had documented threats before 1993 but have since demonstrated the ability to remain stable. Under these circumstances, the species no longer qualified for Level II or III monitoring. In most cases they were "downgraded" to Level I (usually presence/absence), or put on a longer monitoring interval (as resources allow). Therefore, Table 3 reflects the current (2010) level of these species' populations.

**Table 3**. Current (2010) rare plant species by monitoring level.

| Level I | Level II | Level III |
|---|---|---|
| *Adlumia fungosa* | *Botrychium lanceolatum* | *Panax quinquefolius* |
| *Betula papyrifera var. cordifolia* | *Botrychium matricariifolium* | *Silene ovata* |
| *Calamagrostis cainii* | *Cardamine flagellifera* | |
| *Cardamine clematitis* | *Cardamine rotundifolia* | |
| *Campanula aparinoides* | *Clematis glaucophylla* | |
| *Euphorbia purpurea* | *Dodecatheon meadia* | |
| *Frasera caroliniensis* | *Dryopteris cristata* | |
| *Glyceria nubigena* | *Geum radiatum* | |
| *Helianthus glaucophyllus* | *Gymnoderma lineare* | |
| *Hydrastis canadensis* | *Gymnomitrion laceratum* | |
| *Philadelphus sharpianus* | *Huperzia appalachiana* | |
| *Platanthera peramoena* | *Ilex collina* | |
| *Rugelia nudicaulis* | *Liparis loeselii* | |
| *Spiranthes ochroleuca* | *Scutellaria saxatilis* | |
| *Synandra hispidula* | *Spiraea virginiana* | |
| | *Thermopsis mollis* | |
| | *Trichomanes petersii* | |
| | *Trientalis borealis* | |
| | *Trillium rugelii* | |

## Recommended frequency and timing of monitoring

The frequency of rare plant monitoring can change over time based on changes in rare plant population status, and monitoring is adjusted accordingly. Generally, Level I monitoring occurs less frequently and is represented by the selected monitoring interval in Table 4. Table 4 lists the rare plant species' baseline year (many of which have a baseline year of 1989 before the program was formally accepted as part of the Long-term Monitoring Program in 1993), recommended month of monitoring, monitoring level, and interval. In general, target plants are monitored every year or every other year until their status is deemed secure. The Rare Plant Monitoring Protocol (Rock 2010) provides more detail about methods used and includes data forms in the Appendices.

**Table 4**. Rare plant species with month monitored, disturbances, monitoring level and frequency.

| Scientific Name | Disturbances(s) | Baseline Year | Month | Monitoring Level | Interval |
|---|---|---|---|---|---|
| *Adlumia fungosa* | Road maintenance | 1995 | April | I | 2 years |
| *Betula papyrifera* var. *cordifolia* | Forest succession | 1991 | June | I | 10 years |
| *Botrychium lanceolatum* | Forest succession | 1989 | August | II | 2 years |
| *Botrychium matricariifolium* | Trail maintenance | 1989 | May | II | 2 years |
| *Calamagrostis cainii* | None observed | 1989 | June | I | As resources allow |
| *Campanula aparinoides* | Forest succession | 1989 | July | I | As resources allow |
| *Cardamine clematitis* | None observed | 1992 | May | I | As resources allow |
| *Cardamine flagellifera* | Low reproduction | 1989 | April | II | As resources allow |
| *Cardamine rotundifolia* | Wild boar rooting | 1989 | May | II | 5 years |
| *Clematis glaucophylla* | Road maintenance | 1988 | May | II | 1 year |
| *Dodecatheon meadia* | Trampling, poaching | 1992 | April | I | 2 years |
| *Dryopteris cristata* | Ditching wetland habitat | 1989 | June | II | 2 years |
| *Euphorbia purpurea* | None observed | 1988 | May | I | As resources allow |
| *Frasera caroliniensis* | Deer browsing | 1988 | May | I | 2 years |
| *Geum radiatum* | Trampling, vandalism | 1989 | June | II | 5 years |
| *Glyceria nubigena* | Trail maintenance | 1989 | July | I | As resources allow |
| *Gymnoderma lineare* | Decline of Fraser fir | 1995 | July | II | 2 years |
| *Gymnomitrion laceratum* | None observed | 1999 | July | II | 20 years |
| *Helianthus glaucophyllus* | Forest succession | 1989 | August | I | As resources allow |
| *Huperzia appalachiana* | None observed | 1999 | July | I | As resources allow |
| *Hydrastis canadensis* | Poaching, fungal disease | 1989 | June | I | 2 years |
| *Ilex collina* | Trail maintenance | 1988 | June | I | 10 years |
| *Liparis loeselii* | Roadside maintenance | 1993 | July | II | 1 year |
| *Panax quinquefolius* | Poaching | 1992 | July | III | 1 year |
| *Philadelphus sharpianus* | None observed | 1989 | May | I | As resources allow |
| *Platanthera peramoena* | Deer browsing | 1989 | June | I | As resources allow |
| *Rugelia nudicaulis* | Decline of Fraser fir | 1989 | August | I | As resources allow |

**Table 4**. Rare plant species with month monitored, disturbances, monitoring level and frequency (continued)

| Scientific Name | Disturbances(s) | Baseline Year | Month | Monitoring Level | Interval |
|---|---|---|---|---|---|
| *Scutellaria saxatilis* | Forest succession, non-native plants | 1989 | May | II | 2 years |
| *Silene ovata* | Trail maintenance, lack of natural disturbance | 1989 | August | III | 2 years |
| *Spiraea virginiana* | Non-native plants | 1990 | July | II | 5 years |
| *Spiranthes ochroleuca* | Forest succession, lack of natural disturbance | 1990 | October | I | As resources allow |
| *Synandra hispidula* | None observed | 1989 | May | I | As resources allow |
| *Thermopsis mollis* | Forest succession, lack of fire | 2002 | April | II | 2 years |
| *Trichomanes petersii* | Trail work (one population) | 1998 | April | I | 10 years |
| *Trientalis borealis* | Road work (one population) | 1993 | April | II | 10 years |
| *Trillium rugelii* | Trail maintenance | 1998 | April | II | 2 years |

Species with the time interval "As resources allow" are those species whose populations have been monitored in some cases since the late 1980s and appear to be secure from disturbances.

## Level of change that can be detected

Presuming no sampling error, no statistical analysis is necessary if censusing the entire population. Population changes are real in this case. For the plant species that we were unable to census (when counting was not practical), sampling was employed - that is, measuring only a portion of the population. Given that, a sampling design that allows detection of change at the level of 20% was employed using power analysis.

## Disturbances to rare plant populations

During baseline monitoring, plant populations were assessed for disturbances – documented or potential. Figure 1 shows forest succession and NPS operations, such as roadside mowing or trailside brushing, as being the largest disturbances. Visitor impacts and none-native insects and diseases have great potential for disturbing populations.

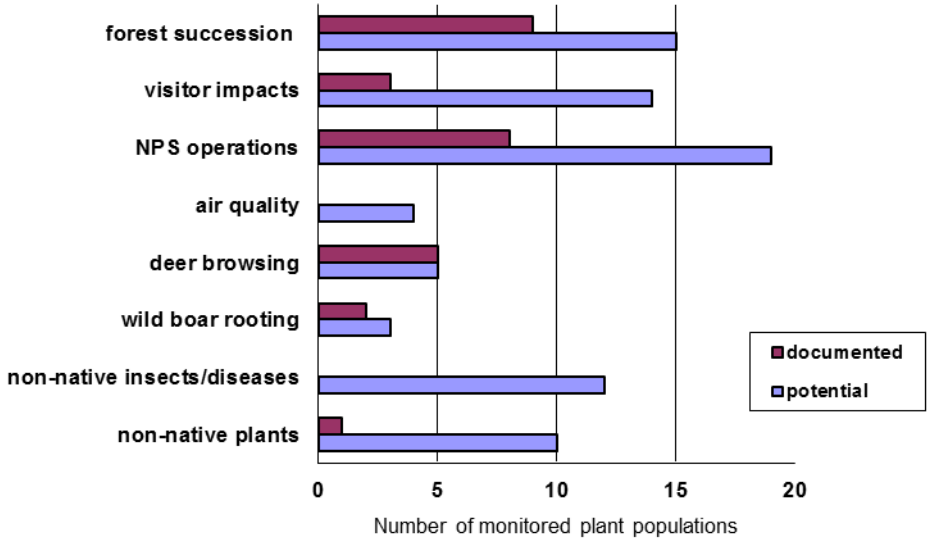



**Figure 1**. Number of rare plant populations in which documented and potential disturbances have been observed.

## Plant Summaries: Status/Recommendations

The following summaries provide an overview to the monitored species in the Rare Plant Monitoring Program. Field data have been stored in the Rare Plant Monitoring Database, an Access database developed in 2004. Before 2004, data were stored in Excel spreadsheets and then migrated into the Access database once the database was developed. The species are presented in alphabetical order.

***Adlumia fungosa* (Climbing fumitory) (Level I)**

This TN threatened species is a biennial and, therefore, blooms every other year. The population was discovered in 1995 and has been monitored in odd years. It is a fragile plant growing in unstable rock and soil, so intensive monitoring (Level II or III) is not advised.

Recommendations: Collect baseline data on an odd year and continue to conduct site checks every two (odd) years.

***Betula papyrifera* var. *cordifolia* (Heart-leaf paper birch) (Level II)**

This is the only rare tree species monitored in the park. It is endangered in TN where the park's population occurs. The population is comprised of individuals of all age classes. Several larger trees were cored in 1991 and their ages ranged from 30 to 50 years. In 2000, a permanent plot was established within the population. An adjacent drainage was searched but no *B. cordifolia* was found.

Recommendations: Recollect permanent plot data and compare to 2000 data. Delineate the population with an accurate GPS if a strong signal is available. Attempt to collect permanent plot data every 10 years.

***Botrychium lanceolatum* var. *angustisegmentum* (Lance-leaf moonwort) (Level II)**
This NC rare species is threatened by campground visitor trampling and forest succession. Over time the population shifted from its baseline location and white pines grew into the understory. White pines were removed in 2001 but the population is still in decline.

Recommendation: Attempt to locate more plants outside of the original population perimeter and continue to manage encroaching vegetation around plants. Continue to monitor every two years.

***Botrychium matricariifolium* (Daisy-leaf moonwort) (Level II)**
This NC and TN listed species became a management concern after the data showed a sharp decline in population size. Raking and a prescribed burn were employed in 1998 to reduce the litter layer that was inhibiting new plants from becoming established. The management tools were effective and the population increased in size by the spring of 1999.

Recommendation: Because raking was as effective as fire and is cost efficient, raking is recommended for management. Inclusion in a larger prescribed burn is desirable as a longer term solution. Continue to monitor every two years.

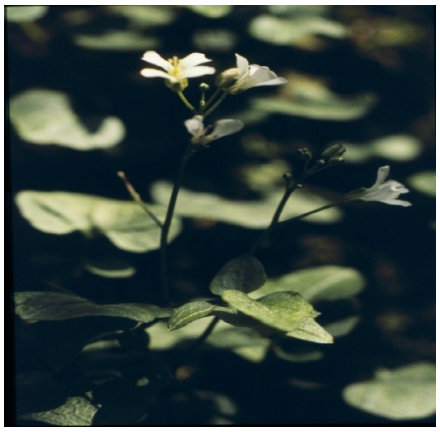
***Calamagrostis cainii* (Cain's reed grass) (Level I)**
Photopoints were established in 1989 and searches were made of this species as part of a high-elevation plant survey (Rock and Boetsch 1999). Only three locations of this strict endemic were found within the park but they are large and secure from disturbance.

Recommendation: Long interval monitoring as resources allow.

***Campanula aparinoides* (Marsh bellflower) (Level I)**

In 1989 there was only one known population of this NC and TN rare species in the park. It occurred in a marsh-like meadow and appeared to be thriving. Over the years the water regime changed and trees grew into the site. Since 1995 the population has been in decline. Some trees have been removed from the site, but no effort has been made to restore the original habitat. Another population was discovered in 1995 and its perimeter was GPSed in 2009. This more recent occurrence is large and healthy and does not seem to be threatened by water table changes or succession.

Recommendation: Efforts should be made to restore the first location as several other park rare plants, although not listed, (*Sabatia campanulata*, *Xyris torta*, *Dulichium arudinaceum*, and *Andropogon glomeratus*) occur at the site. Consultation with a hydrologist could provide the appropriate steps to habitat restoration. Monitor as resources allow.



***Cardamine clematitis* (Small mountain bittercress) (Level I)**

This Federal Species of Concern was part of a high-elevation plant survey (Rock and Boetsch 1999). A predictive habitat model using Mahalanobis Distance, a multivariate modeling technique, was created and the methodology and analyses were published in 2003 (Boetsch et al.). The survey revealed 43 healthy populations within the park.

Recommendation: Surveillance of plant health throughout as resources allow.

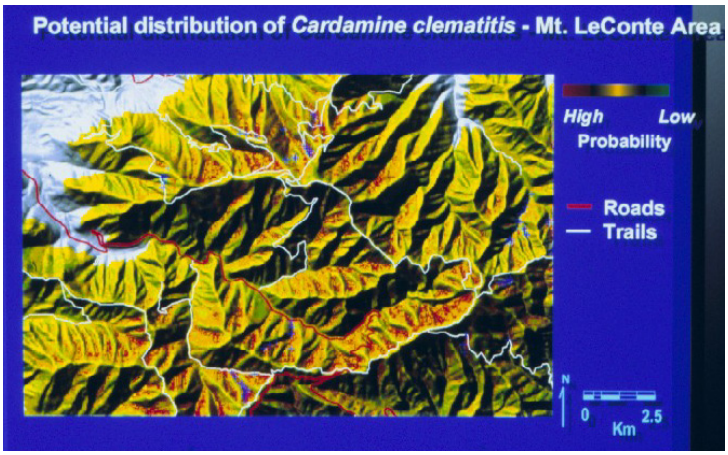



**Figure 2.** Habitat model of *Cardamine clematitis*

### *Cardamine flagellifera* (Blue Ridge bittercress) (Level II)

This TN listed species appears to need disturbance because the park's three populations grow either on steep north-facing slopes or streamside flats where periodic scouring occurs. The monitored population has few fertile rosettes but showed a two-fold increase of sterile rosettes after a prescribed fire in 1997. As of 2001, rosette numbers increased dramatically.

Recommendation: Monitor this population as resources allow. If the rosette count falls below 1998 numbers, a prescribed fire should be scheduled.

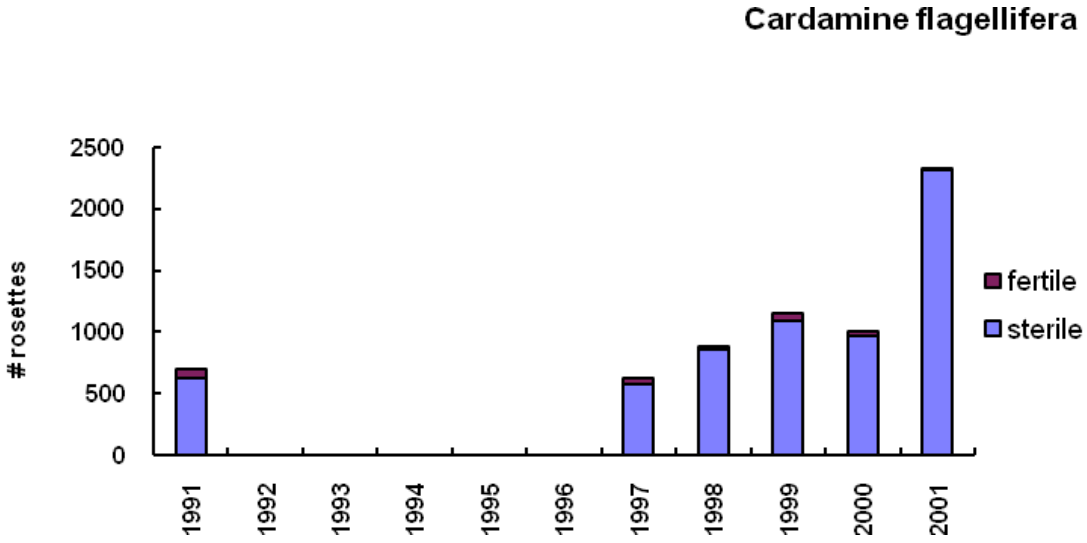



**Figure 3.** Sterile and fertile rosettes of *Cardamine flagellifera*, 1991-2001. The population was not monitored in 1992 through 1996.

***Cardamine rotundifolia* (American watercress) (Level II)**
The park has two populations of this NC and TN listed species. Wild boar rooting has been common during winter months at one of the populations so we implemented a mapping system using transects and a 1x1 meter PVC frame. After several years of following groups of plants (1991- 1996), a decrease due to wild boar activity that caused the plants to uproot and shift location was not detected. Plants have re-established (re-rooted) every growing season. Plants were last counted in 2009 and did not show a decline.

Recommendation: Monitor every five years.

***Clematis glaucophylla* (White-leaf leatherflower) (Level II)**
This TN endangered herbaceous vine is vulnerable to roadside mowing and herbicide treatment by TDOT. It has been monitored periodically over two decades.

Recommendation: Because it is listed in TN as endangered and threats to this population have been documented, monitoring should be done annually. Contact TDOT and sign the roadside "no herbicide."

***Dodecatheon meadia* (Shootingstar) (Level I)**
This is a showy plant in bloom during the annual Gatlinburg's Wildflower Pilgrimage and is therefore monitored. The park's population appears stable although much trampling occurs in the area due to photographing by wildflower enthusiasts.

Recommendation: Check for trampling/poaching every two years.

***Dryopteris cristata* (Crested wood fern) (Level II)**

In 2008, the perimeter of the population was GPSed, baseline data were collected, and plants counted. As long as the water table in the wetland habitat remains at its present level, this population should remain stable. However, because the wetland is in close proximity to a gravel road, alterations to the wetland could threaten the target species.

Recommendation: Notify Facility Management about the wetland. Periodically check to see if damage (e.g., ditching or berming) has occurred. Monitor the population every two years and include the wetland in a wetland restoration proposal if any degradation occurs.

***Euphorbia purpurea* (Glade spurge) (Level I)**

Surveys for populations of this Federal Species of Concern have been conducted since 1988. A large population was located in 1988 and from habitat data, other similar drainages became targets for more surveys. Surveys were conducted during the field season in 1991, 1994-96. Suitable habitat was encountered, but no additional populations were found.

Recommendation: As there appears to be no potential or documented threats, monitor as resources allow.

### *Frasera caroliniensis* (American columbo) (Level I)

*Frasera* was first monitored in 1988 due to deer browsing concerns. Annual counts were attempted until it became obvious that an accurate count could not be made due to the large population size. In 1996, a sampling scheme was employed and the population size was estimated. Concerns of browsing lessened after 1996 as browsed plants were fewer in number. Sampling was discontinued in 2002 as the population appeared secure.

Recommendation: Check on populations as resources allow.

### *Geum radiatum* (Spreading avens) (Level II)

There is only one population in the park of this federally endangered species. The park's population is small and has low genetic variation (Godt et al, 1996). In 1997, rehabilitation of the site was undertaken. The site was closed to alleviate trampling and then, with assistance by the USFWS, the NC Arboretum, and the Knoxville Garden Club, 350 greenhouse-reared seedlings were planted among the existing population. Although few transplanted plants survived due to three consecutive summers of dry weather, recovery of the site is evident using photopoints.

Recommendation: Monitor every five years with assistance from USFWS using their standardized methodology.

### *Glyceria nubigena* (Smoky Mountain manna grass) (Level I)

This species is nearly endemic to the park (only a few locations outside of the park) with low genetic variation (Godt et al. 1995). This species needs light, moisture, and mineral soil in which to get established, and although artificial, trailsides provide suitable habitat. In 1987, a trailside inventory revealed as many as 25% of all clumps were damaged by trail brushing. However, timing of brushing has been such that the seeds are dispersed; individual plants may be harmed, but the populations appear secure.

Recommendation: Repeat the trail inventory as resources allow. This could be combined with another high elevation species, *Rugelia nudicaulis*.

### *Gymnoderma lineare* (Rock gnome lichen) (Level II)

Beginning in 1994, baseline data for this federally endangered lichen was collected and eight colonies at one population were sampled using an acetate grid to determine area covered. In 1999, baseline data were collected at one location along with associated rare species *Gymnomitrion laceratum* and *Huperzia appalachiana*. We sampled two additional populations in 2001. In 2009, we began developing a protocol using a digital camera and imaging software. This is still in progress and could prove useful to the scientific community involved in monitoring on a small scale (non-vascular plants or lichens).

Recommendation: Complete the protocol and test as soon as possible. Monitor every two years.

***Gymnomitrion laceratum* (A liverwort) (Level II)**
Baseline data were established for this TN listed liverwort at one location in 1999 along with two associated rare plant species, *Gymnoderma lineare* and *Huperzia appalachiana*.

Recommendation: Monitor every 20 years as this is a slow-growing plant and has no observed threats.

***Helianthus glaucophyllus* (White-leaf sunflower) (Level I)**
Three populations have received monitoring since 1988 to 1989; all occur along roadsides with one part of a population occupying a powerline cut. The extent of one population was GPSed in 2008 revealing this species to be more secure in the park than previously believed.

Recommendation: Monitor as resources allow.

***Huperzia appalachiana* (Appalachian clubmoss) (Level I)**
Baseline data were established for this NC and TN listed species at one location in 1999 along with two associated rare plant species, *Gymnoderma lineare* and *Gymnomitrion laceratum*.

Recommendation: Monitor as resources allow for this is a slow-growing plant and has no observed threats.

### *Hydrastis canadensis* (Goldenseal) (Level I)

This species is listed as threatened in NC. The only known population in the park was monitored from 1989 through 2008. The population developed a native fungal disease in 1991 and the number of stems decreased. Experimental clipping and raking were performed in 1991 to reduce the infection with good results. A prescribed fire was introduced to the population in 1997, also with good results. Reports of additional populations have been received and several more populations have been verified and GPSed.

Recommendation: Obtain GPS points or perimeters for all reported NC locations. Monitor as resources allow.

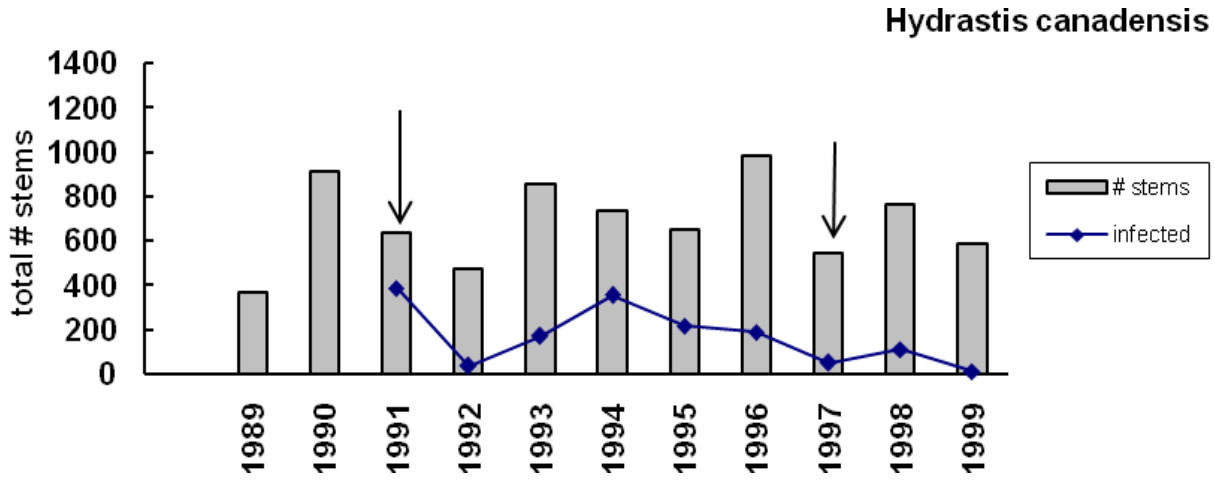



**Figure 4**. *Hydrastis* leaf blight and experimental control results. Arrows indicate year of treatment.

***Ilex collina* (Long-stalk holly) (Level I)**
One population of this southern Appalachian endemic shrub occurs trailside in the central portion of GRSM. Stems were counted in 1988, but no formal monitoring has been conducted since. Periodic monitoring shows the population to be stable. Several more remote populations of this species have since been located.

Recommendation: Monitor every 10 years.

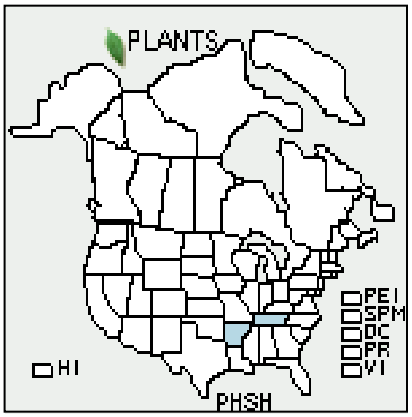
***Liparis loeselii* (Fen orchid) (Level II)**
This NC and TN listed species requires open moist areas with a mycorrhizal fungi association that limits its distribution. Roadside mowing has been an issue; one population was extirpated due to a combination of mowing during flowering and possible depletion of the fungus at the site (Sheviak, pers. comm.). Timing of mowing is critical if the park's remaining population is to survive.

Recommendation: Monitor every year and work with Facilities Management to adjust the mowing schedule.

***Panax quinquefolius* (American ginseng) (Level III)**
Park law enforcement rangers have seized nearly 12,000 ginseng roots from poachers since 1992. More than 9,000 roots have been weighed and aged by staff to track the health of ginseng populations throughout the park, and undamaged roots have been replanted for monitoring. Roots as young as one to three years have been aged and weighed. Ginseng plants younger than five years are usually not reproductively mature. There are approximately 50 sites throughout the park, many of which have not been monitored since 1995.

Results from a four-year demographic study suggest that park populations need a minimal viable population (MVP) of 510 plants (Gagnon et al. 2006) and 300 plants have a 95% chance of persisting over the next 60 years with good climate conditions (D. Gagnon, pers. comm.). However, poaching devastates populations before they get to this size.
Genetic analysis using Randomly Amplified Polymorphic DNA (RAPD) markers showed the park's ginseng possesses unique genetic integrity and may represent a distinct center of genetic diversity when compared to wild ginseng populations in Pennsylvania and Wisconsin (Boehm et al. 1999). To lose, or even reduce, populations of ginseng on a local scale will represent a significant loss for the species as a whole.

Recommendation: All sites need to be GPSed and plants monitored to assess the health of these populations and incidence of poaching. Annually monitor a selection of 10 sites so that all sites receive monitoring at least every five years.




***Philadelphus sharpianus* (Sharp's mock-orange) (Level I)**
The park's only known population and type locale for the species is comprised of about 42 stems. Believed by some to be just a morph and not a distinct taxon, it is still listed as a distinct taxon by the Integrated Taxonomic Information System (ITIS). This population has not been visited since baseline data were collected in 1990, but it is believed to be secure.

Recommendation: Obtain genetic analysis of this taxon to verify its taxonomic status.

***Platanthera peramoena* (Purple fringeless orchid) (Level I)**
Searches have been made over the years to relocate the one known population of this NC listed orchid that was last seen in bud (one plant) in 1982. This population is now believed extirpated due to deer browsing as the population hasn't been seen in over two decades and occurred in an area of high deer density. One plant was discovered growing in an adjacent field in 1995, but it has not been seen since.

Recommendation: Continue surveys as resources allow, and protect from deer through exclusion if found.

***Rugelia nudicaulis* (Rugel's ragwort) (Level I)**
This is a strict Smoky Mountain endemic and, therefore, considered globally rare. This species was monitored in six plots from 1989 to 1999. Fertile crowns peaked in 1993 but crown numbers and flowering declined due to an increase in Fraser fir seedling and sapling cover. This species possesses low genetic diversity (Godt et al.) however populations are very extensive and, where it occurs, is often the dominant herb. The loss of Fraser fir does not appear to pose a problem to the species as a whole because this endemic grows in other mid to high elevation forest types. Peter White conducted a comprehensive trailside survey of this species in 1981, but this survey has not been repeated.

Recommendation: Repeat trailside survey as resources allow. This can be combined with another high elevation trailside species, *Glyceria nubigena*.

### *Scutellaria saxatilis* (Rock skullcap) (Level II)

This NC and TN listed species was in decline in 1998 through 2000. Mechanical clearing in 2001 had a positive effect, but a non-native grass, *Microstegium vimineum*, is at the site and needs to be routinely pulled.

Recommendation: Continue monitoring the population every two years, pull encroaching *Microstegium*, and prune branches and remove saplings if plant numbers decline. Verify a reported population and, if located, establish baseline monitoring.

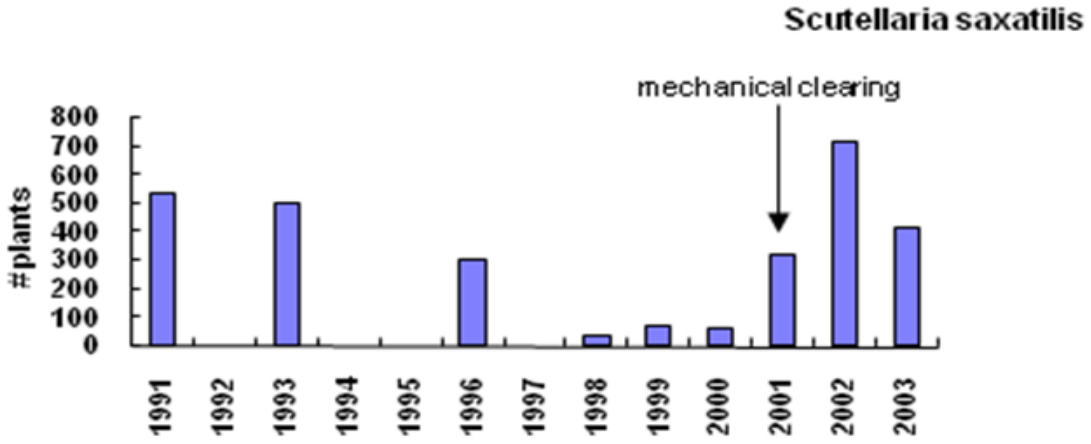



**Figure 5**. *Scutellaria* response to mechanical clearing. 1992, 1994, 1995, and 1997 monitoring did not take place.

### *Silene ovata* (Blue Ridge catchfly) (Level III)

Six populations of this NC and TN listed species have been monitored over the past two decades. All populations are small (ca. two to 16 clumps) and occur in trailside habitat in the eastern portion of the park. A small prescribed fire was conducted on one population in 2000 which stimulated more stems and flowering the following year. The smallest population was mechanically cleared of nearby saplings with no apparent effect.

Recommendation: Continue monitoring all populations every two years. Consider including some of the populations in larger prescribed burns and then monitor every year for several years.

***Spiraea virginiana* (Virginia spiraea) (Level II)**

This federally threatened shrub is located in a remote drainage on the western end of the park. The population of four clones was accurately GPSed for the first time in 2008. Stems of clones were counted and mapped

Recommendation: Monitor the population every five years to check for changes in number and health of clones.

***Spiranthes ochroleuca* (Yellow nodding ladies' tresses) (Level I)**

This NC and TN listed orchid was last seen on the TN side of the park in 1958 where it is listed as endangered. Several TN locations were searched based on historical records with no success in finding plants. This species is more secure on the NC side of the park and roadside mapping has been successful.

Recommendation: Complete roadside searches in potential habitat as resources allow.

***Synandra hispidula* (Guyandotte-beauty) (Level I)**

The park's only population of this NC listed species was believed to be threatened by wild hog rooting and deer browsing. A biennial, there are essentially two populations, odd numbered years having the larger population. Both populations were monitored for a decade, but it became apparent that this species was secure and did not require further monitoring. It has been placed in Level I

Recommendation: GPS perimeter of population as resources allow.

***Thermopsis mollis* (Allegheny golden-banner) (Level II)**

This population was originally believed to be that of *T. fraxinifolia* (threatened in TN) due to taxonomic difficulties. Baseline data were collected in April 2002 and 2003 as a consequence. A master's student researching the genus *Thermopsis* subsequently identified it as *T. mollis* which is listed as special concern, a lower listing than threatened. The population appears stable, but its habitat would benefit from fire.

Recommendation: Schedule a burn within the next few years. Monitor every five years.

***Trichomanes petersii* (Dwarf bristle fern) (Level I)**

The park has nine known populations of this NC and TN listed fern. All populations were monitored in 1998. An effort was made in 2008 to relocate all nine populations and to obtain a GPS point upon documenting population size and vigor. All nine populations were found to be secure.

Recommendation: Monitor every 10 years.

***Trientalis borealis* (Starflower) (Level II)**

Baseline data were collected on a population of this NC and TN listed species in 1993 on the TN side of the park. No threats were observed. A NC population was reported in 2008 which led to collection of baseline data and a census. No threats were observed.

Recommendation: Monitor every 10 years.

***Trillium rugelii* (Southern nodding trillium) (Level II)**

Listed as endangered in TN, an effort to locate the five known populations in the park in 1998 was successful and baseline data were collected at three. Counts were made of fertile and sterile plants.

Recommendation: Obtain accurate GPS points or polygons as this species occurs primarily near developed areas. Monitor three TN populations every two years.

# Discussion, recommendations, and conclusion

## Discussion

The park is currently monitoring 36 of the 125 rare plant species that have state or federal listing. Most rare plant populations in the park have an unknown status. These have not been included in the monitoring program. Plant species new to the park are discovered every year. Since 1998, when the All Taxa Biodiversity Inventory (ATBI) began, the park has added 66 new native plant records.

Park operations (e.g., trail reroutes), wild boar rooting, visitor impacts, deer browsing, non-native insects and diseases, non-native plants, and poaching are major threats to rare plants. Climate change has the potential to affect rare plant populations as well. It is important to know where these rare species occur in the park and the plant species they are associated with in order to protect them.

Changes in precipitation, temperature, solar radiation, and wind events, have both primary and secondary effects on plant communities and individual plant species. Because so many rare plants are disjuncts, peripherals, or endemics, they may be more sensitive to these changes than wider-ranging rare species.

Unfortunately, new exotic forest diseases and insects such as Hemlock woolly adelgid and Beech bark disease have been discovered in the park since the Rare Plant Monitoring Program began. Hopefully long-term monitoring of rare plant populations will reveal the impacts of these newcomers and populations can be managed accordingly.

## Recommendations

### *Advance planning/scheduling*

Monitoring for highest priority rare plant populations should be scheduled several years out to ensure there is adequate staff to conduct the appropriate level of monitoring. An effort should be made by managers to add additional rare plant species to the monitoring program since there are many more species (of the 125) that warrant some level of monitoring. Focus should be on state threatened and endangered plant species first as opposed to park rare plant species that have no state listing. Figure 6 presents the number of rare plant species by monitoring interval. Approximately 10 plant species will need to be monitored annually when taking into account at least half of the two year interval species (12 total) should be monitored on an annual basis.

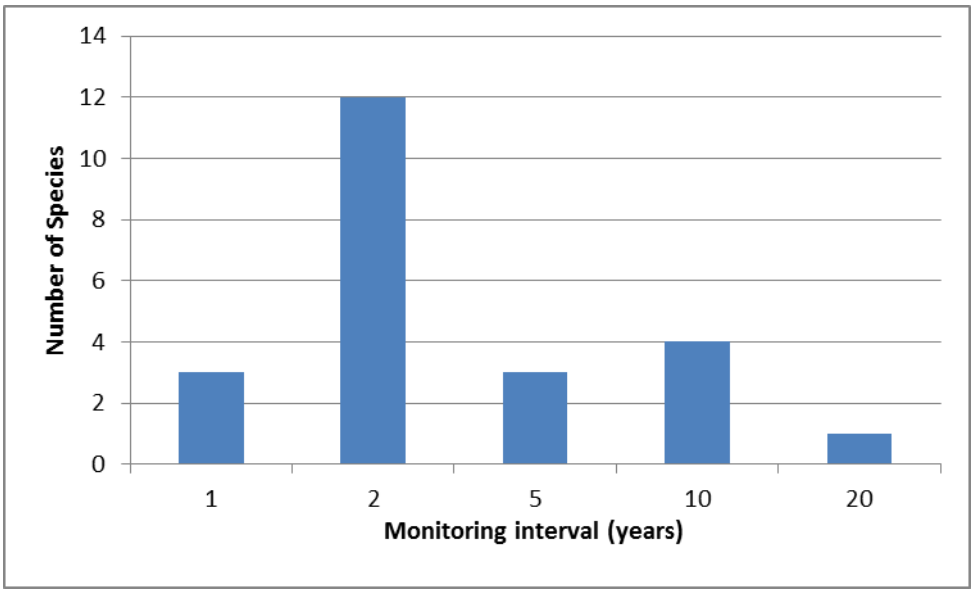



**Figure 6**. Number of rare plant species sorted by monitoring interval.

### *Rare Species GeoDatabase Completion*

Development of a Rare Species GeoDatabase was initiated in 2010 to accommodate population attribute and location data collected in the GRSM Rare Plant Monitoring Program. This database, once finalized, should streamline the park's compliance process (PEPC) by offering quick geographic displays of rare plants, animals, and natural communities with their level of rarity. It will serve as the database to consult prior to park projects and also serve as a quick reference in the event of a wildfire or other unanticipated events. This database will assist park managers in making decisions concerning park operations, such as prescribed fires or fire suppression, maintenance of roads and trails, construction, archaeological investigations, wild boar control, and visitor disturbance. A focused effort should be made to finalize the database and make available to park managers.

### *GPS Accuracy*

An accurate GPS (sub-meter) is necessary for rare plant population documentation and delineation (currently crews are using a Trimble XT with this accuracy). With the appropriate software such as ArcPad, data on location, population description, and measurements can be made in the field and then uploaded into the Rare Species GeoDatabase with little difficulty. Park staff determined that having plant monitoring data available instantaneously is a high priority and will reduce plant damage or worse, extirpation due to the park's high visitation rate and park operation issues. Having the ability to notify rangers or park maintenance staff of areas that need to be protected from visitation or mowing operations in a timely manner will help protect rare plants at GRSM. A recommendation is to obtain additional sub-meter GPS units so that all rare plant monitoring crews have the ability to upload monitoring data in the field.

### *Collectible Plant Species*

Special attention should be given to collectible species that may not be listed at the state or federal level. These species include orchids, ramps, ginseng, and other medicinal plant species.

Information exchange and coordination with state and federal agencies can provide an early warning as to which species are under pressure. Communicate to law enforcement rangers annually through PowerPoint presentations showing vulnerable plant species so that the rangers can provide more surveillance. These plant species may require some level of monitoring and will be added to the Rare Plant Monitoring Program if poaching pressure occurs.

***Create a Management Team***

Population-specific front-country management needs should be determined through a task force that involves both Natural Resource Management staff (I&M branch coordinator, botanist, and ecologist) and Facilities Management staff (roads and trails foremen). This group could share ideas and develop appropriate projects through a series of meetings. Using the Project Management Information System (PMIS) to ensure rare plant considerations are included early in the planning process should be emphasized.

***Inform Managers***

The botanist should summarize the status of rare plants annually and send briefs to the Chief of Natural Resource Management and Science. Staff in Facilities Management and Resource Education should be made aware of vulnerable populations that may be affected by their operations.

***Volunteer/Student Outreach***

The botanist should work with the Resource Education Division to reach out to volunteers and students to adopt rare plant populations for citizen science monitoring. Programs that have been successful in recruiting volunteers include Great Smoky Mountains Institute at Tremont (http://www.gsmit.org/volunteer.html) and the Appalachian Highlands Learning Resource Center at Purchase Knob (http://www.nps.gov/grsm/naturescience/pk-homepage.htm).

***Organize Rare Plant Files***

The rare plant files (electronic/paper and photos) should be organized to reflect the recommendations in this document. Scan paper files which include sketch maps of rare plant locations and archive them according to the Rare Plant Monitoring Protocol archiving procedures (Rock 2010).

***Monitoring***

Table 5 lists the 36 rare plant species with recommendations from the summaries in this document.

**Table 5**. Recommendations for monitored rare plant species

| Scientific Name (Common Name) | Recommendation |
|---|---|
| *Adlumia fungosa* (Climbing fumitory) | Collect baseline data on an odd year and conduct site checks every two (odd) years. |
| *Betula papyrifera* var. *cordifolia* (Heart-leaf paper birch) | Recollect permanent plot data and compare to 2000 data. Delineate the population with an accurate GPS if a strong signal is available. Attempt to collect plot data every 10 years. |
| *Botrychium lanceolatum* var. *angustisegmentum* (Lance-leaf moonwort) | Attempt to locate more plants outside of the original population perimeter and continue to manage encroaching vegetation around plants. Continue monitoring every two years. |
| *Botrychium matricariifolium* (Daisy-leaf moonwort) | Because raking was as effective as fire and is cost efficient, raking is recommended for management. Inclusion in a larger prescribed burn is desirable as a longer term solution. Continue monitoring every two years. |
| *Calamagrostis cainii* (Cain's reed grass) | Long interval monitoring as resources allow. |
| *Campanula aparinoides* (Marsh bellflower) | Efforts should be made to restore the first location as several other park rare plants, although not listed, (*Sabatia campanulata*, *Xyris torta*, *Dulichium arudinaceum*, and *Andropogon glomeratus*) occur at the site. Consultation with a hydrologist could provide the appropriate steps to habitat restoration. Monitor as resources allow. |
| *Cardamine clematitis* (Small mountain bittercress) | Surveillance of plant health throughout as resources allow. |
| *Cardamine flagellifera* (Blue Ridge bittercress) | Monitor this population as resources allow. If the rosette count falls below 1998 numbers, a prescribed fire should be scheduled. |
| *Cardamine rotundifolia* (American watercress) | Monitor every five years. |
| *Clematis glaucophylla* (White-leaf leatherflower) | Because it is listed in TN as endangered and threats to this population have been documented, monitoring should be done annually. Contact TDOT and sign the roadside "no herbicide." |
| *Dodecatheon meadia* (Shootingstar) | Check for trampling/poaching every two years. |
| *Dryopteris cristata* (Crested wood fern) | Notify Facility Management about the wetland. Periodically check the wetland to see if damage (e.g., ditching or berming) has occurred. Monitor the population every two years and include the wetland in a restoration proposal if any degradation occurs. |
| *Euphorbia purpurea* (Glade spurge) | As there appears to be no potential or documented threats, monitor as resources allow. |
| *Frasera caroliniensis* (American columbo) | Check on populations as resources allow. |
| *Geum radiatum* (Spreading avens) | Monitor every five years with assistance from USFWS using their standard methodology. |
| *Glyceria nubigena* (Smoky Mountain manna grass) | Repeat the trail survey as resources allow. This could be combined with another high elevation species, *Rugelia nudicaulis*. |
| *Gymnoderma lineare* (Rock gnome lichen) | Complete the protocol and test as soon as possible. Monitor every two years, |
| *Gymnomitrion laceratum* (A liverwort) | Monitor every 20 years as this is a slow-growing plant and has no observed threats. |
| *Helianthus glaucophyllus* (White-leaf sunflower) | Monitor as resources allow. |
| *Huperzia appalachiana* (Appalachian clubmoss) | Monitor as resources allow as this is a slow-growing plant and has no observed threats. |
| *Hydrastis canadensis* (Goldenseal) | Obtain GPS perimeters and points for reported locations. Monitor as resources allow. |
| *Ilex collina* (Long-stalk holly) | Monitor every 10 years. |

**Table 5**. Recommendations for monitored rare plant species (continued)

| Scientific Name (Common Name) | Recommendation |
|---|---|
| *Liparis loeselii* (Fen orchid) | Monitor every year and work with Facilities Management to adjust the mowing schedule. |
| *Panax quinquefolius* (American ginseng) | All sites need to be GPSed and plants monitored to assess the health of these populations and incidence of poaching. Annually monitor a selection of 10 sites so that all sites receive monitoring at least every five years. |
| *Philadelphus sharpianus* (Sharp's mock-orange) | Obtain genetic analysis of this taxon to verify its taxonomic status. |
| *Platanthera peramoena* (Purple fringeless orchid) | Continue surveys as resources allow and protect from deer through exclusion if found. |
| *Rugelia nudicaulis* (Rugel's ragwort) | Repeat trailside survey as resources allow. This can be combined with another high elevation trailside species, *Glyceria nubigena*. |
| *Scutellaria saxatilis* (Rock skullcap) | Continue monitoring the population every two years, pull encroaching *Microstegium*, and prune branches and remove saplings if plant numbers decline. Verify a reported population and, if located, establish baseline monitoring. |
| *Silene ovata* (Blue Ridge catchfly) | Continue monitoring all populations every two years. Consider including some of the populations in larger prescribed burns and then monitor every year for several years. |
| *Spiraea virginiana* (Virginia spiraea) | Monitor every five years to check for changes in number and health of clones. |
| *Spiranthes ochroleuca* (Yellow nodding ladies' tresses) | Complete roadside searches in potential habitat as resources allow. |
| *Synandra hispidula* (Guyandotte-beauty) | GPS perimeter of population as resources allow. |
| *Thermopsis mollis* (Allegheny golden-banner) | Schedule a burn within the next few years. Monitor every five years. |
| *Trichomanes petersii* (Dwarf bristle fern) | Monitor every 10 years. |
| *Trientalis borealis* (Starflower) | Monitor every 10 years. |
| *Trillium rugelii* (Southern nodding trillium) | Obtain accurate GPS points or polygons because this species occurs primarily near developed areas. Monitor three TN populations every two years. |

Top priority plant species are presented below:

**Priority 1 -** Federally listed plant species (*Geum radiatum*, *Gymnoderma lineare*, and *Spiraea virginiana*)

**Priority 2 -** State threatened or endangered plant species with documented threats (*Botrychium lanceolatum*, *Clematis glaucophylla*, *Liparis loeselii*, *Scutellaria saxatilis*, and *Silene ovata*).

## Conclusion

The Rare Plant Monitoring Program has been successful in monitoring 36 rare plant species. Populations have been managed through prescribed burns, mechanical clearing, or raking to increase numbers, vigor (plant height, reproductive status), and health (lack of insect or disease damage). A list of accomplishments follows:

- Prescribed burns have led to population increases in three species (*Botrychium matricarifolium*, *Cardamine rotundifolia*, and *Silene ovata*).
- A prescribed burn has led to a decrease in fungal infection in one species (*Hydrastis canadensis*).
- Raking has led to a population increase in one species (*Botrychium matricariifolium*).
- One of three populations comprised of two species responded positively to mechanical clearing (*Scutellaria saxatilis* and *Silene ovata*).
- Thirteen species are considered secure after several years of monitoring or locating more populations and can now be monitored as resources allow.

Twenty-one species still warrant monitoring at some level and intensity. This can be achieved through careful planning and current resources.

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NPS 133/120296, April 2013

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