Managing Rare Plant Populations With Fire in Great Smoky Mountains National Park

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Abstract

Previous to 1996, wildland fires were effectively excluded from Great Smoky Mountains National Park (GSMNP) for over 60 years. The National Park Service now recognizes the importance of fire as a natural disturbance and considers fire a critical disturbance factor in GSMNP. A Management Ignited Prescribed Fire Program, part of the Park's Fire Management Plan, was created to address some resource management objectives. Prescribed fire is now being used as a tool to enhance natural resources such as rare plant populations. Four rare plant species have been managed by prescribed fire since 1997 and all populations have responded with increased plant numbers and vigor. Based upon our success, two additional species are scheduled for management by prescribed fire in 2000.

Introduction

Fire has been excluded from Great Smoky Mountains National Park (GSMNP) since the Park's establishment (1934). An approved Fire Management Plan (1996), and the institution of a Fire Management Program, has allowed GSMNP to restore an important natural disturbance to various natural communities as well as individual plant populations. A Rare Plant Program was initiated in 1989 to monitor rare plant populations and, if these species were observed to be declining, to manage these populations in order to stabilize or reverse the trend. Currently, the following four rare plant species are being managed with prescribed fire:

- Daisy-leaved moonwort (*Botrychium matricariifolium* A. Braun)
- Bittercress (*Cardamine flagellifera* O. E. Schulz)
- Goldenseal (*Hydrastis canandensis* L.)
- Indian grass (*Sorgastrum nutans* (L.) Nash)

Southern Appalachian cove forests are typically affected by small-scale, mild disturbances such as tree falls, and many rare plant species require some level of disturbance in order to survive (Denslow 1987). Through our monitoring efforts, we determined that two species – Daisy-leaved moonwort and Bittercress – appeared to require some leaf litter disturbance to stimulate germination and thrive. We chose prescribed fire to create disturbance to the leaf litter although fires were relatively infrequent within these mountains in general, and north-facing lower slopes have the lowest incidence of fire (Harmon 1982). Three populations (Daisy-leaved moonwort, Bittercress, and Goldenseal) are located on north-facing slopes (elevation range 381-686 meters) in mixed mesophytic hardwoods. In addition, GSMNP's single population of Goldenseal was infected with a native fungus, *Streptobotrys streptothrix,* and fire was used to reduce the sclerotia of the fungus which overwinter in leaf litter. The fourth species, Indian grass, has been negatively affected by annual mowing and competition from non-native Fescue (*Festuca pratensis*). Prescribed fire was used to stimulate flowering in the native grass.

Methods

Daisy-leaved moonwort

Two populations of Daisy-leaved moonwort (*Botrychium matricariifolium* A. Braun), a small, primitive fern (3-19 cm in height), are known to occur in GSMNP. This species is listed as significantly rare in North Carolina and as a species of special concern in Tennessee. One population is comprised of 42 plants and the other approximately 114 plants, or fewer, depending on the year.

Their habitat is second-growth tulip poplar (*Lirodendron tulipifera*), red maple (*Acer rubrum*), and Eastern hemlock (*Tsuga canadensis*). We chose the larger population for management. A trail bisects the population creating a light gap. Disturbance to the leaf litter layer periodically occurs from episodes of heavy rainfall, wild boar rooting (usually in the winter), and hikers. The population is north-facing with a slope of 5-50 percent (elevation 686 meters).

Two permanent transects (21 meters and 10 meters) were established in the study population in 1991, and plants occurring within three meters of each transect were mapped. Since 1991, plants were most abundant in locations devoid of leaf litter and duff. Due to a severe decline in plant numbers in 1997 (67 percent), fire and raking were selected as management tools. Mapped plants were used as a guide to establish three 7 meter x 10 meter treatment plots to which we applied three different management techniques: (1) fire to decrease leaf litter and duff, (2) raking, and (3) no treatment in March 1998.

Bittercress

Bittercress (*Cardamine flagellifera* O. E. Schulz), a stoloniferous perennial, is listed as state threatened in Tennessee. The Park has three known populations and two are actively monitored due to potential threats (e.g. wild boar rooting and deer browsing). Baseline data were collected at one population in 1989 and censused in 1991.

The study population is on a north-facing slope in second-growth mesic hardwoods comprised of tulip poplar, red oak (*Quercus rubra*) and white oak (*Quercus alba*) (elevation 610 meters). Due to a decrease in rosettes observed in April 1997 (16 percent), a portion of the population was burned in September 1997. The study population was re-censused in April 1998.

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Goldenseal

Goldenseal (*Hydrastis canadensis* L.) is a highly valued perennial herb with thick yellow rhizomes. This plant is listed in the Convention on International Trade of Endangered Species (CITES) Appendix II (USFWS/OSA 1997), and is state-listed as endangered in North Carolina and threatened in Tennessee due to over-collection and habitat loss. The Park has one population comprised of two colonies (subpopulations 1 and 2). Goldenseal prefers rich moist woods, and in GSMNP it is found growing in mesic second-growth woods comprised of sugar maple (*Acer saccharum*), American beech (*Fagus grandifolia*), red oak (*Quercus rubra*), and Eastern hemlock on a north-facing slope of 50 percent (elevation is 381 meters).

Data has been collected each year since 1989. In 1991 a native fungal disease, identified as *Streptobotrys streptothrix*, was observed on the stems and leaves throughout the population (Alan Windham, University of Tennessee Agricultural Extension Agency). Subpopulation 1 showed the highest incidence of infection, and by June 1991 it was observed that the total number of stems had decreased by 30 percent in just one year.

Based on Windham's recommendation, in September 1991 leaves and stems were clipped, bagged, and removed from the site in both subpopulations. Leaf litter directly under the stems was bagged and removed from the site as well. In addition, in March 1998, a low-intensity fire was set at subpopulation 1 in order to consume sclerotia of the fungus overwintering in the leaf litter layer.

Indian grass

Indian grass (*Sorgastrum nutans* (L.) Nash) is a warm-season grass. Increase in Indian grass stems after burning is well-documented (Dix and Butler 1954; Robocker and Miller 1955; Kucera and Ehrenreich 1962; Hadley and Kieckhefer 1963; Anderson and others 1970). Scattered populations occur on the western end of the Park, particularly in open fields in Cades Cove. It has been suppressed as a result of haying operations since the 1940s, and is out-competed by a non-native cool-season grass, Fescue (*Festuca pratensis*). To stimulate flowering (Kucera and Ehrenreich 1962) and encourage the spread of Indian grass into larger areas, we experimented with a late-fall burn in 1997. Three 50 meter x 3 meter belt transects were established to facilitate counting fertile stems before and after the treatment.

Results and Discussion

Daisy-leaved moonwort

The population responded favorably to both treatments, prescribed fire and raking (23 plants in 1997 to 114 plants in 1999) (Figs. 1-4). The fire treatment showed a 35 percent increase in plants and the raking treatment showed a 33 percent increase. The control has shown no increase.

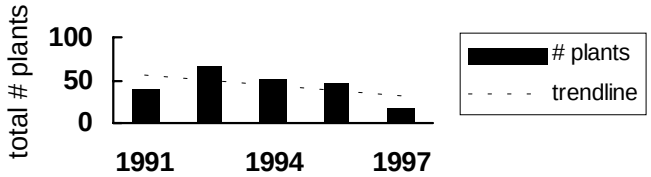

Figure 1.—Number of Daisy-leaved moonworts (*Botrychium matricariifolium*) before the 1998 spring fire.

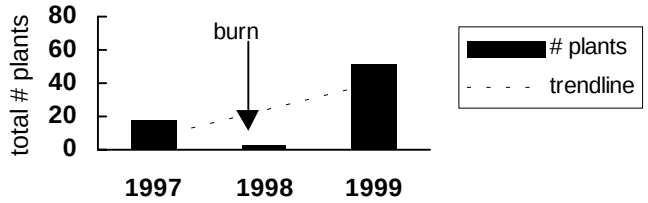

Figure 2.—Number of Daisy-leaved moonworts (*Botrychium matricariifolium*) after the 1998 spring fire.

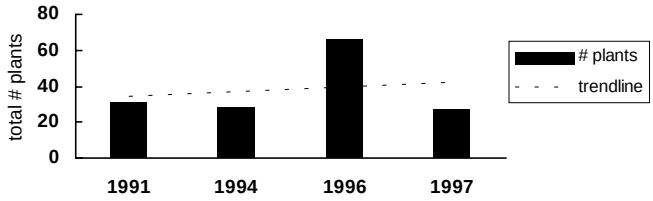

Figure 3.—Number of Daisy-leaved moonworts (*Botrychium matricariifolium*) before 1998 spring raking.

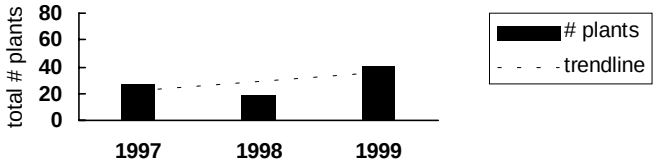

Figure 4.—Number of Daisy-leaved moonworts (*Botrychium matricariifolium*) after 1998 spring raking.

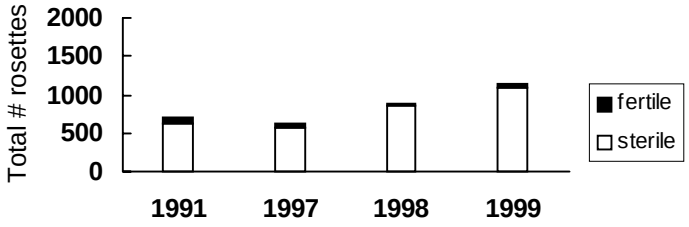

Figure 5.—Number of fertile and stertile Bittercress (*Cardamine flagellifera*) rosettes 1991-1999 in burned portions of the population.

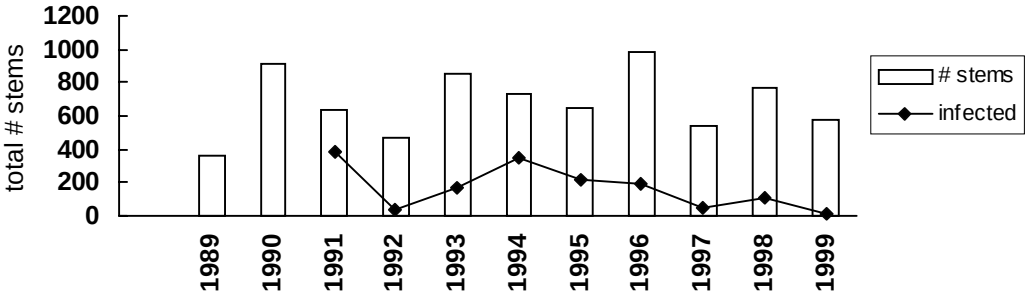

Figure 6.—Number of Goldenseal (*Hydrastis canadensis*) stems in subpopulation 1 from 1989-1999 with number of infected stems.

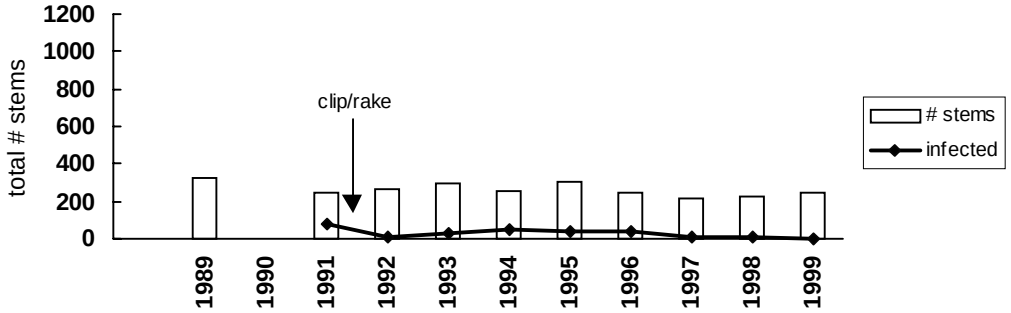

Figure 7.—Number of Goldenseal (*Hydrastis canadensis*) stems in subpopulation 2 from 1989-1999 with number of infected stems.

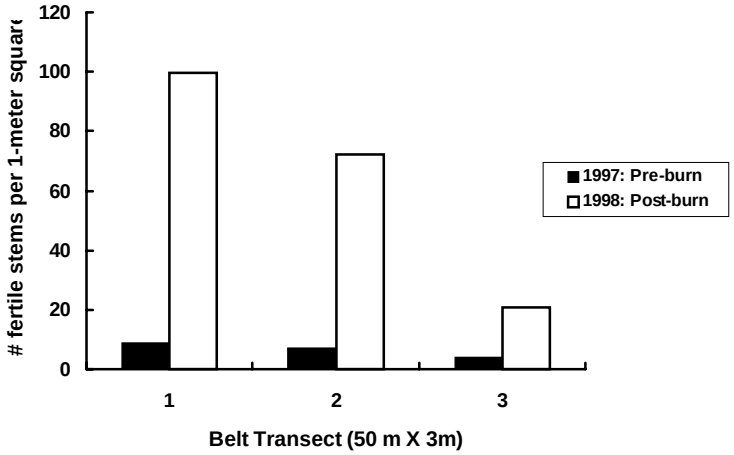

Figure 8.—Average number of fertile stems per 1-meter square in Indian grass population (*Sorgastrum nutans*) before fire (1997) and after fire (1998).

Bittercress

A 27 percent increase in rosettes was observed from 1998 to 1999, all within the burned portion of the study site. In addition, fertile rosettes showed a twofold increase (118 percent) after prescribed fire (Fig. 5).

Goldenseal

After our first treatment (clipping, etc.), a large reduction in diseased stems was documented in 1992 (90 percent). Subsequently, diseased stems in subpopulation 1 more than doubled (110 percent increase) from 1993 to 1994 (two years after our first treatment) (Fig. 6). However, the incidence of disease again decreased in 1995 without intervention. An additional 93 percent decrease in infected stems in this subpopulation was observed from 1998 to 1999 following our second treatment (prescribed fire) in March 1998 (Fig. 7). Data indicates both treatments (clip and rake, or burn) are effective management tools.

Indian Grass

Indian grass responded favorably to prescribed fire. Average number of fertile stems per 1-meter square increased in all three belt transects after treatment (Fig. 8). Transect 1 had the highest increase in average number of fertile stems per 1-meter square (8.94 in 1997 to 99.73 in 1998). Transects 2 and 3 had an average of 6.92 and 4.08 fertile stems in 1997, respectively. In 1998, the average fertile stems per 1-meter square increased to 72.05 and 20.9 in transects 2 and 3, respectively.

Conclusions

Although fires were historically uncommon in southern Appalachian cove forests (Harmon 1982), prescribed fire has been an effective management tool for some rare plant populations in GSMNP. Dormant-season burning to reduce leaf litter buildup was successful. Daisy-leaved moonwort and Bittercress populations increased after fire was experimentally introduced. Prescribed fire also reduced the incidence of a fungal infection in Goldenseal.

Raking was an effective tool at the Daisy-leaved moonwort and Goldenseal populations as well. Managing selected rare plant populations with prescribed fire and/or raking will continue to be a part of our Rare Plant Program.

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