Grassy Balds of the Great Smoky Mountains: Their History and Flora in Relation to Potential Management

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ABSTRACT / The origin of the grassy balds of the Great Smoky Mountains is examined. Some of the areas were cleared by settlers. Grazing by sheep and cattle and the cutting of trees were probably the most important factors in maintaining the grass sward; fire apparently was not used.

Vegetation survey plots indicated that little of the original balds' area was still grassy and that most of the invading trees and shrubs could be expected to sprout if cut or burned. Areas presently trampled or mowed had a flora similar to a bald that was still grazed. High-elevation burn scars had many species in common with the grassy balds but had dissimilar community structures; therefore, a policy favoring natural fires would be unlikely to encourage maintanence or formation of grassy balds.

The management of open grassy areas on National Forest lands was investigated. Burning was the favored technique, although hand cutting, mowing, and grazing were used. The results of testing various management practices on Gregory Bald are reviewed in terms of cost, impact, and historical authenticity. Implications for park management are discussed.

Introduction

The grassy balds of the Southern Appalachians have long fascinated both hikers and botanists. These open, meadowlike plant communities occupy ridges well below the expected climatic timberline and provide vistas of the Blue Ridge and Great Smoky Mountains from otherwise tree-covered slopes (Figs. 1-3). Several balds are sites for rare plants (Bratton and White in press) and their community composition itself is unique. Mountain oat grass (*Danthonia compressa*) was originally the dominant species, accompanied by other grasses and herbs. The only treeless high-elevation plant communities in the area other than grassy balds are dominated by ericaceous shrubs (and are called heath balds; Whittaker 1956) or have a recent history of cutting or burning.

The origin of grassy balds is much disputed. Although all the grassy balds have been grazed by domestic stock, many botanists have assumed that they are natural plant communities established by variations in the physical environment (Billings and Mark 1957, Mark 1958). Other researchers have hypothesized burning by aboriginal man or clearing by white settlers (Wells 1936, 1937, 1938, 1946, Gersmehl 1970).

The grassy balds now included in Great Smoky Mountains National Park (GRSM) have a long history as a "resources management problem." After the GRSM acquired the balds (late in the 1920s to mid-1930s) (Fig. 4), grazing ceased and complete fire suppression was practiced. The grass grew into a thick sward, and flowering shrubs that dominated the forest edges spread onto the open balds (Figs. 1 and 2). The shrub succession was noticeable by the late 1930s and by the mid-1950s had become a management issue. Oaks, hawthorns, and other woody species were filling the views, replacing the grass, and beginning to obscure the flowering shrubs, such as azaleas, some hybrids of which occur only on Gregory Bald. A number of groups, particularly the Great Smoky Mountains Conservation Association, took an interest in preserving the balds and encouraged the National Park Service to initiate artificial management to inhibit the woody succession. The GRSM Natural History Association funded a study (Bruhn 1964) that documented the return to forest and quantified the invasion rates; this was followed by a National Park Service supported study (S. W. Radford 1968), but no definite action was taken at that time.

In 1974 a proposal was introduced to the United States Congress giving most of the GRSM wilderness status. This complicated the management issue because human intervention is very restricted in areas legislated as wilderness. A number of exclusions from the GRSM wilderness have been suggested. These include Gregory and Andrews Balds, which were to be managed as historic areas (National Park Service 1974), allowing greater intervention.

In 1975, park management considered initiating management consisting largely of cutting and removing trees and shrubs on Gregory and Andrews Balds. Because root sprouting and other problems might arise, however, it was decided to test the potential techniques before they were

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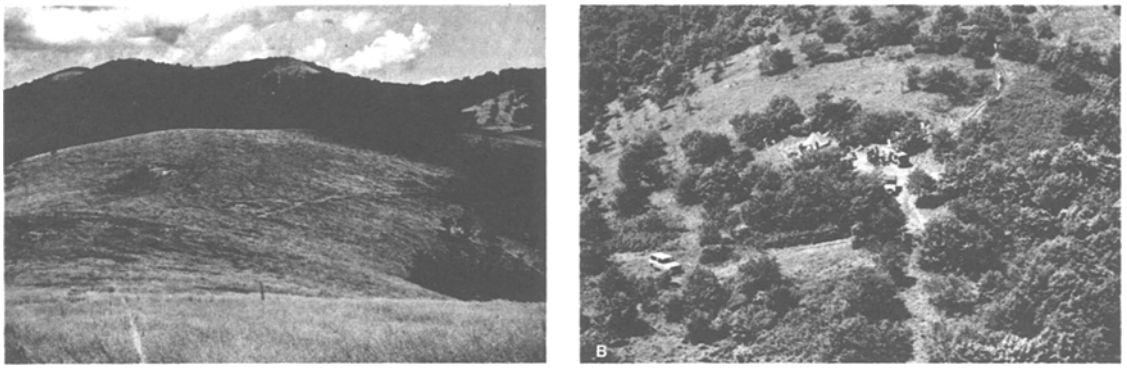

Figure 1. (a) A photograph of Spence Field taken in 1935. Note the open grass sward and the balds on Thunderhead Mountain (in background). (Photograph by Carlos C. Campbell.) **Figure 1.**(b) A photograph of the same site shown in the foreground of Fig. 1a, taken in 1969. Note the shrub succession. The edge of the bald has moved toward the top of the ridge and the open grassy area is much reduced. (Photograph by U.S. Army.)

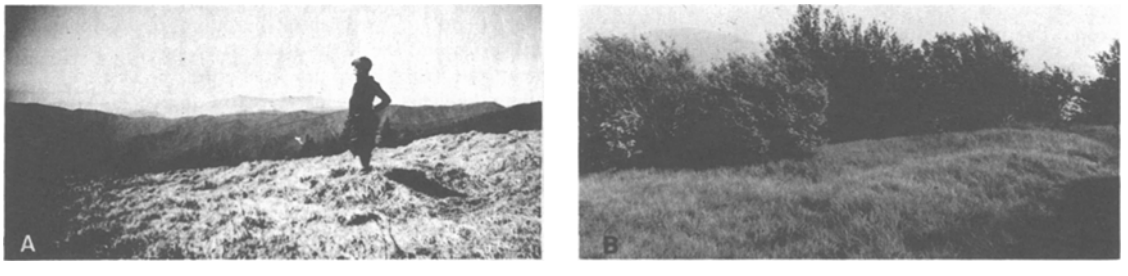

Figure 2. (a) The view from Andrews Bald during the 1930s. Shrub succession was just beginning and the grass had grown taller after grazing ceased. Ridges of the Great Smoky Mountains and the Blue Ridge Mountains of North Carolina are in the background. (Photograph by Carlos C. Campbell.) **Figure 2.** (b) About the same view as in Fig. 2a as it appeared in 1976. Shrubs have invaded from the bald edge and are blocking most of the vista of other peaks. (Photograph by M. Lindsay.)

applied on a large scale. Further historical research was also considered necessary to determine how the balds originated. If these plant communities are primarily anthropogenic, they are not natural ecosystems as defined by Park Service policy and can only be considered "historical areas," even if maintained by a natural factor imitator such as like prescribed burning (National Park Service 1975).

The purpose of this study was to answer the following questions:

1. How were the balds maintained historically?
2. What is the present status of the balds?
3. What techniques can be used to keep the areas open and what is their relative expense?
4. What are the potential impacts of managing the areas?

Methods

This study was begun in June 1975 and was divided into three parts.

The basic research approach was to determine how the balds looked in the past and what factors were important historically in their maintenance. This information was related to the balds' present floristic composition and to the effects of known disturbances, such as fire, mowing, trampling, and grazing in high mountain areas. Potential man-

Figure 3. A view from the north-facing side of Gregory Bald in 1934. Cades Cove and Rich Mountain are clearly visible in the distance. This lookout was originally cut out of forest, according to informants, and since then hawthorn, oak, and yellow birch have grown in to the point that Cades Cove cannot be seen from the bald. (Photograph by Carlos C. Campbell.)

agement techniques could then be evaluated in terms of efficiency, impact, and historical authenticity.

Part One

First, a historical study and a literature search were conducted. Archival materials, such as old aerial photographs, were collected and people were interviewed who had herded cattle on the balds or who had visited them frequently before they became park lands. The interview questions emphasized the agricultural management of the areas and past vegetation. The transcripts from the interviews and a summary of the historical information can be found in Lindsay (1976).

Part Two

The second part of the study compared the plant communities from disturbed high-elevation areas and investigated patterns of woody plant succession on Gregory and on Andrews Balds, the two areas primarily involved in the management decisions. Color aerial photography was flown for both Gregory and Andrews Balds in October 1975.

The other study sites (Fig. 4) included Parsons Bald, Silers Bald, High Springs Bald, Little Bald, Thunderhead, and Mount Sterling Bald, all of which were previously grazed open balds; Spence Field and Russell Field, which were previously grazed areas and were probably completely cleared by settlers (Lindsay 1976); Hemphill Bald, which adjoins the park and is still grazed by cattle; Newton Bald and Nettle Creek Bald, which were grazed but never clear of trees; Rich Gap, the site of a cattle holding pen or gant lot; Rye Patch, a high-elevation abandoned farm; Appalachian Trail shelter clearings in both spruce-fir and hardwood forest, which are presently impacted by human trampling; roadsides and roadcuts in spruce-fir and hardwood forest; and two large burn scars resulting from logging-related fires in the 1920s. In most cases, samples were taken in the open areas, in the adjoining successional forest, and in nearby older forest stands present during or before the disturbance.

The vegetation was sampled in 200-m^2 plots on most of the study sites. On Gregory and Andrews Balds, 20-m by 10-m plots were laid out along measured transect lines so the plots could be relocated to record changes resulting from management. On other sites, circular plots with 8-m radii were used.

Within each 200-m^2 plot, all trees were identified and their diameters at breast height (1.5 m) measured. Percent cover of herbs and shrubs was estimated visually in ten 1-m^2 plots. In the 10-m × 20-m rectangles, the herb plots were located 1 m apart on alternate sides of a line through the center of the plot. On circular plots, eight herb plots were placed similarly along a diameter and one was placed on each side of the diameter 4 m out from the center. In shelter clearings and along roadsides, six 1-m^2 quadrats were placed at each site. To simplify the analysis of over 200 plots, data were averaged from several plots that occurred in a single vegetation type on a single stand, with the exception of Gregory and Andrews Balds, where the plots were grouped by principal components analysis (Gauch 1973). Nomenclature follows Fernald (1970) where possible, but A. E. Radford and others (1974) is followed for species not given in Fernald.

Woody plant invasion on Gregory Bald and Andrews Bald was analyzed by two methods. To determine areas occupied by identifiable vegetation groups, tracings distinguishing different types of trees and shrubs were made from aerial photographs and examined with an International Imaging System Digicol Processor 4010-32. Increment cores for determining age were taken from up to 20 trees on each 200-m^2 sample plot.

Part Three

The third part of this study covered the potential management techniques. First, contact was made with individuals involved in grassy bald management elsewhere in the Southern Appalachians and their areas were visited so that their experience and the relative impacts of the methods could be evaluated before any action was taken in the GRSM.

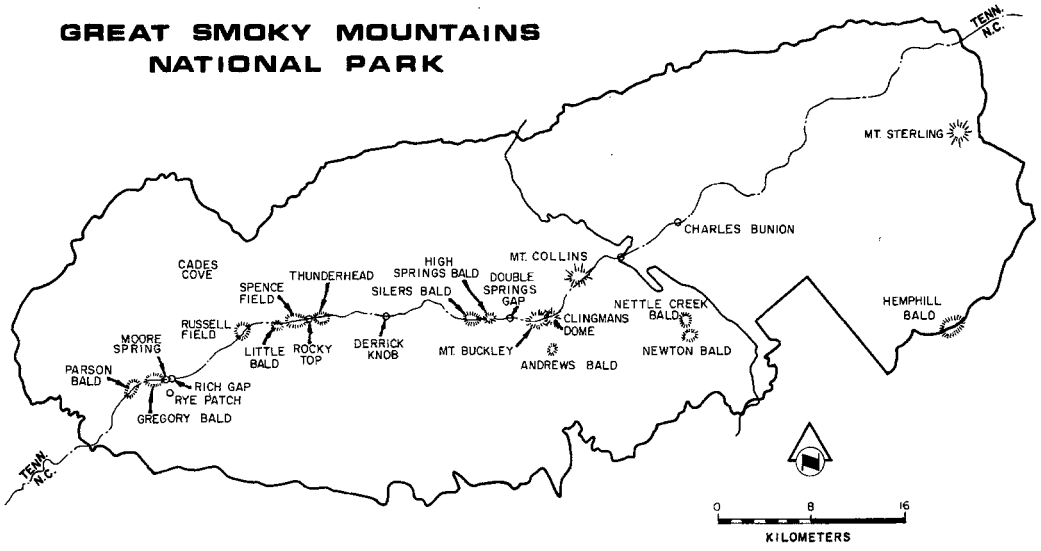

Figure 4. A map of Great Smoky Mountains National Park showing the positions of various grassy balds and other sampling sites used in this study.

Then various methods of clearing and maintenance were tested on Gregory Bald in the summers of 1975 and 1976 (Lindsay 1977). Initial work in August and October 1975, was confined to clearing small patches of hawthorn, selectively cutting larger plots, and removing blueberry (*Vaccinium* spp.) patches (Fig. 5). Twelve plots were cleared in June and July of 1976. Six 20-m × 20-m plots were on the open bald and included all cover types present except for extremely dense hawthorn scrub. All trees and visible seedlings were cut down and, on selected plots, blueberries were also cut and burned on site. The six other plots were belts 25-m wide, extending from near the original edge of the bald to the present edge. Three of these were in the dry oak forest on the south side of the bald and three were in the more mesic oak–birch–birch forest on the north side. The areas of these plots ranged from 780 to 1050 m^2. On half of each strip, all trees less than 10 cm in diameter at breast height (dbh) were removed; on the other half, all trees less than 20 cm dbh were removed. In addition, about 0.4 ha was cleared and enclosed by an electric fence to test the effects of grazing animals. The effectiveness, cost, visual and aural impact, and difficulty of using of various methods and tools were compared.

Grazing by domestic stock was tested from July 14 to August 14, 1976. The animals used were two Holstein heifers, six sheep, two goats, and two donkeys. The animals were led up the foot trail to the bald (about 7 km) and then kept in a 0.4-ha pen fenced with a single strand of electrified wire powered by a battery-type charger. After they had been on the bald for 2 days, all animals were measured for girth, height, and length. The animals were then enclosed in 100- or 200-m^2 test grazing areas until they lost weight, as assessed by girth measurements.

Each of the small pens was mapped to show the locations of major concentrations of each important plant species and the degree to which it had been grazed or browsed. The degree of woody species browsing was assigned to one of four classes: (1) 0–22%; (2) 22–50%; (3) 50–75%; and (4) 75–100%, after Caslick (1974). Although most of the herb cover was mountain oat grass, all herbs were considered as one vegetation group in estimating grazing. Grazing amount was estimated by height classes: (1) ≥5 cm; (2) 2–4 cm; (3) 1–1.9 cm; (4) 0–0.9 cm.

Results

The Historical Survey: Origin and Maintenance

For National Park Service management purposes, the origin of the balds and their maintenance need to be carefully distinguished. The removal of the canopy and the establishment of a grass sward may or may not have been caused by the same agent.

Among the proposed "natural" causes for balds are past

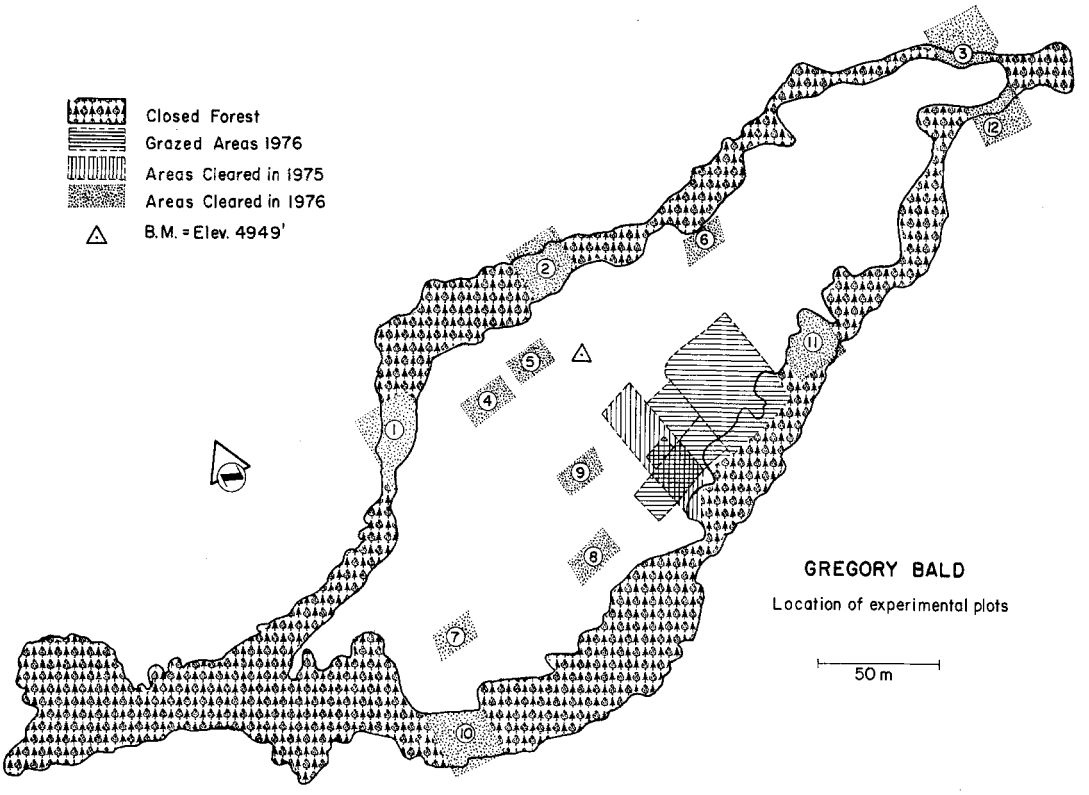

Figure 5. The location of experimental plots on Gregory Bald. The map shows the original outline of the bald, the area that has succeeded into closed forest, and the locations of the plots that were grazed or cut during this study. Compare with Fig. 7.

changes in climate (Camp 1931, Whittaker 1956, Mark 1958, Billings and Mark 1957), fire (Clements 1936), ice and forest damage (Harshberger 1903), windthrow (Brown 1941), and gall wasps (Gates 1941).

The most commonly proposed anthropogenic causes for the balds are clearing by the Cherokee Indians (Wells 1936, 1937, 1938, 1946, 1956) and clearing by white settlers, mainly through the use of fire (Gersmehl 1970).

Historical research indicates that some of the balds were almost certainly cleared by white settlers. One of our informants, Asa Sparks (whose father, Tom Sparks, was a herder), claimed his grandfather had cleared Spence Field, probably in the 1870s or 1880s. Another informant confirmed this, mentioning the area was a beech forest in 1870. A photograph was located showing large stumps on much of Russell Field in 1931, and informants reported clearing activities on Andrews and Silers Balds before the Civil War. A recent archaeologic survey (Bass 1977) found little evidence for Indian use of the areas.

Several of the natural causes previously proposed by botanists, such as blowdowns, gall wasp kills, or fires, could have created openings in the forest canopy that were then expanded or maintained by human activity. Climatic origin seems improbable because the balds occur in such a variety of forest types and topographic positions. At present, there is no plant community resembling a grassy bald in the GRSM that does not have a history of human interference, and maintenance of the balds during the period immediately preceding the establishment of the park was almost certainly not by natural factors.

All the balds in the GRSM were grazed and stock densities were high. Each herder, with a territory centered on a bald but extending into the surrounding forest, looked after 200–500 cattle, a few hundred sheep (Fig. 6a), and a few

Figure 6. (a) Sheep on a grass bald in prepark days. Note the low grass and absence of shrubs. (Photographer unknown.) **Figure 6.** (b) Sheep on Gregory Bald in 1976 as part of the experimental management of the area. Note the shrubs, especially blueberries, on the bald. (Photograph by M. Lindsay.)

horses, goats, and mules. The stock on a single bald belonged to a number of families and was grazed usually from around early May to mid-September.

Informants reported tree cutting on many of the balds (Fig. 3). In some cases this may have been to enlarge the grazing area, but wood was also used to construct herders' cabins and animal pens and to provide fires for cooking and distilling whiskey.

Burning does not seem to have been a major factor in maintaining the balds. Informants reported that the grass on the balds was kept so short by the grazing animals that there was not enough fuel to support a grass fire (much less one that would kill shrubs and seedlings). The surrounding forests were sometimes burned lightly in the fall to remove the leaf litter so that chestnuts (*Castanea dentata* fruit) could be gathered more easily.

Photographs taken before the park was established show an almost complete absence of trees and shrubs from the centers of the balds and that the very few shrubs growing in the open were heavily browsed by livestock (Figs. 1a and 2a). The edges of the balds were much farther from their centers than at present (Figs. 1b and 6a). There were few tall weeds, and blueberries, now common on the balds, were present only around the edges. The flame azaleas on Gregory Bald were confined to the rim but the display was impressive, even in the 1890s.

The forest around the balds (except spruce–fir communities) consisted of a few large, widely spaced trees, usually oak (*Quercus* spp.), beech (*Fagus grandifolia*), or yellow birch (*Betula lutea*) (see Fig. 9b). Years of trampling and browsing by stock kept the understory clear. The woods all along the main ridge in the western half of the park had this parklike aspect, as did such places as Newton Bald, which were never completely open but were used for grazing.

In summary, then, some of the grassy balds were probably cleared by settlers, but some might be of natural origin. These open areas were maintained primarily by grazing, but cutting was also important. Burning may have been used to clear the areas but was not commonly employed to keep them open.

Table 1 Changes in area of Gregory and Andrews Balds

Date	Area of Gregory Bald (acres)	Percent of original area	Percent change per year	Area of Andrews Bald (acres)	Percent of original area	Percent change per year
1937[a]	Not measured	—	—	12.5	—	—
1944[a]	15.7	—	—	Not measured	—	—
1952[b]	13.34	85	1.9	9.67	77	1.5
1961[b]	11.71	74	1.2	9.17	73	0.44
1975	7.91	50	1.7	8.05	64	0.68

[a] Based on surveys by Bye. Maps are in GRSM archives.
[b] From Bruhn (1964).

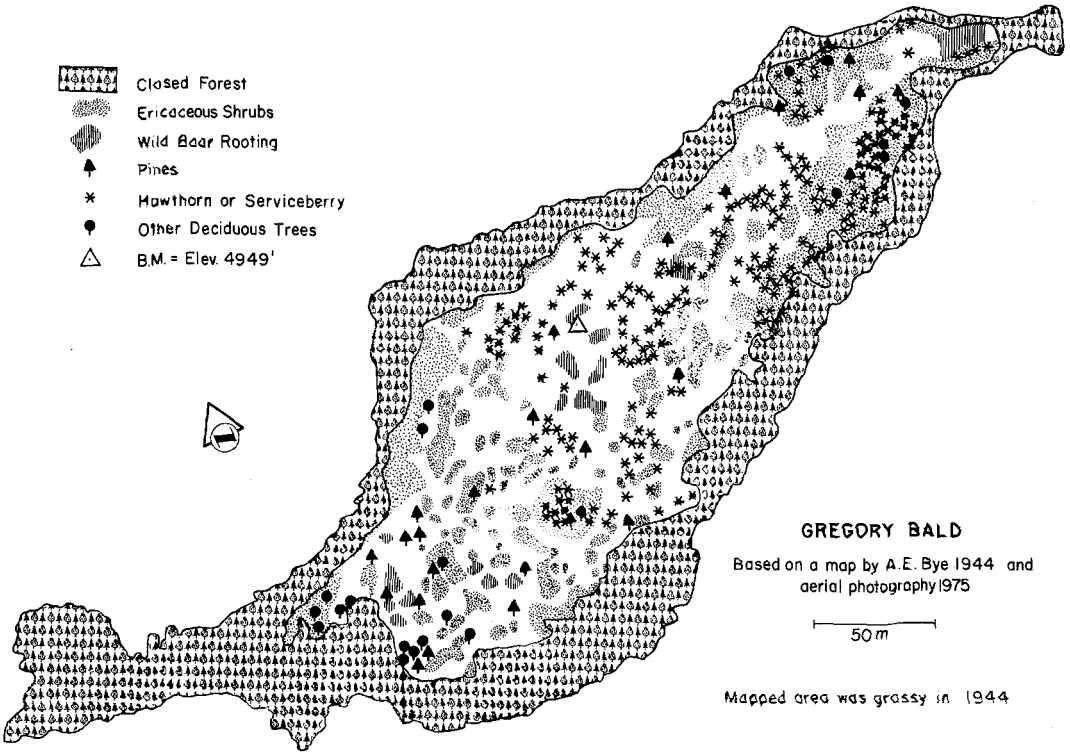

Figure 7. A map of Gregory Bald showing the invasion pattern of different woody species. The area outlined was almost entirely grass in prepark days.

Successional Patterns and Present Flora

After the park was established and grazing ceased, the flora of the balds began to change. Letters in the archives of the GRSM indicate that blueberries were invading Andrews Bald 5 years after grazing was stopped (J. R. Eakin 1936, letters in GRSM Archives). Silers Bald and Thunderhead (where grazing was stopped in 1918 and 1933, respectively) were matted with weeds and briars by 1938 and beech and other small trees were filling them in (George Stephens 1938, letter in GRSM Archives). The azaleas and other flowering shrubs spread out onto the balds, evidently reaching the peak of showiness in the 1950s.

Analysis of aerial photographs shows that the area of Andrews and Gregory Balds has decreased considerably since surveys were made in 1937 and 1944, respectively (Table 1). Figure 7 shows the area of Gregory Bald that was open and grassy when the original surveys were made and the position of invading vegetation in 1976. The most dramatic change since Bruhn's (1964) study of Gregory Bald is the increase in the cover of blueberries, from 29.9 to 53% cover (Table 2).

In and around Gregory Bald, ring counts from tree cores indicate that nearly all trees have grown up since grazing ceased. Even at the original forest edge, most of the trees are less than 40 years old. Tree establishment was most rapid 10–20 years after grazing ceased. Hawthorn (*Crataegus* sp.) is the most aggressive invader of the bald, followed by serviceberry (*Amelanchier laevis*) and oak. The surrounding forests are dominated by oak.

At the time of this study, *Danthonia compressa* was dominant, at least in patches, on the remaining open areas of the balds. Sheep sorrel (*Rumex acetosella*) and cinquefoil (*Potentilla canadensis*) were also present in all stands. Blackberry (*Rubus canadensis*), blueberry (*Vaccinium vacillans*), and violet (*Viola rotunifolia*) were present on almost all balds. All balds had at least one species of aster, goldenrod (*Solidago*), and sedge (*Carex*).

Table 2 Percent cover of various woody plants on remaining unforested areas of Andrews and Gregory Balds

Plant	Gregory Bald		Andrews Bald	
	Area (acres)	Percent	Area (acres)	Percent
Blueberries	5.25	53	0.64	8
Potential overstory trees, deciduous	1.09	11	0.80	10
Rhododendron	—	—	0.97	12
Pines	0.79	8	—	—
Spruce and fir	—	—	1.05	13
Hawthorn and serviceberry	1.49	15	0.64	8
Total nongrass	8.62	87	4.10	51

The flora of the open, lower elevation balds, of unknown origin, is very similar to that of the cleared fields, such as Russell and Spence Fields. Rye Patch, and Rich Gap had many species in common with the oak forest, and mountain oat grass was not the dominant species. Other grasses and weedy forbs were more common.

Trees and shrubs on the balds tended to occur in patches. Their basal area on the balds was less than 10 m^2/ha and was sometimes less than 1 m^2/ha. The surrounding younger forests had basal areas averaging from 14 to 24 m^2/ha, depending on the forest type. The surrounding mature forests had basal areas ranging from 36 m^2/ha in dry oak forest to 52 m^2/ha for mature spruce–fir.

The species primarily invading the balds, hawthorn, serviceberry, and red oak, are hardwoods that sprout from roots or stumps. Only on balds in spruce–fir forest, where Fraser fir (*Abies fraseri*) is the dominant invader, could a large portion of trees be removed by cutting without control of sprouts.

The two burn scars examined were quite different from any of the open balds. Blackberry (*Rubus canadensis*) averaged 63.4% cover, the highest it attained in any community sampled. Native forbs and sedges were far more important than exotic forbs or mountain oat grass, the latter occurring only in a few trampled places along the trails. Nearly all the species on the burn scars were present on and around balds at a similar elevation but their distributions were so different that the general community appearances were entirely dissimilar.

Roadsides and shelter clearings, under constant disturbance from mowing or trampling, were dominated by bluegrass (*Poa annua*) and such exotic forbs as plantains (*Plantago* spp.), clover (*Trifolium* spp.), and dandelions (*Taraxacum officinale*). These species were very infrequent on balds and were confined to heavily trampled places.

Hemphill Bald, which still had cattle grazing on it, was very similar to the roadsides and shelters examined. Bluegrass and plantains, clover, and dandelions dominated the vegetation. Mountain oat grass was present but only as small plants cropped close to the ground (Fig. 8).

The percentage of exotic plant species varied widely, from 59.1% at Hemphill Bald and 29.8% for roadsides and clearings to 15.7% for balds in oak forest, 11% for cleared balds, 6.2% for balds in beech forest, 3.2% for burn scars, and 2.1% for balds in spruce–fir forest.

The differences between the balds and the burn scars imply that intensive continuing disturbance, presumably grazing, was responsible for the floristic composition of the grassy balds at the time the park was established and has influenced the composition of the areas remaining open. The importance of anthropogenic factors in the community structure is further supported by the similarities between the cleared fields and the balds of unknown origin. Although some open "grassy" (sedgy) areas in the park have resulted from large fires (also anthropogenic), there is no evidence to indicate that the grassy balds are a pyric disclimax. High-elevation areas disturbed by trampling, mowing, or grazing had a low grass sward with a high percentage of exotics.

Possible Maintenance

The Experiences of Other Agencies[1]

The United States Forest Service manages several grassy balds, heath balds, and other open grassy areas in the Southern Appalachians, and Shenandoah National Park maintains a large open grassy area, Big Meadows, for scenic and historic purposes.

At the time of this study, fire was being used more than any other management technique. In Pisgah National Forest, for example, there is a grassy bald that originally supported mature spruce–fir forest (Zeedyk 1973, Sanders 1975). After the original forest was logged in the 1930s, fires swept through the slash and removed all tree cover. The area now managed is bounded on the north by Shining Rock Wilderness Area and on the south by the Blue Ridge Parkway. The vegetation of the highest, most exposed points is dominated by mountain oat grass. timothy (*Phleum pratense*) and other grass species. These areas closely resemble "natural" grassy balds except for the frequent old stumps.

Since 1972, different parts of this area have been burned

when suitable weather conditions have occurred in the spring or fall. Burns usually included 100–150 ha at a time. Fires generally have more effect in the fall because favorable weather conditions last longer and the fuel is less compacted.

The technique used in both spring and fall was to set perimeter lines of fire with drip torches and to spray the outer side wth backpack pumps. After the perimeter was secure, interior fire lines were set. Roads and streams were often used as fire breaks, reducing the need to set perimeter fires. An eight- or ten-man crew could burn about 100 ha in 6 or 7 hr.

The intensity of the burn depended on cover type. Grass cover burned in a light surface fire; the cured grass cover burned, but very little of the surface detritus covering the soil burned. Dense patches of blackberry burned intensely because of the fuel density and the surface detritus was often burned off the soil, exposing it to erosion. Unburned areas were most common on northerly aspects and in wet seepages.

Between 30 and 70% of the woody plant cover was killed, depending on the species and the understory cover. The tops of nearly all the trees in stands of fire cherry with blackberry in the understory were killed, although many of the killed trees sprouted. Larger trees (>15 cm dbh) burned in the spring of 1973 seem to be almost unaffected by the fire. Fire killed the tops of rhododendron, mountain laurel, and blueberry but most of these shrubs sprouted. Although the young sprouts seem to be preferred deer browse, the dead tops often protected them. The grasses responded favorably to the burns, becoming thick and lush. Even when the fire had little effect on the large trees, it opened up the understory, leaving an orchard-type forest.

The visual impact of the fires was most striking between the time of the burn and the subsequent regrowth of ground cover. After a spring burn this period was only a week or two long, because grass grew faster on burned than on unburned sites. On a site burned in the fall, regrowth does not occur for 5 or 6 months. Because the dead tops of woody plants were not removed, their visual impact persisted for several years. A newly burned area had a strong smoky odor that persisted through several days of rain.

Burning on Mount Rogers Recreation Area seems to have had a similar impact (Charles Blankenship personal communication 1975; Byrne Junius Beaver personal communication 1975) and had also been used to retard woody plant invasion in Big Meadows (Dean Cocking personal communication 1975).

In 1976 prescribed burns were estimated to cost between $10 and $15 an acre (.45 ha) for large areas. They have been accepted by the public where they have been used. In general, fire is more effective for preventing invasion than for causing retrogression of already established shrubs.

Mechanical mowing has been used on Beauty Spot on the Cherokee National Forest and Big Meadows in Shenandoah National Park, both easily accessible by tractor. On Beauty Spot, a high, exposed, and relatively dry site, mowing has maintained a grass sward with very few shrub and tree sprouts. On Big Meadows, which is less exposed and wetter, blueberries and black locust seedlings are very common although the mowing keeps them low. The 1976 estimated cost per acre was $40–75.

Grazing has been tested on Pine Mountain on the Mount Rogers National Recreation Area. The area was originally spruce–fir forest which was logged, then burned and grazed, in the early 1900s. Cattle have had some impact on the woody vegetation but do not show much weight gain. A herd of ponies left on the area has increased in numbers and is slightly impacting the woody vegetation. Sheep were tried but difficulties were encountered with *Kalmia latifolia* poisoning. Grazing appears to be effective in controlling blueberries and blackberries.

The effects of grazing on Hemphill Bald, which is divided by the Great Smoky Mountains National Park boundary, and also of interest. On the park side of the boundary, hawthorn, black locust, yellow birch, and buckeye trees have grown up and shaded the ground sufficiently to produce a typical forest understory. The side that is owned by Cataloochee Ranch has been kept open by cattle, which have maintained a short, dense sward (see Fig. 8). The few trees present show heavy browsing. Severe erosion has occurred on some of the steeper slopes.

Hand cutting has been tried on several small balds, Roan Mountain Gardens, and parts of the Mount Rogers National Recreation Area. It has been found effective where tree species are encroaching on grass or heath balds, but it is not feasible for controlling invasion of grass by heath. It can be applied to almost any site, and for small scattered balds the difference in cost between this method and burning is not as high as it is on very large areas. Impacts can be controlled very precisely and heavy sprouting of some species has been observed. The main drawback is the high cost—estimated to be about $100 per acre (1976)—which does not include the labor cost of disposing of the slash.

Tests of Potential Management Schemes On Gregory Bald

Cutting. In tests of cutting on Gregory Bald, only hand tools were used to clear six of the plots because park policy discourages the use of power tools in backcountry areas. The number of trees on each of these 500-m^2 plots ranged

Figure 8. Hemphill Bald, which was still grazed by cattle in 1976. The forest on the left side of the photo is within the Great Smoky Mountains National Park boundary and has not been grazed since the 1930s. The area to the right has been used as pasture. Note the dead trees, which are not being replaced by sprouts, and the browse damage to the trees and shrubs in the pasture.

from 6 to 29, and the time required to cut down all trees ranged from 1 to 5 man-hr. Because these plots were slightly lower in woody plant density than the bald average and because the area of the open part of the bald is about 2.5 ha, equivalent to about 50 of these plots, it would probably take about 150 man-hr just to cut down the trees on the bald with hand tools, not counting time needed to sharpen axes and so forth. The most time-consuming part of clearing was cutting the felled trees into pieces small enough to be dragged and dragging them far enough downhill into the woods so that they would not be seen by the average visitor. This took from two to eight times as long as cutting down the trees.

An inexperienced crew of seven could clear shrubs from four or five plots in a day. Blueberries, blackberries, and other shrubs were cleared from some plots (Nos. 4–7, Fig. 5). The piled-up clippings burned very readily after they had dried a few days. Blueberries on the burned patches sprouted much less but the sprouts grew faster than sprouts on unburned plots. Seedlings of mountain oat grass and cinquefoil started growing on burned areas within a week.

A total of 0.6 ha was cleared in the forest with both hand tools and chain saws. We estimate the total time required to fell all the forest that has grown up around the edge of the bald to be between 120 and 300 man-hr. The amount of time needed to dispose of the slash may be as much as 3000 man-hr because it increases disproportionately to the amount of slash. (It becomes increasingly difficult to find a place to put it.)

Hauling slash through the forest flattened herbs and removed the surface litter in places, increasing the likelihood of erosion. Moreover, there was not enough room for all the slash that would be created in clearing the whole bald, so burning in small piles would be advisable. With slash removed, the appearance of the cleared forest areas, with larger trees left standing, was reminiscent of the original parklike border of the bald (Figs. 9 and 10).

All woody species growing on the balds, except for conifers (pines, spruce, fir, and hemlock), will sprout after they are cut unless a herbicide is used. Because the use of herbicides is probably incompatible with the wilderness character of the park and in conflict with its role as a biosphere reserve, other methods must be used to kill the stumps.

Species seemed to be the only important factor in determining how much the trees cut in 1976 sprouted. Age and location made very little difference. Of common species, oak grew the most sprouts and had the fastest growing sprouts. An oak stump from which sprouts had been removed for 2 years was still sprouting, so many years would be required to kill oaks. Hawthorn sprouts grow much more slowly but they are not browsed by deer or rabbits and seem more tolerant of winter weather. Cherry, maple, birch, and serviceberry sprout moderately and are browsed lightly. Beech stumps grew many slow-growing root sprouts. Blueberries sprouted thickly on patches that had been cleared completely by clipping off at ground level but were not preferred by native browsers. They sprouted more on burned areas than on unburned areas.

Many years of frequent hand cutting or grazing by goats or other animals that prefer woody browse will be necessary to bring sprouts under control without herbicides.

Grazing. The grazing animals used had widely differing preferences for the various food plants available (Fig. 11). The goats ate mainly oaks, hawthorn, and blueberries, in that order, and grazed the grass lightly. They preferred woody plants to grass and, by standing on their hind legs, reached even higher than cattle. They are difficult to confine, however, expensive to purchase in large numbers, and not important elements of the herd historically. We estimate a herd of 70 to be required to manage the entire original area of Gregory Bald.

Sheep were the next best browsers (Fig. 6b). They ate oak, hawthorn, and blueberry sprouts quite readily but ate mature blueberries only when they had eaten the grass down to the ground. If the blueberries were cut first, sheep could probably keep them under control. A herd of 70

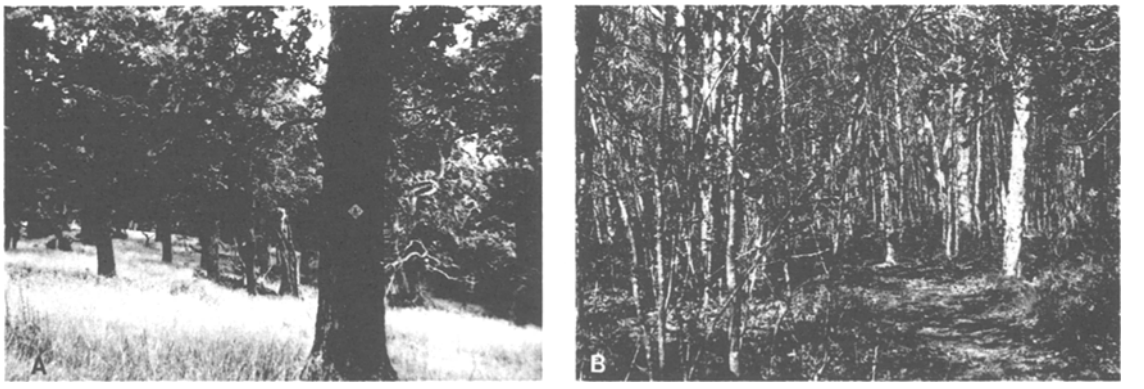

Figure 9. (a) The east edge of Gregory Bald just after grazing was stopped about 1935. Cattle and sheep had browsed most of the woody regeneration to the ground, leaving the forest with an open, parklike aspect. (Photograph by Carlos C. Campbell.) (b) The east end of Gregory Bald in 1976. Yellow birches and oaks have filled in the forest understory, creating a forest with two different age classes of trees—larger, older individuals present during grazing, and stems 40 years and younger established after grazing ceased. (Photograph by M. Lindsay.)

could probably manage the entire bald. Sheep were the animals that maintained the bald before the park was established (Lindsay 1976), but they were more vulnerable to disease and predators (bears, mountain lions) than goats and donkeys.

The two heifers grazed down the grass faster than all other animals combined. They browsed frequently on oak and serviceberry, ripping off whole branches. They seldom ate hawthorn and would not eat blueberries even if they were exceedingly hungry. They were the only animals that ate azaleas; the young shoots and flowers were among their preferred foods. Cattle need much water, which makes a large herd extremely difficult to manage. A large and possibly unsightly catchment device would be needed to provide enough water to keep cattle unless they could be led down to a nearby spring daily.

Donkeys ate mostly grass but would eat hawthorn and oak when grass ran short. They would not set back succession but would be effective in retarding its advance. They were the easiest animals to manage and were probably the best able to fight off predators.

Grazing would undoubtedly be effective in setting back succession and maintaining the balds. Because the historical control was grazing and because it has specific effects in trampling, selective removal of plants, and fertilization, grazing would lead to a species composition most like that before the establishment of the park. Grazing by animals other than cattle would discriminate in favor of azaleas on Gregory Bald as could no other method short of cutting every other kind of woody plant by hand. On the negative side, grazing requires a large initial investment of time and money for building fences and otherwise preparing the sites. The small size and remote location of Gregory and Andrews Balds make farmers unlikely to want to graze their stock there, so the park would probably have to buy the animals or pay a large fee to someone who consented to take the stock up there. The amount of money that would have to be invested in animals would approximate $12,000 (1975 prices) for both balds. Animals might be lost to predators. Artiodactyls (sheep, goats, and cattle) would be likely to get diseases from the native deer population or to transmit diseases to them. Whereas grazing is probably the most effective long-run method, it also has the most problems associated with it.

Discussion

The first question the National Park Service faces is whether to manage the grassy balds artificially. Allowing natural successional processes to take their course is also "managing" the sites. An exclusion from legislated wilderness status is required to keep the balds open, as is a frequent input of manpower and money. The balds would remain as disturbed islands surrounded by relatively unimpacted forest. Most of the potential artificial management techniques would cause some soil erosion or encourage exotic plant species.

Wilderness values, such as the lack of human interference, must be weighed against the uniqueness of the balds and their esthetic appeal. Usually, "wilderness"

Figure 10. A partially cleared plot on the east end of Gregory Bald. Small trees have been removed to return the area to the Appalachian Trail's prepark condition. The remaining larger trees are similar to those present during grazing. (Photograph by M. Lindsay.)

would have the greatest weight in terms of both "uniqueness" and "esthetic value." In this case, however, a plant community that is of very limited distribution is being replaced by successional forest, and vistas are being obscured. The balds also provide habitat for some rare plants, including *Carex misera* and *Prenanthes roanensis* and the hybrid azaleas found only on Gregory Bald.

It has been suggested (personal communication with GRSM staff) that a change in the fire management policy in the GRSM may help maintain the balds without human interference. If lightning fires were not suppressed immediately in the wilderness area, the balds might burn and new openings might also be created. Experimentation would, of course, be necessary, but the data gathered in this study indicate that fires would have to be either very frequent or very intense to suppress woody plant succession and that any new openings created would not have a typical "grassy balds" flora. On most burns of light to moderate intensity, a shrub succession, particularly of ericads, might be expected.

The presence or absence of grassy balds also has implications for visitor distribution. Several balds are extremely popular hiker goals. With the proposed wilderness, fire towers will be removed and the grassy balds and burn scars will be allowed to grow in. Ironically, a majority of the most famous views in the park either have a tower or are openings previously maintained by anthropogenic disturbance. If no vista clearing is made at these sites, hiker use may shift toward the heath balds. Maintaining open only one or two grassy balds, however, would probably divert visitors to these areas.

If the government chooses to maintain the grassy balds, historical authenticity, impact, effectiveness, and cost must all be weighed before management is implemented. Grazing is the most historically proper technique and selects for a flora similar to that on the prepark balds but it has a number of adverse impacts and is very expensive. Furthermore, the "historic" sheep and cattle, are more difficult to manage than such animals as donkeys and are less effective browsers than such animals as goats. Grazing, as it would now have to be practiced, would require the construction of fences and other structures that were not present when the areas were originally grazed and would intrude on the historic scene and the wilderness value of the surrounding area. The costs of grazing include fences, livestock, and the herder's salary.

Fire is not a historically authentic technique but would probably be effective in suppressing shrub succession if repeated burns were used. The methods used by the Forest Service are probably the best and are relatively inexpensive. Burning is more difficult to schedule in the spring, but the areas recover more quickly. Fuel is less compacted in the fall and suitable weather is more common, but the burned areas are exposed to erosion and nutrient loss during the winter. Fire does not necessarily affect the plant species the same way grazing does and may not select for desirable or traditional species, such as azaleas, but fire does not encourage exotic plant species to the extent that grazing and trampling do.

If burning fails to retard sprouts (particularly blueberries) and seedlings, mowing could be used. A person with a scythe, walking steadily at 1 km/hr and cutting a swathe 0.8-m wide, can cut about 1 ha/day. A crew of 10 fit workers could probably mow each bald in 2 days. Mechanical mowing by a hand mower specially constructed for such terrain (Duffy and others 1974) probably requires about the same amount of time.

If grazing, mowing, or burning is used to maintain the balds, some cutting must first be completed around the edges. This may be done in a single year (which is probably cheaper but has a high visual impact) or over a period of several years, which is more difficult to organize but makes the change less obvious to visitors.

The initial restoration effort should certainly not be undertaken unless some type of maintenance activity is expected to follow. If the trees were cut and the effort were then abandoned, root sprouting would quickly replace the shrub cover and the results would probably be an even denser shrub layer than is now present. However, if the areas

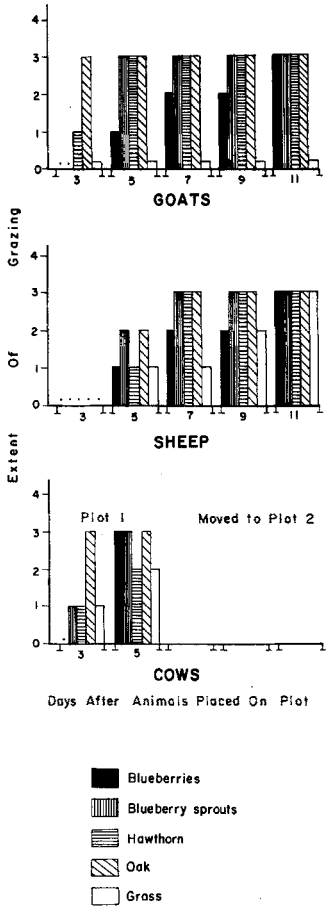

Figure 11. The relative impacts of three different types of grazing animals on five types of grassy balds plants. The class numbers for extent of grazing are explained in the test.

were abandoned after maintenance had proceeded to the point where the grass sward had been completely reestablished, the returning successional flora should be very similar to that at present. If park management decided to clear the areas, they would therefore need to make a long-term commitment to the program or a successional flora composed mostly of root sprouts might result. Artificial management carried to the point of reestablishing the prepark communities would merely "set the clock back" and if human interference were later decided to be impractical or undesirable, the areas could be left to natural succession with no adverse effects on the surrounding environment.

The need for a long-term management commitment and the expenses of the various techniques are important elements in the decision to take action. The park must be able to free enough resource management time and money to initiate and continue an intensive program that concerns a very small area, about 10–15 ha, for each bald and the surrounding forest. The most historically authentic techniques have the greatest impacts on the surrounding area and require the greatest input of time and money.

The solution, then, must involve decision making at several levels. The Congress (and associated political pressures) must decide whether the areas can be artificially managed or not. If the decision is made to exclude them from wilderness status, the National Park Service must decide whether management action is to be initiated and when. This decision would be based, at least partially, on finances, priorities, and technical feasibility. Although cutting and grazing would be the most historically correct sequence of grassy balds management and would likely best maintain their character, the most practical techniques would probably be cutting followed by mowing or cutting followed by burning and mowing.

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[1] References for this section include personal communications from Ben Sanders and E.V. Komarek; unpublished U.S. Forest Service Reports including Sanders (1975), Zeedyk (1973), and Byrne (1973); and personal communication with numerous Forest Service staff and with Dean Cocking.

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