RARE PLANT MANAGEMENT — AFTER PRESERVATION WHAT?

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Conservation of rare species is often thought of primarily as a battle to protect the lands on which they occur. After snatching a bog from highway builders, halting a power company dam, or wrestling a tract of virgin timber from a logging company, everyone pats himself on the back for a job well done. Bringing critical habitat under some type of legal protection is, of course, the first step in insuring the survival of rare species (Meijer, 1973; Drury, 1974; Smithsonian Institution, 1975; Nature Conservancy, 1975; Smith, 1976). The job of preservation and ecologically sound population management does not stop, however, after the purchase papers are signed and a property is transferred to a conservation group or a government agency to administer for "all eternity." Human activities may still threaten species, and disturbances and ecological changes continue, even in protected areas.

Some of these changes may be related to preserve size and geographical relations (Hooper, 1971; Willis, 1974; Terborgh, 1974; Diamond, 1975), others to environmental change, natural disturbance, or community processes such as succession (Stone, 1965; Watt, 1971; Westhoff, 1971; Owen, 1972; Wright, 1974; Dolan et al., 1978; White, in press). No preserve is totally free of human influence (Owen, 1972; Miller & Botkin, 1974). People are attracted to preserves, in part due to their scarcity in the developed landscape. There is currently a worldwide trend for visitor pressure to increase, e.g., in Europe (Brotherton, 1975; Dory, 1977; Slater & Agnew, 1977), Australia (Boden & Ovington, 1973), Japan (Simmons, 1973), and the United States.

Giving a natural area legal protection does not guarantee the perpetuation of the species present nor does it solve many of the philosophical issues involved in endangered species management. The purpose of this paper is to discuss some of the major issues involved in decision making for rare plant management in a reserve setting. Most of the examples of botanical management and the associated problems will be taken from Great Smoky Mountains National Park (GRSM).

WHY PRESERVATION?

The Great Smoky Mountains National Park has relatively high species diversity for an eastern forest area. About 1500 vascular species (including exotics) have been recorded from its 209,000 hectares (Hoffman, 1962). Twenty-one vascular species have been proposed for national status as endangered or threatened (Smithsonian Institution, 1975) and one fungus has also been proposed for national status as endangered (Peterson, 1974). One hundred species found in GRSM are considered endangered or threatened in North Carolina (Cooper et al, 1977) and 79 are considered endangered or threatened in Tennessee (Committee for Tennessee Rare Plants, 1978) with 29 species appearing on both state lists (herafter referred to as the state lists). The park flora includes Appalachian endemics, species with disjunct distributions, species at the edge of their range and species with very narrow habitat preferences.

Looking at the history of GRSM, however, one realizes that the inclusion of some of the rarer species was at least partially coincidental and many of the populations were not located until long after the boundaries of the area had been determined. Although "the unexampled variety of trees, shrubs and plants . . ." was a primary reason for choosing the Smokies location for a park (Campbell, 1960, p. 29), the protection of the tracts of virgin timber and the preservation of the rugged mountain scenery were probably the most important goals of early park advocates.

Parks and reserves are established for a variety of reasons, or become multiple purpose as their use increases.
Typical motives for protecting land include:

1) Preserving scenery
2) Preserving unusual ecosystems
3) Preserving representative ecosystems
4) Preserving pristine ecosystems
5) Preserving rare species
6) Preserving geologic formations
7) Preserving historic or archeological sites
8) Providing for recreational use
9) Providing for educational use
10) Providing for research use

Although other managerial objectives are not necessarily in conflict with rare plant management, they frequently overshadow it.

Also, the initial thrust of a management program is usually determined by the qualities of a reserve area which are conceptualized as most important. If the presence of a population of a rare plant species is not as "important" as some other element, it may not be considered when policies are established.

Even preserves which are established for primarily botanical reasons will probably be visited by a wide variety of people. One might expect:

1) Biologists, plant or animal collectors, (whether informal or research oriented)
2) Other scientists such as geologists, archeologists
3) Field trips of university, school, or nature groups
4) Recreation or wilderness seekers
5) Gardeners, fishermen, and hunters, with or without permission

and, if the area is heavily developed for visitors,

6) Sightseers and organized tour groups.

Any of these users may impact an area and all of them influence its management, whether directly or through political action. In addition, outside groups not directly using a preserve may also have political influence (e.g., hunting clubs which view GRSM as an important reservoir of wild boar for lands adjacent to the park which are open to hunting). The location of a preserve near large centers of population means that visitor pressure may be high. GRSM, for instance, experiences over nine million visitor days annually (records in GRSM files).

THE GREATEST THREAT

Man is still present in a preserve system and exerts his influence both directly and indirectly. Despite legal protection, the greatest threat to rare plant populations in most preserve settings is anthropogenic interference. The reserve is a microcosm which is still potentially subject to disturbances which endanger plant species elsewhere. In the case of GRSM, one mandate for the park was "to preserve and protect the native flora and fauna" but another was "to provide for the enjoyment" of the American people (U.S. Department of the Interior, National Park Service, 1970). Providing for public use usually means developments such as roads, trails, campgrounds, and museums, all of which have direct impacts on the native flora.

Initial land acquisition for GRSM began in 1927 and status as a national park was finalized in 1940. Despite over forty years as a preserve and much scientific research, a major lesson from the history of the park is that there is still a need to focus management goals, set policy, and carry out basic research. Below we will discuss problems experienced in the last 50 years at GRSM. For purposes of discussion we have divided human impacts into direct (discussed first) and indirect.

Direct Impacts

When the GRSM was first established very little attention was paid to the potential effects of development. Early advocates of the park promised to have a road built between Tennessee and North Carolina and thus gained the backing of the local citizenry. The Newfound Gap road was eventually struck across the main ridge, through virgin forest and a high elevation "beech gap". At that time, Environmental Impact Statements were unheard of, and no surveys of natural resources were required prior to construction. It is now known that the road disturbed the type locality of a rare snail and probably removed several populations of rare plants as well. Was the Newfound Gap road a mistake, or was it a logical trade made in the preservation and use of an extremely important natural area?

The promise of some kind of development or access to the public is a continuing issue in most national parks and in many state or other agency properties. Groups fighting to protect various areas frequently propose nature centers, trail systems, scenic roads, and other recreational developments, either because they believe they are necessary or because they will attract public support. The GRSM, over 40 years after its official dedication, is still having difficulties with development as a threat to native species. Despite a wilderness proposal for the park, road construction is a continuing issue with strong lobbies, both for and against, in several communities near the park.

Throughout the history of the park quite a number of roads have been proposed both by various interest groups and government planning teams. Until recently, no botanical survey was completed before a proposal was made and routes were chosen for scenic, engineering, or economic reasons. A typical conflict concerns an agreement made on acquiring an additional 20,000 ha from the Tennessee Valley Authority in 1944. A TVA reservoir had flooded a county road; the park agreed to build a road along the shore of the

Fontana reservoir on its newly acquired TVA land. Since 1944, two alternative road routes to the one along Fontana have been suggested, one supposedly better for traffic flow and tourist use and the other supposedly causing less environmental damage. After 25 years, the matter is still unsettled. There have been numerous public hearings and much conflict between different interest groups.

Although the original route has never been ecologically surveyed, the other two proposed are now known to present threats to rare plants (Baron & Mathews, 1977). Ironically, the route best accepted by groups interested in protection of wildnerness probably presents the greater danger to unique botanical resources. Within 100 m of the most likely right of way is the type locality and one of the two known populations of *Gleocantharellus purpurascens,* a fungus which has been proposed for national status as endangered (Peterson, 1974). This route also traverses several wild flower areas and unlogged white oak stands (Baron & Mathews, 1977).

Most politicians probably prefer mushrooms with beef and gravy, and may not be very pleased when a small purple fungus with no common name thwarts a possible settlement of an old squabble over a road likely to be economically advantageous to local business. The fungus, however, has as yet no special legal status. The park, at the time the issue first arose, did not have any detailed policy on maintaining population levels of individual plant species. It may seem silly to have to continue to protect the native flora from development once it is inside a national park, but the multi-purpose use of the park, lack of information, and shifting managerial directions have all led to conflicts over where developments should be placed.

Smaller preserves and wilderness areas may never be damaged by heavy construction, but less intensive development than road building can also cause difficulties in all types of areas. For instance, the presence of a lodge and a backcountry shelter, accompanied by high day use, has probably impacted a number of rare species on Mt. LeConte in GRSM. Of particular concern are *Calamagrostis cainii,* which is endemic to the park, and a population of *Geum radiatum,* which is nominated as nationally endangered (Nichols, 1977; Bratton & Whittaker, 1977). A recent survey of human impacts in eight heavily used backcountry campsites in GRSM found that four of the sites had plants on the state lists growing in or near them, including *Glyceria nubigena* (also of national concern), *Cacalia rugelia, Stachys clingmanii, Streptopus roseus, Clintonia borealis* and *Chrysoplenium americanum* (Linda Stromberg & Susan Bratton, unpublished data).

In some cases, human use, without any development, affects plant populations. In GRSM, visitors poach plants along roadsides and nature trails, taking those with showy flowers, such as *Lilium* spp. Commercial diggers illegally impact *Panax quinquefolium,* and possible other species having medicinal value. The use of *Panax quinquefolium* by the local population has a long tradition — both medicinally and as a source of cash in an economically depressed region. The taking of ramps (*Allium tricoccum*) leaves and roots is also a traditional part of regional culture and, unlike collection of *Panax* and ornamentals, is currently permitted in GRSM. The use of these plants underscores the kinds of pressures a park manager must be aware of in the local commmunities. Current NPS policy allows the taking of fruits such as mushrooms, blueberries, and acorns for personal (non-commercial) use and allows the gathering of dead wood and down wood for burning in campsites within the park.

In some preserves, sensitive areas such as dunes, bogs or alpine meadows may become so heavily used that trails or boardwalks are required. Technical climbers are able to disturb rock outcrops unavailable to the casual tourist. Even use by researchers and school groups stresses sites, and some rare plant populations are easily over-collected or trampled. Visitor loads in established areas tend to increase through time, and a preserve manager may find both developed facilities and undeveloped areas are becoming overused and deteriorating. The question recurs and recurs — how much human use and under what circumstances?

Recreation and public access, even for educational purposes, are in direct conflict in most parks with preservation of systems whose value and rarity stem from their being relatively man-free (Stone, 1965; Boden & Ovington, 1973; Simmons, 1973; Brotherton, 1975). This conflict is often explicitly decreed in the founding legislation of many parks (*e.g.* GRSM).

Indirect Impact

Unfortunately, not all human threats are due to direct impact and cannot be controlled by limiting the numbers of people in a preserve. Some impacts, in fact, are rather subtle and may not be immediately thought of as human in origin. Foremost among these "indirect impacts" in GRSM is the introduction of exotic species. The demise of the *Abies fraseri* by the exotic balsam wooly aphid, for instance, was not anticipated by the people instrumental in securing the virgin spruce-fir forests of the Smokies for the park, and began just after the disastrous chestnut blight had eliminated American chestnut as a dominant tree in the park.

One of the primary threats to rare species in GRSM at present is the European wild boar (*Sus scrofa*). Originally introduced into North Carolina in 1912 as a game animal, the species probably entered the park in the late 1940's. Park records indicate the species was not recognized as present until 1951. The hog population was probably well entrenched when control officially started in 1959 (Bratton, 1975, 1977).

Not only was the hog invasion unexpected, and action delayed until damage was noticeable in highly visible areas such as the grassy balds, but no serious attempts were made to determine the impact of the wild boar on the native flora until the 1970's. Wild boar are thought to eat a number of species on the state lists, including *Stachys clingmanii, Lilium canadense* and *Lilium philadelphicum*. Other species may be eaten or disturbed by rooting activity, including *Disporum maculatum, Streptopus roseus* and *Phacelia purshii* (Bratton, 1977; Bratton, 1979). Hogs severely disturbed high elevation wild flower areas, grassy balds, and low elevation successional areas near old homesites (Bratton, 1974, 1975; Howe & Bratton, 1976). The National Park Service has, as a policy, controlled exotic species, but the effect of hogs on rare plant species was not investigated until approximately twenty-five years after the hogs entered the park.

Besides the introduction of exotic species, a variety of other human impacts are likely to originate outside of a preserve and a manager may have no control over their source. Air pollution is a widespread concern, including the direct effects of agents such as ozone, sulfur, and heavy metals, and possibility of climatic effects, such as a general warming (Johnson & Bratton, 1978). In GRSM, as in some areas of New England, there is evidence that lead deposition is greater at high elevations (Wiersma et al., 1978; Schlesinger et al., 1974), and therefore more likely to affect rarer species.

Unfortunately, very little is known about the tolerances of rare plant species for pollutants. High ozone levels, for instance, are presently damaging and sometimes killing white pine (*Pinus stro-*

bus) along the Blue Ridge Parkway (John Skelly, Virginia Polytechnic Institute, pers. comm.). The effects of these ozone levels on *Lilium grayii* are, by contrast, totally unknown. Pesticide traces have been found even in remote GRSM watersheds. Their source is presumably agricultural dust transported by atmospheric circulation. GRSM is downwind from both midwestern agricultural centers and local farmland.

An equally insidious, but often more dramatic, anthropogenic impact is a change in ecosystem structure due to interference with the hydrologic regime or geologic substrate originating either inside or outside the preserve. Canal building and drainage outside the Everglades National Park is modifying the hydrology of 500,000 ha; dredging near Gulf Islands National Seashore is influencing patterns of sand deposition. Rather than just losing a species or two to this activity, Petit Bois Island itself may become extinct (Shabica et al., 1978). A small preserve, such as a marsh or bog which does not control its own watershed, is especially vulnerable to this sort of disturbance.

Accidental or purposeful manipulation of populations of native animal species may in turn affect plant populations, especially through overgrazing. In the case of large predators, migratory species, or game animals, the preserve manager, again, may not have complete control over the agent of disturbance. These animals are not restricted by legislated reserve boundaries. Throughout the eastern United States, the white-tailed deer is liable to become a problem species, and rodents like rabbit and beaver may also "overpopulate" an area.

In GRSM, overbrowse by deer is affecting the major limestone area in the park, Cades Cove. The extirpation of the wolf and near extirpation of the mountain lion may be related to an increase in the deer population, but the primary factor appears to be the maintenance of part of Cades Cove under an agricultural regime (Bratton et al., in prep.). In areas like the Alleghenies or Adirondacks, logging, which provides browse, and the states' attempts to maintain a "huntable" deer herd, may result in heavy browsing in adjacent preserves, such as Hearts Content, Pennsylvania, which may themselves be protected from logging.

Ironically, the conflict in GRSM is between resources within the park: Cades Cove not only contains sinkholes, swamps and limestone outcrops which support rare plants and unusual communities, but also contains dozens of historic buildings and archeological sites. The whole valley below the 2000 foot contour is now included in the National Register of Historic Places as an historic district, and is managed to retain the vistas provided by the open fields. Deer and other wildlife flourish with an abundance of both food, such as hay, and cover. Even though historical management is not intended to influence the surrounding natural area or to disturb the non-cultivated portion of the historic district, a number of rare plant species on the state lists could be affected by the deer and by manipulation of drainage. *Agrostis borealis, Campanula aparanoides,* and *Carex trisperma,* occur or have occurred in the Cove. It is only within the past two years that the impacts of agricultural management on native species have been investigated, and that area has been surveyed for rare species. The situation in Cades Cove is not only a case of weighing the value of certain resources, historic versus botanical, but also a case where the management of one area affects the adjoining systems. The large deer herd around Cades Cove creates browse pressure in surrounding natural areas, up to 1 km away from the Cove itself (Bratton, in press). Human preferences are important here, as is the all too frequently held idea that an historic area does not require natural management and vice versa.

As many elements in a community are interdependent, removal of animal or plant species can be as undesirable as over population. In GRSM, beaver were extirpated before the turn of the century (Lindzey & Lindzey, 1970). Marsh and pond plants are now uncommon in the Park, and the reintroduction of beaver could possibly result in more wet habitat in the form of beaver meadows. Although beaver were previously present, managerial action has been postponed until the consequences of encouraging the species (which may be reinvading on its own from animals stocked in western North Carolina) can be determined. Possible problems include: flooding of roads, invasion of properties near the park, overpopulation and damage to big tree stands. No one knows, of course, if any plant species originally disappeared with the beaver.

In summary, then, human impacts may still damage or destroy plant populations in a preserve, and some of these impacts may be unexpected. Some changes may be initiated years after a preserve is established and may have their source far outside of the preserve itself.

NATURAL MANAGEMENT

Preserves can never be totally free of human influence, whether direct or indirect (Owen, 1972). In addition preserves experience dynamics initiated by natural factors and have special problems associated with their size and proximity to other natural landscapes. The first step after legal protection is inventory and monitoring (Dawkins, 1971; Miller & Botkin, 1974; Johnson & Bratton, 1978). A strictly hands-off preservationist attitude is, in most cases, no longer possible; active management, if only to regulate visitation, will usually be necessary (Stone, 1965; Owen, 1972). This introduces a paradox: management policies, designed to preserve resources, also impact natural systems, change the environment of a species, its population structure, and genetic constitution (Berry, 1971). We turn next to a discussion of management goals, problems, and dilemmas.

One of the first questions which the manager has to answer is at what "genetic level" should we manage — species, subspecies, variety, deme, hybrid, or local population? The national and most state lists of endangered or threatened vascular plants emphasize species but include rare subspecies, varieties, and even some persistent hybrids (Mathews, 1977). Forms and "chance" hybrids are usually not considered.

Preserves may also have unique populations. *Geum radiatum* is not only nationally endangered, but the population on Mt. LeConte in GRSM has a number of minor morphological differences from populations further to the north, and is now probably completely disjunct as a reproductive unit (Robert Farmer, Tennessee Valley Authority, pers. comm.). How important is it to maintain the integrity of such a population?

A related question concerns the geographical significance of rare species. Many of the plants on the state lists are abundant in GRSM. Their rarity stems from the fact that they are found within North Carolina and Tennessee only within GRSM or the adjacent counties. On the other hand, some of the rarest plants in the park are abundant in other parts of the two states, and hence are not listed (e.g., limestone plants found commonly westward in Tennessee and low elevation plants found generally away from the mountains). Should we manage for protection of species whose significance and endangerment are of local import only? Where should the line be drawn?

In cases where populations have been severely depleted, the temptation is always present to transplant individuals from other areas. Under what circumstances should this be done? An example from the GRSM is the case of the eastern mountain lion. Lion sightings are becoming increasingly frequent in the Smokies and Blue Ridge (Bratton, 1978). Although it is thought that this might be a recovery of the eastern mountain lion population, western mountain lions are known to have escaped in the east, and the status of the present population is not known (Culbertson, 1977). Would the introduction of lions from stock outside the Appalachians be appropriate? How important is the "purity" of the gene pool (e.g., native eastern versus western mountain lions) versus the ecological role of the species — in this case a top carnivore? The GRSM is currently discussing the possibility of reintroducing extirpated animals such as river otter.

Most endangered species lists ignore hybrids and odd forms or varieties, yet these may be the basic building blocks in the process of evolution. Should these be given special protection in a reserve? An example from GRSM is the hybrid swarm of azaleas on Gregory Bald. A mixture of at least three species, the variety of flower color is unknown from any other locality. Since the population is not a species, it is not on any endangered list. It is, however, a completely unique resource. As will be mentioned later, the grassy balds were previously disturbed, and may require artificial management to maintain them —— should this very aesthetically appealing population of hybrids be protected by the park?

The problem of "genetic level" is related to the more general problem of management for "species" or some other genetic unit, versus managment for evolutionary or ecological "processes" (Drury, 1974; Dolan et al, 1978). This brings us from the static view of species as a biological entity at a fixed point in time to the concept of genetic change which includes evolution and extinction of various varieties, the appearance and disappearance of mutants and hybrids, and ultimately the process of speciation itself. The time scale for "natural" evolutionary change is rather long compared to that for "man-caused" changes in species genetics and distribution, but both may operate simultaneously.

Perhaps the most difficult process to accept or manage, is that of "natural extinction". Preserves are in many ways islands, and through time some gain and loss of species is to be expected

(Hooper, 1971; Willis, 1974; Terborgh, 1974; Diamond, 1975). Unfortunately, very little is known about rates of extinction for rare plant species or about the role of minor species in the communities in which they occur.

In GRSM a number of species on the state lists have been collected from one or two localities and a number of other native species have been collected at a single site. Some of these populations could be easily extingiushed by a fire, landslide or by competition with other native species. *Prunus virginiana* is known from one cove, for instance, and *Woodwardia virginiana* is found only in a poorly drained sinkhole. Some species may be relicts of glacial times and their habitats may now be "naturally" disappearing. A specimen of *Linnaea borealis* was collected in "the mountains of Sevier County," Tennessee in 1891. This collection was probably made in GRSM but *L. borealis* has not been seen since. Is this a case of recent natural extinction — related to climatic shifts? Should a manager in a preserve like GRSM accept a reduction in such relict populations?

Similarly, successional habitats are critical for some species and either a long-term trend which is slowly modifying a successional process or a temporary lack of a particular disturbed community, such as intensively burned areas, may help to eliminate a species from a preserve. The question of the disappearance of some communities, such as bogs in glacial deposits, is problematic — the habitat may be undergoing cyclical changes rather than directional succession (Drury & Nisbet, 1973). Either may naturally modify species composition.

The GRSM has limestone areas where a number of sinkholes are slowly filling with sediment. These sites are of varying sizes and depths, and several have their own distinctive communities, or are the only known site for a rare plant species. Although sinkhole formation is an ongoing geologic process, the collapse of a new area would not necessarily provide habitat like that of other existing sites. Succession in one area could eliminate a species, at least within the park.

Successional habitats could also be substitutes for late glacial alpine or wet environments, thus changes in climate and in the successional management of a preserve could be synergistic, encouraging either extinction or population expansion of a rare species. Very little is known about the biology of relict or disjunct species, and some may have already "outlived" their habitat, whereas others may be able to perpetuate themselves indefinitely under the appropriate conditions.

In the face of apparent long-term climatic, geologic, or successional changes, should a manager try to maintain species or communities that are naturally disappearing or changing in geographic distribution? Should a manager try to reestablish a species eliminated by a natural catastrophic event? Should a manger try to provide habitat for a species whose range is swiftly decreasing? Should a manager maintain disturbance-dependent species by artificially interrupting succession (Green, 1972; Owen, 1972; Smith, 1976)?

Related to the question of natural loss of successional communities is the present role of natural disturbances in a preserve. Some catastrophic events, such as landslides, may be difficult to prevent; therefore managerial options concerning them are few. Others, such as fire, flooding, and herbivore utilization may be at least partially controlled by a preserve manager. The attempt to control or suppress natural disturbances has often led to detrimental and unforeseen changes, including enhanced damage by subsequent natural disturbance (Brown, 1961; Mutch, 1970; Schroeder et al., 1976; Johnson et al., 1976).

In GRSM, fires were much more frequent in pre-park days than at present (Mark Harmon, unpublished data; Lindsay & Bratton, in press), and may have influenced the distribution of a number of rare species including *Carex misera* and *Gillenia stipulata* (Bratton, 1978). The present park policy is to suppress all fires including those caused by lightning. The manager must now ask not only what is the natural fire regime for the park, but also what is the most manageable fire regime for the park?

In developing a "natural" fire management program the first temptation is to declare lightning-caused fires "good and acceptable" and man-caused fires "bad and unacceptable". The second temptation is to suggest controlled burning to select for fire-dependent species or to improve habitat for rare plants and wildlife. The matter of "naturalness" or "historic authenticity" is not at all clear in GRSM, however. The settlers burned extensively (Lindsay & Bratton, in press) and an earlier timber cruise (1936) of the park indicates that many of the stands sampled had been burned at least once during the previous 20 to 30 years (Frank Miller, data in GRSM archives). To complicate matters, the Indians certainly burned when clearing for agriculture and may have burned when hunting. Escaped campfires were also likely. The lower elevations then have probably been subject to some man-caused fire for several thousand years, more than enough time to influence community structure and select for pyric elements in the flora. A "lightning fire only" policy is not necessarily the equivalent of any conditions that have existed in post glacial times, and controlled burning could, under many circumstances, also be a new variant in terms of evolutionary pressure. Would a burning regime that had no historic precedent be appropriate for maintaining a rare plant population? Controlled burning is often aimed at reducing the likelihood of a conflagration rather than allowing for fires with a variety of intensities. Therefore the burning policy which is usually safest in terms of property damage and personal injury may not be helpful for maintaining some rare plant populations unless it is applied under special conditions.

In many instances, the decisions presently being made about disturbance management are based on preconceptions of naturalness or idealized views of wilderness. The population ecology and genetics of the rarer disturbance-dependent species is often not well understood. In the case of a plant like *Glyceria nubigena* which now grows on grassy balds and burn scars from logging fires, around parking areas and highly disturbed campsites, as well as in blowdowns and small canopy openings, the manager needs to know where the species was found originally and what conditions maintained the populations in the past.

Disturbance management is problematic even if the disturbance is recent or clearly anthropogenic. The grassy balds of GRSM were once cleared and intensively grazed by livestock (Lindsay and Bratton, 1979). Since coming under the protection of the park, woody plant invasion has slowly reduced the grass sward and thus the open successional habitat. Natural phenomena do not appear to be creating new grassy balds in the Park and the communities could well be relicts of earlier agricultural practices (Lindsay & Bratton, 1979). Although the bald flora was maintained and influenced by settler activities, botanists have collected several rare species including *Glyceria nubigena, Prenanthes roanensis, Carex misera,* and *Polygonum cilinode* on the balds or at their edges (Lindsay & Bratton, 1979; Bratton 1979). The hybrid azaleas of Gregory Bald could predate the sheep and cattle grazing or their presence could be related to disturbances caused by agriculture. The grassy bald, like some of the grasslands and heathlands of Great Britain (Duffey et al., 1974), might be termed an "historic plant community", a grouping created at some point in time by a complex of factors no longer present. Does the presence of rare plant species warrant the continued anthropogenic disturbance of the areas, or should natural succession be permitted to proceed? Should unusual or rare "historic" plant communities be maintained inside a reserve or natural area? People have long been important in the state of European vegetation; many preserves there are managed to maintain communities that are anthropogenic in origin (Wells, 1969; Haber, 1973).

Populations of some rare disturbance-dependent species can potentially be increased by creating bands of successional vegetation around developments like parking areas, by raising plants in a greenhouse and transplanting them, or by modifying mowing, burning, or clearing schedules. Is it desirable to increase a population by artificial means or to move it to an "unnatural habitat"? What effect will human interference with ecological and evolutionary processes have on a species? Will we influence its evolution (Berry, 1971)?

The same types of questions follow if managing for aesthetics is a major goal. Is clearing a grassy bald to allow for better vistas of surrounding mountains a practice encouraging a weedy flora? Is clearing the oak saplings away from the hybrid azaleas on Gregory Bald creating an azalea garden?

SHOULD A PRESERVE BE AN ARK?

Ofttimes, like Noah, we try to load a selection of everything into a safe place and float above the flood of mankind's mistakes. The ark philosophy has started and helped protect many preserves but it can present some difficult managerial decisions.

One dilemma concerns the transplantation or reintroduction of endangered species from other locales (Wayre, 1969; Rawes & Welch, 1972; Drury, 1974; Thompson, 1974, 1976). This has rarely been approached in botanical management, but suppose a bog plant were threatened with extinction because its habitat was being drained; would it be better to move it to a protected bog elsewhere or to a botanical garden? An animal example, which illustrates the complexities of this issue, is a recent informal suggestion that a pair of red wolves be placed on Horn Island in Gulf Islands National Seashore. No one may ever be certain if red wolves were on Horn in the past, so the introduction could be "unnatural". On the other hand, relatively undisturbed and protected coastal habitat is hard to find today. Further, Horn Island has two exotic species, nutria and feral hogs, that have impacted the island's flora and need to be controlled. What is more important, getting the wolves out of the Takoma Zoo, or keeping the island fauna to its historically certain elements?

A second dilemma concerns managing for maximum possible species diversity. This would be an easy issue if succession weren't such an important element in most reserves. In GRSM, the changes occurring in former agricultural areas may well eliminate species from the park. Since the park is bordered by farms, housing developments, and logged forests, most new elements in the flora are likely to be adventitious species, invading along the roads. Is the total species count in the park of any importance? Is it worth preserving some examples of historic communities to maximize the number of habitats represented in the park?

Sometimes new species (usually Eurasian exotics) once added are difficult to control or exclude. Even a species which disturbs the native elements of the biota may have its fan club, and public pressure can favor exotics such as wild horses or wild boar. Introduced species may be "ecological equivalents" of species extirpated in the late Pleistocene. Should the manager accept such species and let "nature seek a new balance"? If complete eradication isn't possible, should partial control be initiated (which makes the manager an integral part of the ecosystem)?

THROUGH A GLASS DARKLY

The flora of North America has been profoundly influenced by two major phenomena in the last few thousand years: the coming and going of the glaciers and the arrival of man. The key to managing rare species in a preserve setting is not just understanding ecological and evolutionary processes, but also understanding our role in them.

Administrative policy may, like a great glacier slowly advancing and receding, change through time and the magnitude of its impacts may vary (Dory, 1977). Managerial systems evolve, strengthen, and decay as a function of public interest, financial support, public pressure on the resource, fashions in our perception of the natural world, chance variations in staffing, and the increment of changes in the ecosystems themselves. The best example of this type of managerial history is the continual change in attitude toward the policy on the role of fire in our national parks and forests. A typical trend might be from uncontrolled fires on slash, to complete fire suppression, to controlled burning, to some allowance for natural fire, and then possibly even a return to controlled burning. In each case, cost-benefit, manpower, the physical resources of the agency, scientific information, and public opinion will all have been considered, at least informally.

The structuring of policy on rare and endangered plants is likely to go through similar processes, and it is well to remember that there may be no greater threat to an endangered species than an unsympathetic bureaucrat or politician. The very fact that so little is known about the biology of most rare plants indicates that the opinions of the scientific community are likely to change through time, and that some mangerial experiments may be conducted on an inadequate data base or with insufficient understanding of ecological processes, and are therefore likely to fail. The need in a preserve like GRSM is to establish management which is strong enough and directed enough to offer the individual species and the associated ecosystems and ecosystem processes the best protection possible and yet is flexible enough to evolve with an increased knowledge of the biology of the systems.

On the other hand, we need to realize that the academic tendency towards infinite data collection is a severe burden to management, and that administrators will frequently use "lack of information" as an excuse to do nothing, when a positive management alternative already exists. The ultimate managerial program for rare plants must have policy safeguards that prevent the program from slowing down, being dissolved, or becoming too much a function of public pressure, administrative convenience, or mere managerial opinion (Dory, 1977). Research and management action need to be balanced and coordinated with each other.

Sometimes managers have the feeling that non-interference with the ecosystem is the best and most "natural" policy. Frequently, this is true (Stone, 1965; Owen 1972), but the hand of man is everywhere today — there are traces of pesticides in even the most inaccessible streams in GRSM. There is no way to lock up a preserve absolutely to keep man out. We should, at the very least, be monitoring our own effects (Dawkins, 1971; Miller & Botkin, 1974; Johnson & Bratton, 1978), and if something needs to be done to protect a rare plant in a preserve, there is no reason not to take action, even if it is only deciding what we need to know. Foremost among research needs are population biology of rare plants (Jeffrey, 1971; Dring & Frost, 1971; Namkoong & Roberds, 1974; Massey & Whitson, 1977), and ecology of natural disturbances and community dynamics (Watt, 1971; Wright, 1974; Franz & Bazzaz, 1977; Dolan et al., 1978; White, 1979).

ESTABLISHING A DIRECTION

In the concluding section of this paper, we would like to establish a direction, show how rare plant management might be instituted in a preserve, and suggest tentative answers (relative to GRSM) to some of the questions we have proposed. Each preserve has its own problems, of course, and each has its own mandates and reasons for being, but the basic procedures for developing managerial programs are often rather similar.

The following, using GRSM as an example, is a typical sequence for establishing a program:

Step One: **Establishing a basic policy.** Even before a data base is accumulated, certain policy decisions have to be made. In GRSM original policy was "to protect the native flora and fauna", thus excluding exotic plantings, etc. A new preserve might establish a policy that no developments be constructed before a resource inventory of a set standard was completed, or that virgin forest areas be excluded from all types of controllable anthropogenic disturbance. Policy on acquiring a data base, and on establishing managerial flow charts and decision making structures is usually an immediate problem. Most preserves should have as an initial policy, complete protection of rare plant species and the construction of an inventory of their populations and locations. It is important to establish some policy on rare species as soon as possible.

Step Two: **Inventory and basic data collection.** In GRSM, the first inventory effort, conducted largely in the 1930's, consisted of developing species lists, accumulating vouchers, conducting a timber cruise and drawing a vegetation map. After this initial effort, the interest in "inventory" declined and the records were not consistently updated. The present approach in GRSM is aimed more at monitoring than at simple listing of species occurrences, and is also intended to allow for and encourage continual updating.

The vascular species list for the park has been computerized and each species has its own six letter code. Additional information such as phenology, height class, and status in the park is being added for each species and may eventually be included for varieties. The two main herbarium collections for the park, one in GRSM, and one at the University of Tennessee, Knoxville, are presently being computerized also. The computer records include collector, date, forest type, Universal Transmercador coordinates, etc. The information can be sorted by species, county, watershed, collector, and so forth. This permits quick construction of floristic lists for specific areas of the park, and can also be used to answer a multitude of questions about the quality of the data base, i.e., which areas tend to be under-collected (Peter White, unpublished instructions and data).

An attempt has also been made to keep computerized field records, for sightings where no collection was made. This is obviously a critical data management problem, especially in the case of endangered species where collection may be undesirable. Eventually this information should interface with the herbarium records.

The GRSM, as part of the International Biosphere Reserve Program, is establishing permanently marked plots, in all major vegetation types and in a variety of geographic locations throughout the park. A number of plots (usually 1 ha, 20 × 50m) have been placed in unique habitats or near rare or endangered plant populations. Species on the state lists have also been recorded in plots established for a variety of other monitoring purposes, including quantifying campsite, deer, and wild boar disturbance. This year the program should be continued to include permanent herb plots in specialized areas for careful census of very limited populations. These herb plots should be exactly relocatable, whereas those in a 1 ha plot are laid out in a regular pattern but are not placed relative to rare species or exactly marked. Data collection will include type and intensity of natural and unnatural disturbances.

Step Three: **Prioritization of research and management issues.** After basic data is accumulated the manager can begin to sort through potential management problems. Not only should rare plant management, in general, be given a priority (usually a high one), but the status of the individual species should be evaluated. The position of the species on a national or state list may not reflect the condition of populations in the preserve. In GRSM, *Cacalia rugellii* has an extensive and probably stable population but is of high concern on both state lists. A number of plants such as *Lilium* spp., are not only rarer, but are being disturbed by wild boar or other agents.

Some species and situations may need close attention, others very little. In GRSM, most rare species can still be found where they were originally discovered, and few radical changes can be expected in most populations over short periods of time. The exceptions to this should be at the head of the research/management lists.

There is presently a preliminary report for GRSM which lists rare species, their known status and possible threats (Bratton, 1979). This is being thoroughly revised and all species on the park vascular species list which are on the national or state endangered lists are being field checked. Eventually all the species (and areas where such species are concentrated) will have individual files containing the information suggested in Henifin et al (1979).

The resources manager can then not only organize species according to the anticipated management program but can locate sites on master quad maps and integrate rare plant information into other managerial decisions.

Step Four: **Answering critical questions and converting to active management.** Management then has to turn towards collecting more data on top priority problems and implementing actions where necessary. Frequently, the effects of management actions themselves will have to be monitored.

In GRSM, for instance, resources management is trying to eliminate wild boar from certain high elevation deciduous forests where damage is extreme. Management has also been proposed for the visitor-trampled areas on the top of Mt. LeConte and for some of the poorly drained limestone areas in Cades Cove. Some of these sites should eventually have individual management plans and continual checks on the success of the program.

Step Five: **Detailed policy decisions on all philosophical questions and on rare plant problems that are integral parts of other managerial issues.** Eventually, rare plant management has to interface with other managerial issues such as fire management.

The following is an abbreviated example of a possible set of policies on rare, threatened or endangered plants in a park or preserve in a temperate deciduous forest. We have included this list, partially to show that, although we enjoy philosophizing, we also believe it is necessary to make decisions and to act on them. The list is not intended to be an absolute statement of the best policies but is included as an example of how one could make a series of coordinated decisions for an area such as GRSM.

I. Any plant considered of concern on a national or state level will be considered for special status in the preserve.

II. Ubiquitous species, those frequently found in a major vegetation type in the preserve, may be excluded from the list if vegetation samples indicate low levels of disturbance (i.e., trail construction) are not a threat to the population.

III. The preserve will manage to protect unique gene pools of regional or local significance which may include protection at the subspecies, variety, form, hybrid, or local population level. Hybrids or other genetically unique populations will be given high priority for protection if they are endemic to the preserve or of very limited distribution elsewhere. In practice, it is recognized that "unique gene pools" and "local significance" are subjective and relative terms; hence, botanical research and informed judgment are required in this process.

IV. *First priority* on the preserve list will be given to species with very limited populations which are also endemic to the preserve and to species which are nationally endangered.
Second priority will be given to nationally threatened species, those in the highest category on the state list(s) (endangered) and to regional endemics with limited populations.
Third priority will be given to species considered threatened by the state(s), and species with disjunct distributions which have limited populations in the preserve, and variants or hybrids limited to the preserve.
Fourth priority will be given to all other native species known from ten sites or fewer, and to varieties or hybrids limited to the preserve.

V. Management priority will be adjusted according to the status of the plant in the preserve.
First managerial priority will be given to any plant in the first category above which is in immediate danger of extinction.
Second management priority will be given to any plant in the first three categories which is in immediate danger of extirpation from the preserve.
Third management priority will be given (in order of the above categories) to plants whose populations are being reduced by anthropogenic disturbance.
Fourth management priority will be given to all other species.

VI. Populations eliminated by natural catastrophic events will only be artificially reestablished if the removal of the population in question is detrimental to the species' chances for survival in toto (not just in the preserve) or if the preserve population is considered significantly different (genetically) from those outside the preserve, and the population can be replaced by native stock.

VII. Any population of a rare species removed by an anthropogenic disturbance may be artificially reestablished, but natural propagation is to be favored where possible.

VIII. No attempt will be made to maintain populations of rare exotic species or of species common in the adjoining states, but rare in the preserve due to lack of habitat (i.e., certain roadside weeds and successional species).

IX. An attempt will be made to protect unique natural habitats.

X. Artificial mixing of preserve populations with gene pools from outside the preserve will only be practiced where there is no viable alternative for maintaining the population of a native species. Removal of material from the preserve, artificial propagation, and return to the preserve is to be preferred where introduction is necessary.

XI. Species thought not to be native to the preserve will not be introduced, even if they are native to surrounding state(s) and/or are endangered in their original habitat.

XII. Severe natural disturbances should be allowed to occur whenever and wherever other considerations such as visitor safety or possible damage to property outside the preserve do not inhibit them.

XIII. Artificial disturbances, particularly natural factor imitators like controlled burning, may be used on sites where rare plant populations are disturbance-dependent, but the natural disturbance regime cannot operate due to cultural restrictions.

XIV. All rare plant populations will be monitored. This effort may be limited by available manpower, but the most desirable scheme would include annual population estimates for species thought to be in flux, and longer term (once every five years) checks for species with larger and/or stable populations.

XV. Scientific collection of rare species will be limited to those having permits specifically for those species and conducting work which will further our knowledge of their biology without damaging the populations in the preserve.

XVI. Individual species and areas of concern will each have a management plan. Each plan should include:
A. Geographic location and description of the area
B. Reason for protection status or management action
C. Present status of species or site (including threats)
D. Managerial needs and alternatives

CONCLUSION

The mere establishment of legal boundaries does not protect plants in preserves from human impacts. Active policy formation and management are usually necessary and should be instituted as early in the history of the preserve as possible. In order to manage rare plant populations, decisions concerning philosophical issues have to be made. Important areas for future research and discussion include allowable disturbance levels and population reduction for rare species, relationships between process oriented and species oriented management, impacts of management on the population genetics of species, and accurate methods of monitoring rare plant populations.

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