Georgia's Mountain Bogs: Rare Gems of the Southern Blue Ridge

Mountain Bog. A "beaver-influenced" sedge meadow/stream/shrub swamp complex. Alan Cressler

J. Mincy Moffett, Jr., and Carrie Radcliffe

Mountain bogs are among the rarest of all habitat types in North America and are also one of the most threatened. Recognized as biodiversity hotspots supporting numerous rare biological elements, they were likely never common across the landscape. They are even rarer today as a result of the tremendous habitat degradation throughout the southern Appalachians beginning in the mid-19th century. Although the pace of degradation has slowed in the last half century, forces continue to reduce, fragment and threaten this most precious of natural communities. In 1995, a glimmer of hope for mountain bogs would arrive in the form of a new and passionate group dedicated to plant conservation: the Georgia Plant Conservation Alliance (GPCA). The GPCA coalesced around the early conservation efforts of the "Bog Fathers" at two mountain bogs. This is their story.

Rebecca Byrd/DNR

Dense sphagnum mat. Monitoring a Swamp Pink safeguarding microsite.

Mountain Bog Primer

Mountain bogs, the Georgia variety, are wetlands situated in relatively flat topography and poorly drained soils of the Southern Appalachians. The majority of the intact mountain bogs are found between 2,500 and 3,500 feet. a.s.l. Soils are both mineral and organic in nature, although deep organic soils, characterized by some depth of peat accumulation, are most common. Mountain bogs vary considerably in their appearance, especially vegetative structure and composition, owing principally to differences in bog origin, hydrology, disturbance regime, and historic land use.

Bog hydrology is complex and varies among sites, being affected by both surface flows (seeps, springs, creeks, overland flow from floods), subsurface flows (groundwater exchange), as well as direct precipitation. Mountain bogs develop in association with seepage slopes, springheads, small order stream alluvial floodplains/old channel beds, and beaver swamps/ponds. Most mountain bogs in Georgia have multiple hydrologic inputs and support multiple habitat types, thus the term "mountain bog complex" is frequently applied to them.

Nearly all mountain bogs in Georgia possess some coverage by sphagnum moss and some degree of peat development. Peat is the layered, compressed, partially decomposed vegetable matter supplied by bog plants, potentially accumulating over centuries or even millennia. The sphagnum mosses, of which Georgia boasts twenty species, are the greatest contributor. The cool, wet, acidic nature of bogs promotes anaerobic and antiseptic conditions, severely limiting the decomposition of plant matter. Peat's thick deposits are mined throughout the northern hemisphere for use as both fuel and as a soil amendment, the latter known commonly as "peat moss" and capable of holding 20+ times its weight in water. Sphagnum moss can form living mats six inches deep, as well as mounding tussocks of a foot or more, capable of covering logs, micro-topography, and even small plants.

Invariably, the question arises as to whether our bogs are actually bogs or fens. The classical distinction was based exclusively on hydrology, and was developed using northern ecosystem models. Traditionally, bogs are defined as peatlands having only precipitation as a hydrologic source and are referred to as ombrotrophic (cloud-fed). Bogs collect acidic rainwater and generate humic acids from their peat. Since they are unable to purge their acids (i.e., no flow-through) they become and remain very acidic (pH 3-4.5). Fens, on the other hand, have at least one hydrologic input in addition to precipitation (i.e., groundwater, seep, etc.), and are termed minerotrophic (mineral containing). Thus, they reflect the chemistry of the geologic substrate through which they flow. Fens can be either acidic "poor fens" (pH 4.6-6.0) or neutral/alkaline "rich fens" (pH 6.1-8.0), depending on the substrate. Erosion of the acidic mountain bedrock of Georgia generally results in the creation of poor fens. There is also the floristic consideration. Vegetatively, many mountain bogs (or sections of mountain bogs) more closely resemble ombrotrophic bogs than minerotrophic fens, despite fen-like hydrology and pH. Consequently, mountain bogs in Georgia can be viewed from varying perspectives: hydrologically as fens (almost all), chemically as poor fens (most), and floristically

as bogs (many to most). The authors prefer the colloquial use of the term bog to describe all of Georgia's mountain peatlands (or wetlands with sphagnum), while acknowledging the definitional challenges and nuances of the bog vs. fen debate.

Beaver are thought to play an important role in many mountain bog systems, even if not currently present. Historically, beaver were more abundant than today. They dammed mountain streams, creating ponds and killing woody vegetation. Periodically, they abandoned their ponds, and their untended dams broke, exposing muddy flats. These were quickly colonized by the sphagnum moss, wetland herbs, and graminoids already present in the beaver swamp ecotone. These "sphagnum flats" constituted an embryonic bog that developed over time as peat increased and floral diversity matured. Open sphagnum bogs gradually succeeded to a shrub bog or even a swamp forest if succession was not interrupted or reset. A return of beaver could completely reset the system, while other ongoing disturbances could retard succession (e.g., large mammal herbivory, periodic wildfire, or Native American activity). It is possible that some bogs have lived, died, and been reborn hundreds of times. Regardless, the lifespan of any single bog (as measured by a continuous stretch of time uninterrupted by intervals of conversion to another habitat type), is relatively short, possibly measured in decades.

Vegetation is remarkably varied among mountain bogs along both bog-fen and woody-herbaceous gradients. Soil and hydrologic conditions (e.g., sodden soils, low pH, low nutrient levels) in the "bog proper" restrict the types of plants able to establish in such habitats. Nevertheless, bog flora is well suited to these realities with adaptations for low nutrient conditions, including nitrogen fixation (e.g., alders), mycorrhizal associations (e.g., laurels and rhododendrons), and carnivory (e.g., pitcher plants and sundews).

Habitat types associated with mountain bogs range from full canopied swamp forests, to shrub bogs, to herbaceous/graminoid meadows, to sphagnum flats; all perhaps interspersed to some degree by open/flowing water. Dominant tree species include Red Maple (*Acer rubrum*), Tulip Tree (*Liriodendron tulipifera*), Black Gum (*Nyssa sylvatica*), and White Pine (*Pinus strobus*). Pitch Pine (*Pinus rigida*), a highly desirable species promoting a fire regime, is relatively uncommon within bog-propers. Less common species that add showiness or interest to the bogs include serviceberry (*Amelanchier arborea*), Sweet Birch (*Betula lenta* var. *lenta*), American Holly (*Ilex opaca*), Cucumber Magnolia (*Magnolia acuminata*), and Fraser Magnolia (*Magnolia fraseri*). Dominant shrub species are Tag Alder (*Alnus serrulata*), Mountain Laurel (*Kalmia latifolia*), Great Laurel (*Rhododendron maximum*), and Possum Haw (*Viburnum nudum*). Where present, the following shrubs can become robust thickets: Black Chokecherry (*Aronia melanocarpa*), Winterberry (*Ilex verticillata*), Mountain Doghobble (*Leucothoe fontanesiana*), Maleberry (*Lyonia ligustrina*), and Northern Wild Raisin (*V. cassinoides*), the latter at higher elevations. Frequent showy shrubs include Mountain Sweet-pepper Bush (*Clethra acuminata*), Sweet Azalea (*Rhododendron arborescens*), Swamp Rose (*Rosa palustris*), and Common Elderberry (*Sambucus canadensis*). Common herbs are White Turtlehead (*Chelone glabra*), Orange Jewelweed (*Impatiens capensis*), Cardinal Flower (*Lobelia cardinalis*), Tear Thumb (*Polygonum sagittatum*), Swamp Aster (*Symphyotrichum puniceum*), Roughleaf Goldenrod (*Solidago patula*), and Primrose-leaved Violet (*Viola primulifolia*). Graminoids dominate the understory of sedge meadows with Prickly Bog Sedge (*Carex atlantica*), Fringed Sedge (*C. crinita*), northern Long Sedge (*C. folliculata*), Greater Bladder Sedge (*C. intumescens*), Bristlystalked Sedge (*C. leptalea*), Shallow Sedge (*C. lurida*), Three-way Sedge (*Dulichium arundinaceum*), Fowl Mannagrass (*Glyceria striata*), Common Rush (*Juncus effusus* ssp. *solutus),* Rice Cutgrass (*Leersia oryzoides*) Brownish Beaksedge (*Rhynchospora capitellata*), Woolgrass (*Scirpus cyperinus*), and

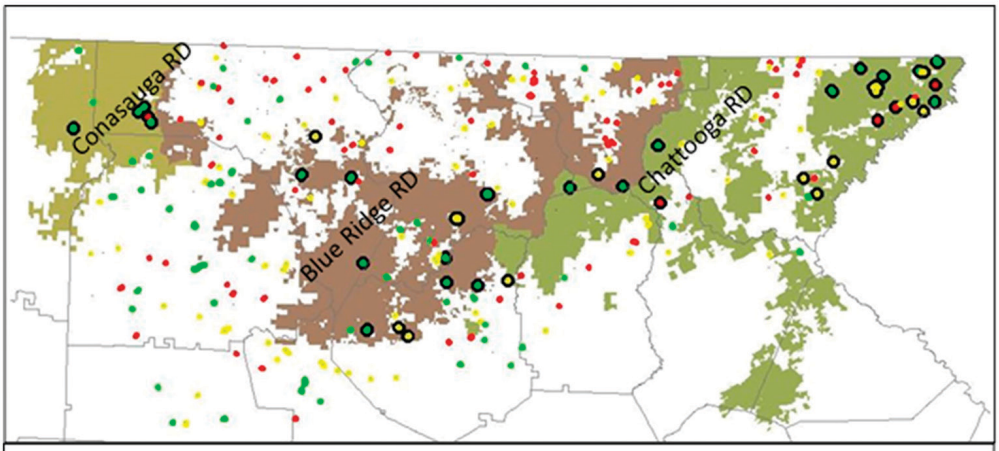

Figure 1. Full extent of wetlands identified (n=330). Dots indicate locations of suspected wetlands (not all dots are distinguishable at this resolution). Colored lands indicate different USFS Ranger Districts. White background indicates private land. Dot color indicates judged wetland integrity: **green = good**, **yellow = fair**, **red = degraded**; black border = USFS ownership; borderless = private ownership.

Leafy Bulrush (*S. polyphyllus*). Less common grasses, yet good mountain bog indicators, are Slender Mannagrass (*Glyceria melicaria*) and Seep Rush (*J. gymnocarpus*). Common ferns include Sensitive Fern (*Onoclea sensibilis*), Cinnamon Fern (*Osmunda cinnamomea*), Royal Fern (*Osmunda spectabilis*), and New York Fern (*Thelypteris noveboracensis*). And, of course, ,sphagnum mosses (*Sphagnum* spp.).

Mountain bogs are exceptionally rare and usually quite small. Most range in size from ½ to two acres, with the largest one in Georgia approaching twenty acres (part of a huge mountain bog/wetland complex). A GIS survey for mountain bogs across Georgia's Blue Ridge was conducted by the Georgia Department of Natural Resources (DNR) and the University of Georgia's Natural Resources Spatial Analysis Laboratory (NARSAL). The study involved visual interpretation of Digital Orthophoto Quarterquads (DOQQs) and Digital Raster Graphics (DRGs) to identify areas of likely wetland development or existence. Historic bog turtle locations, National Wetland Inventory (NWI) data, and maps of hydrologic soils were used to aid in identifying these areas. Over two million acres, across 15+ counties in extreme northeastern Georgia, were remotely surveyed and analyzed. Only 1,160 acres (from 330 sites) qualified as potential mountain bog/wetland sites (<0.06%) (Figure 1).

Extensive ground-truthing of these sites, led by DNR biologist Thomas Floyd, determined that only eighty-five of these were currently, or likely had been recently, mountain bogs. Of these, only fifty-five sites, totaling just 215 acres were judged to be either intact or restorable. This is less than 0.01% of the survey area; a clearer indication of their rarity could not be provided.

It is reasonable to wonder how rare mountain bog flora survived across the millennia, given mountain bogs' historically low numbers, small size, and short life span. One possible explanation involves meta-population dynamics. The idea is that spatially separated populations and unoccupied suitable habitat were, in fact, still connected and interacting at some level. Bogs were constantly being created, and constantly succeeding to other habitat types. Propagules of rare flora moved among sites, and were capable of inoculating new unoccupied sites or

Mountain Bog. A forested wet graminoid meadow—elevation 3,200 a.s.l. Alan Cressler

rescuing failing populations with new genetic material. As one population went extinct, another population was created. Rare flora survived by "hopscotching" from suitable site to suitable site through time. Unfortunately, it now appears that mountain bogs have become too small and too isolated to survive in even this manner. This has profound implications for restoration and management, the principal one being that bogs must be restored to, and managed in, a steady early-seral state. Bogs with rare flora can no longer be permitted to succeed to forest, to be inundated by beaver ponds, or to stochastically "wink out." There just aren't enough bogs in existence or new ones being created to withstand such a loss.

Historically, all wetland types were much more common throughout the Southern Appalachians. Mountain bogs today are mostly restricted to higher elevations in remote areas, although they once would have been common in fertile valleys, behind levees, and associated with all manner of lower elevation seepage slopes. Intensive agriculture and silviculture, employing ditching and draining, and promoting erosion and nutrient runoff were chiefly responsible for the extensive reduction of mountain bogs. Reservoir construction and vacation home development have also taken a toll.

The paucity of quality mountain bog habitat is of serious concern to the DNR. Restoration of mountain bog habitat and the safeguarding of its rare flora are listed as high-priority conservation actions in Georgia's 2005 and 2015 State Wildlife Action Plans (SWAP). Implementation of these conservation actions has been a long-term project of the Georgia Plant Conservation Alliance (GPCA)—even prior to the development of SWAPs. The GPCA is actively involved in the restoration and management of ten mountain bogs.

The Birth of Mountain Bog Conservation and the GPCA:

The Georgia Plant Conservation Alliance (GPCA) is an innovative network of pub-

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Helonias bullata (Swamp Pink) in bloom.

lic gardens, government agencies, academic institutions, utility companies and environmental organizations committed to preserving Georgia's endangered flora. Formed in 1995, the GPCA initiates and coordinates efforts to protect natural habitats and endangered species through biodiversity management, public education, and rare plant propagation and outplanting (i.e., safeguarding). There are over forty institutional members, including: the Atlanta Botanical Garden (ABG); Chattahoochee Nature Center (CNC); DNR; State Botanical Garden of Georgia (SBG); The Nature Conservancy (TNC); the U.S. Fish & Wildlife Service (USFWS); and the U.S. Forest Service (USFS). There are currently 100 species being safeguarded by GPCA member institutions.

Safeguarding is the signature conservation tool of the GPCA. It is also a conservation strategy of last resort, frequently necessary for the survival of many critically endangered species and populations. Safeguarding is concerned with establishing and maintaining *ex situ* collections of rare species and rare ecotypes, as well

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Sarracenia purpurea var. *montana* (Mountain Purple Pitcher Plant) in bloom.

as using this cultivated material to support *in situ* conservation activities. Such activities include re-establishing extirpated populations, augmenting existing populations, and establishing new populations in suitable habitat within their appropriate range. Safeguarding programs also include monitoring, restoration, and management components. The driving idea behind safeguarding is, "spreading the risk of extinction while protecting genetic integrity."

The GPCA's first attempts at safeguarding involved the Swamp Pink (*Helonias bullata*) and Mountain Purple Pitcher Plant (*Sarracenia purpurea* var. *montana*). The two taxa are known historically from just two sites in Georgia (Rabun County): (1) a remote site on USFS land containing only the pitcher plant; and (2) a more easily accessible privately-owned bog supporting both species. The pitcher plant and Swamp Pink were first documented in Georgia by Wilbur Duncan in the 1940s. The history of the GPCA and its safeguarding program are inextricably linked to these species and sites.

The fate of these two mountain bogs has differed markedly. While the privately-owned site suffered extensive degradation, the USFS site fared reasonably well. The USFS bog's location at the top of a watershed on public land provided protection from serious hydrologic alteration. Its remote location and vague discovery details contributed to the lack of collecting and

Safeguarding Collection—Atlanta Botanical Garden Conservation Nursery. Mincy Moffett/DNR

poaching of the rare pitcher plants. In fact, it was so seldomly visited that the bog's location was forgotten by the USFS until rediscovered by Tom Hawkes (USFS District Ranger) in the early 1980s. Later in 1986, Ben Sanders (USFS Biologist) introduced Tom Patrick (DNR Nongame Biologist) to the site. This was the moment when mountain purple pitcher plants and mountain bogs first "blipped the conservation radar" in Georgia.

No single event was more impactful to the history of this site and its pitcher plant inhabitants than a dire mistake committed in 1990 by a well-intentioned USFS employee. In an act of providing "special care for special plants", pelletized fertilizer was fed directly into their pitchers. The inevitable result was short-term chemical burning and long-term promotion of rot that proved lethal to over 90% of the pitcher plants. Only seventeen of the more than two-hundred original pitcher plants would survive.

When Patrick learned of the mistake, he enlisted the help of Ron Determann, founder of the Conservation Horticulture program at ABG, to salvage plant material and, hopefully, the population. By dividing rhizomes in the field and transporting them to the garden, Determann was able to rehabilitate the plants, bring them to flower, pollinate them manually, and produce seed. Ultimately, offspring from the rescued plants would serve to augment and establish populations of mountain purple pitcher plant throughout the Blue Ridge in Georgia. This was the unofficial genesis of the GPCA's safeguarding program

Between 1990 and 1994, the first attempts at bog restoration began with an informal partnership developing among ABG, CNC, DNR, TNC, and USFS. In addition to the rescue of the fertilized plants, collections were also made of pitcher plant and Swamp Pink seed from the privately-owned site. Light manual clearing

Jennifer Ceska/Anna Yellin GPCA

GPCA workday photo. Initial bog clearing.

Carrie Radcliffe/ABG

Mountain Purple Pitcher Plant seedling.

was performed at both bogs, and later, each site was augmented with appropriate seed-grown material. In 1994, the USFS and privately-owned sites received 150 and 10 pitcher plants, respectively. The USFS population would continue to expand over the next 20+ years. The privately-owned pitcher plant population was not so blessed. They would eventually succumb to declining suitability of habitat and poaching, with the last individual disappearing by the late 1990s. Fortunately, the Swamp Pinks have managed to endure.

It was in 1995 that the GPCA, conceived by Jennifer Ceska (SBG) and inspired by her UGA master's thesis project, was established. It formed around the nucleus of early mountain bog activities of Patrick, Determann, Henning von Schmeling (CNC), and Jonathan Streich (TNC), now collectively, and affectionately, referred to as the Bogfathers. Thus it came to be that the first official GPCA projects would forever be tied to mountain bogs.

Since the GPCA's inception, the USFS bog has been augmented with more than 150 additional pitcher plants. Fruit set, the first known from Georgia in decades, was observed in 1999. In 2000, the first seedlings were discovered. A 2013 census indicated multiple generations of plants, flowering recruits, and over 400 individuals (all size/age classes).

The success of the GPCA mountain bog program expanded beyond the original USFS site. In addition to the augmentation at that site, introduced pitcher plant populations have now been established at seven more mountain bogs (total of eight safeguarding sites). Over 400 individuals have been outplanted at these seven bogs since 1997. Recruitment has been documented at four bogs, and is expected soon at a fifth. In total, over 600 individual pitcher plants, seed-grown from the original USFS population, have been outplanted across north Georgia since 1995. Two additional sites have been selected for introduction in the next few years.

The privately-owned site suffered multiple degradations during the last 70+ years. A portion of the site was ditched and drained in the 1940s and converted to a hayfield. Additional alteration of the upstream watershed led to siltation problems and promoted the down-cutting of a nearby creek serving to further dry the bog. Early landowner efforts at keeping the area open with fire and occasional clearing had waned by the 1990s. Succession and shading became a serious problem. Over-collecting and poaching had reduced the pitcher plant population to five individuals by 1995. Sometime shortly thereafter they disappeared altogether. Only a remnant population of the Swamp Pink persists today.

Restoration and management options are

Carrie Radcliffe/ABG

First observed Swamp Pink recruitment.

Hugh Nourse

Chelone cuthbertii (Cuthbert's Turtlehead) in bloom.

Alan Cressler

Kalmia carolina (Carolina Bog Laurel) in bloom.

currently limited at the private site. However, it has provided a reliable seed source for safeguarding Georgia's only naturally occurring, and the world's southernmost, population of Swamp Pink. Sometimes the focus of safeguarding is the preservation of genetic material from certain populations deemed valuable, as opposed to species level conservation. This is especially important for Georgia ecotypes that represent southern edge-of-range populations. A study by Godt et al. (1995) determined that, although relatively small in size, Georgia's Swamp Pink population was the most genetically diverse population analyzed across the entire Swamp Pink range (Georgia to New York). Preservation of these alleles could potentially be important for the global recovery of the species.

The GPCA safeguarding efforts have established new populations of Swamp Pink at four restored mountain bogs, with two additional sites awaiting introductions. From 1997 to 2012 over 300 seed-grown individuals, progeny of the privately-owned population, were returned to the wild. The first flowering was observed in 2010. The resultant first seedlings were documented in 2011. These were oddly the first seedlings ever documented in Georgia, including the donor site.

Other safeguarded species include Carolina Sheep Laurel (*Kalmia carolina)*, Cuthbert's Turtlehead (*Chelone cuthbertii*), Canada Burnet (*Sanguisorba canadensis*), Marsh Bellflower (*Campanula aparinoides*), and White Meadowsweet (*Spiraea latifolia*). Green Pitcher

Alan Cressler

Campanula aparinoides (Marsh Bellflower) in bloom.

Alan Cressler

Sanguisorba canadensis (Canada Burnet) in bloom.

Plant (*Sarracenia oreophila*) is also safeguarded both *ex situ* and *in situ*, and intensively managed. However, its mountain seepage meadow habitat is not technically considered a mountain bog or fen, as it possesses too much surface flow, is too shallow-soiled, and lacks peat accumulation. It is, in fact, a much rarer habitat type. It is only loosely considered part of the GPCA mountain bog project due to its geographic proximity and shared hydric aspect.

GPCA Restoration and Management:

Restoration and management of mountain bogs are multidimensional and can vary greatly among sites. Vegetation management is the principal area of concern. Invasive species control, "micrositing" (defined later), and small scale hydrologic repair are also important. Some mountain bogs have required only limited restoration, usually in the form of light-to-moderate woody vegetation removal with appropriate micrositing of safeguarded elements. Other, more challenging, bogs, have needed extensive clearing, constant attention to invasive plant and animal control, and frequent "hydrologic tinkering." The GPCA utilizes assistance from member institutions and regular volunteers from the Botanical Guardians program, as well as seasonal crews from Americorps, Youth Conservation Corps, and Greening Youth Foundation.

Vegetation management focuses on woody vegetation reduction to address encroachment and succession. It includes daylighting both the bog-proper and the bog ecotone. The bog-proper is the actual wet footprint of the bog, comprising the necessary hydrology, hydric plants, and hydric soils of a true wetland. The bog ecotone is an area of variable width outside the bog-proper and provides a gradual transition into the upland forest matrix. Offending woody vegetation is most frequently large shrubs, (e.g., Rhododendron and Mountain Laurel) and smaller rhizomatous and/or thicket-forming shrubs (e.g. Tag Alder, Chokeberry, Maleberry, Possumhaw, and Winterberry).

Alan Cressler

Spiraea latifolia (Broadleaf Meadowsweet) in bloom.

Rebecca Byrd/DNR

Micrositing, weeding a pitcher plant outplanting site.

David Vinson/USFS

Inaugural year of chemically treating Chinese Silvergrass.

Problematic tree species are Red Maple, Tulip Tree, Black Gum, and White Pine. Management employs both hand tools and chainsaws. Most cut debris is removed or "swamped" from the bog-proper. Small trees are usually cut; large trees are girdled. To date, herbicides have been used only sparingly in a research context.

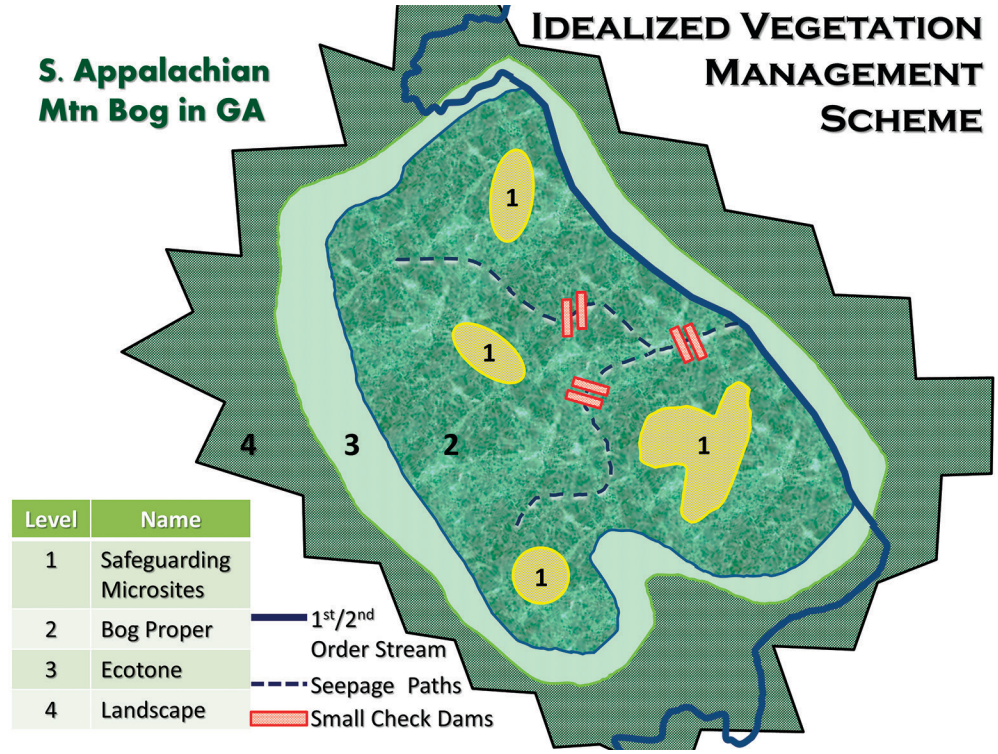
Micrositing is one of many terms coined by the GPCA. A microsite is considered any small patch within a restoration or management area that has received (or will receive) an outplanting. A mountain bog microsite is most often a well-developed sphagnum patch, although some species require a higher/drier setting (e.g., Carolina Bog Laurel). Commonly 10–100 ft^2 in area, microsites possess a suitable mix of micro-topography, sunlight, and hydrology for the species being outplanted. Micrositing refers to all management activities involving a microsite, such as its initial selection, its prep for outplanting, and its on-going maintenance. On-going maintenance requires annual weeding of non-outplanted material, including aggressive herbaceous/graminoid competition. Even sphagnum moss, which is so vital to the development and functioning of the bog, must sometimes be controlled around outplantings as it has a tendency to mound over them.

Invasive species have posed only a modest management concern for GPCA-restored mountain bogs thus far. This is largely due to the selection of relatively invasive-free bogs for inclusion in the GPCA mountain bog project. One notable exception is a large bog complex with an advanced infestation of Chinese Silver Grass (*Miscanthus sinensis*). Careful and faithful chemical treatment for seven years (soon to be eight) has eliminated over 98% of the infestation. Where found, the other most troublesome plant species are Nepalese Browntop (*Microstegium vimineum*), Marsh Dewflower (*Murdannia keisak*), and Multiflora Rose (*Rosa multiflora*), with Japanese Knotweed (*Reynoutria japonica*) showing up recently.

Hog trapped at a restored bog. Mike Brod/USFS

Damage by invasive animals has been limited to feral hogs (*Sus scrofa*), which are capable of doing episodic destructive rooting and wallowing. Trapping by the USFS seems to be reducing the number and severity of incidents. The American Black Bear (*Ursus americanus*) is also capable of wreaking havoc on sensitive outplantings. Although this is considered normal activity by a native creature, bear activity is likely elevated in restored bogs as a result of the increased food production following daylighting. Where conducted, prescribed fire has greatly improved forage and browse opportunities in the adjacent uplands. As additional food options have become available elsewhere, pressure on bogs has been reduced, and destructive bear activity has abated.

Hydrologic repairs are conducted on a very limited and small scale, hence the earlier use of the term hydrologic tinkering. Bogs in need of substantial hydrologic restoration (i.e., those requiring engineering expertise and dedicated funding), have traditionally been beyond the means of the GPCA to address. Nevertheless, construction of modest check dams across small seepage rivulets/intermittent streams, us-



Mincy Moffett/DNR

Hydrologic tinkering, repairing eroded bank beneath Swamp Pink.

Level 2 maintenance, brushcutting. Rebecca Byrd/DNR

Mincy Moffett/DNR

Level 3/4 maintenance, direct ignition for prescription fire in bog.

ing on-site materials (e.g., logs, stones, soil), has been used to raise the water level and increase the retention time of water in the bog. Plugging gaps in historic beaver levees, as well as filling erosion channels conducting water beneath bogs has also helped. Perhaps the greatest determinant of bog moisture levels is the amount of transpiration from woody plants. As bogs are daylighted, and trees and shrubs are removed, the volume of water transpired is lessened. Thus the bogs stay wetter longer.

Mountain bog restoration and management can best be understood as a series of concentric levels (1-2-3-4) (Figure 2). The more interior a level, the more intensive and frequent is the management. **Level 1** encompasses the safeguarding microsites. These areas contain the rarities and are of highest value. Gardening type management to remove all competition (including excessive sphagnum) is applied at least once and sometimes twice a year. **Level 2** is the bog-proper or site level. Initial daylighting removes almost all shrubs and reduces the tree canopy to between 0-30%. The greatest concern going forward is woody shrub resprouts. This is addressed by brush-cutting once every 1–2 years. Prescribed fire is encouraged to spread into Level 2 (and Level 1), but rarely does so due to high fuel moisture content. **Level 3** is the ecotone. Initial daylighting removes most shrubs and reduces the tree canopy to between 50-70%. Maintenance of the ecotone is performed with hand and power tools as needed. Fire is an important management tool here; the ecotone burns when the uplands burn. **Level 4** is the surrounding landscape. Prescribed fire is really the only management tool at this level. Ideally, all mountain bogs will one day be placed into larger prescribed fire units. The USFS and DNR are actively working to accomplish this. Several GPCA-restored bogs are still awaiting ecotone clearing and incorporation into prescribed fire units. Combining careful monitoring and coopera-

tive management has allowed the development of "no-regrets" adaptive management strategies crucial to the success of the mountain bog project. These strategies integrate microsite, site, and landscape level management.

Mountain bogs were never common throughout the Southern Appalachians. Their rare floral elements persisted through time possibly by hopscotching from small patch to small patch. As rare as the bogs and flora were historically, they are even rarer today and under increasing threat. The GPCA is zealous in its dedication to the conservation of mountain bogs. Our very existence is umbilically tied to them. We are increasingly cited as an innovative, progressive, and effective model of plant conservation. Our collaborative "big-tent" approach promotes a high degree of resource sharing, talent blending, and leveraged results. Our mountain bog project, supported by our safeguarding program, is making a noticeable difference in the future of mountain bogs and their flora, both in Georgia and beyond.

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