MOUNTAIN BOGS AND FENS

Contents

MOUNTAIN BOGS AND FENS THEME

Concept: Mountain Bogs and Fens are wetlands of the Mountain Region and nearby Piedmont foothill valleys. They have permanently saturated soils, lack regular floodwater input, and have high soil organic content and very low nutrient availability. They have a flora with numerous distinctive herbaceous species shared with bogs and fens in other regions as well as endemic relatives of them, and they have vegetation structure with the tree canopy open or absent in at least portions.

Distinguishing Features: Mountain Bogs and Fens generally most closely resemble Upland Seepages and Spray Cliffs, which also have saturated soils and lack of flood waters. Seeps may also have mucky soils, though others have mineral soil, gravel, or bedrock; their soils are higher in nutrient status and are best distinguished by the flora. Bogs usually have *Sphagnum* and carnivorous plants, while seeps have little or none. The pool of characteristic bog and fen species not generally found in seeps is fairly large; frequent ones include *Carex folliculata, C. collinsii, C. leptalea*, *C. atlantica, C. echinata*, *Chelone cuthbertii*, *Symphyotrichum puniceum*, *Eriophorum virginicum*, *Juncus gymnocarpus*, *Eriocaulon decangulare*, *Vaccinium macrocarpon*, *Rosa palustris*, and *Toxicodendron vernix*. In wetlands, *Pinus rigida*, *Nyssa sylvatica*, and *Picea rubens* are characteristic of bogs and fens. Species requiring more minerotrophic conditions are rarely found in bogs. These include *Saururus cernuus*, *Onoclea sensibilis*, *Lobelia cardinalis*, *Thalictrum clavatum*, *Glyceria striata*, *Monarda didyma*, *Rudbeckia laciniata, Micranthes micranthidifolia*, *Diphylleia cymosa*, and *Lindera benzoin*. Some other wetland species may be abundant in either group of saturated wetlands, including *Osmundastrum cinnamomeum*, *Osmunda spectabilis*, *Carex intumescens*, *Carex gigantea*, *Oxypolis rigidior*, *Impatiens capensis*, *Viburnum nudum*, *Aronia arbutifolia*, and, in disturbed examples, *Persicaria hastata*, *Persicaria sagittata*, and *Juncus effusus*.

Swamp Forest–Bog Complexes, part of this theme, may resemble Acidic Cove Forests, but are distinguished by having interspersed boggy areas with *Sphagnum* and wetland species.

Sites: Most Mountain Bogs and Fens occur in flat areas in stream bottoms or valleys, at the base of upland slopes, and in sloughs or relict channels but separated from creeks or rivers. A few occur on gentle slopes or in perched upland areas. In almost all cases, there is an uphill source of seepage, and there is some microtopography that blocks or slows drainage. Detailed descriptions of several sites are included in Moorhead et al. (2000).

Soils: Soils are rich in organic matter, usually with a distinct layer of soft muck, though most are not deep enough to be classified as Histosols. Soils may be heterogeneous, with greatly varying depth of organic matter. Underlying material is usually alluvium, and layers of sand or gravel are common in lower horizons. Most soils are extremely acidic and low in nutrients, though the few richer fens may have circumneutral pH and high levels of calcium. In some bogs, there is development of hummock and hollow microtopography, and this may have been more common before widespread grazing.

Hydrology: Soils are saturated most of the time in the wetter parts of Mountain Bogs and Fens. Water comes from groundwater seepage as well as rainfall, and some limitation of drainage appears to be an important contributor to the saturation. See the comments below about the use of terminology of bogs versus fens. All examined examples of all the communities in this theme have significant ground water input. Moisture conditions are often very heterogeneous within sites, with higher and lower areas; with visible areas of water input, rivulets, and areas where water flows or accumulates; with local areas of higher or lower topography; and sometimes with hummock and hollow structure in the organic substrate. Ongoing studies by Jeff Wilcox of University of North Carolina at Asheville demonstrated areas of ground water input by using an infrared camera to look at water temperatures in several of these wetlands; ground water input was identifiable as cool areas in summer and warm areas in winter. Where ground water dynamics have been studied, they track current weather fairly closely, suggesting a shallow source. Moorhead (2003) noted at one site that water tables were clearly affected by transpiration, that the water table was near the surface during winter and spring, dropped to 35 cm in late summer in a normal year, and dropped to 80 cm in a dry year. Most water came from the adjacent slope, but he noted that during the drought the alluvium in the adjacent floodplain would also have been a source of water. Flooding must naturally occur in some bogs at least occasionally, and gravel beds embedded in organic soils give evidence of it in the past. However, no flooding of bogs was noted in the extensive extreme flooding caused by multiple hurricanes in 2004.

Vegetation: Vegetation in this theme varies in structure, with all characteristically being at least somewhat more open than forests. Most of the communities are naturally herbaceous or have a complex zoned or patchy structure of herb and shrub dominance with scattered trees. The Swamp Forest–Bog Complex communities are predominantly forested but have numerous small openings with herbaceous vegetation. The vegetation is a mix of general saturated wetland species with specialists largely confined to boggy wetlands. Both sets of species represent fairly large pools from which a small to moderate number may be present in any given example. Examples are notoriously variable among sites. General wetland species that often are abundant include *Osmundastrum cinnamomeum*, *Osmunda spectabilis*, *Carex intumescens*, *Carex gigantea*, *Oxypolis rigidior*, *Viburnum nudum*, *Aronia arbutifolia*, and in disturbed examples, *Persicaria hastata*, *Persicaria sagittata*, and *Juncus effusus*. Characteristic bog specialists include *Sphagnum* spp., *Drosera rotundifolia*, *Sarracenia* spp., *Carex folliculata, C. collinsii, C. leptalea*, *C. atlantica, C. echinata*, *Chelone cuthbertii*, *Symphyotrichum puniceum*, *Eriophorum virginicum*, *Juncus gymnocarpus*, *Eriocaulon decangulare*, *Vaccinium macrocarpon*, *Rosa palustris*, and *Toxicodendron vernix*. Among trees, *Pinus rigida*, *Nyssa sylvatica*, and *Picea rubens* often join *Acer rubrum, Liriodendron tulipifera*, and *Tsuga canadensis*.

Dynamics: The dynamics of Mountain Bogs and Fens are complex, not fully understood, and somewhat controversial. A nearly universal history of past use for livestock grazing, coupled generally with occurrence in valleys and watersheds with long settlement and land use, may have left no examples without substantial alteration. Within examples valued for conservation, a tradition of intensive, if episodic, management over decades makes discernment of spontaneous dynamics difficult. Much can be surmised from the behavior of bogs and fens in other regions, where they are more numerous and less heavily altered, but it is not clear how readily the lessons apply in our region. However, enough plant species are shared with northern bogs and fens to suggest similar conditions. The most crucial characteristics of Mountain Bogs and Fens for

considering their dynamics is that bogs and fens in general are naturally poor in available plant nutrients, thanks to immobilization in undecomposed organic matter, and that their most distinctive plant species are conservative, not generally dispersing readily.

The number of plant species largely confined to bogs suggests bogs have existed in our region for a long period. They probably were more extensive and widespread in the wetter and cooler conditions of the Pleistocene; they have been a small part of the landscape since the modern climate was established, and likely were even less extensive during the warmer, drier Hypsithermal period. The occurrence of conservative flora suggests that bogs are not ephemeral communities and did not appear and disappear widely across the landscape, but that they have long occurred where they are found. Few bogs have been studied to determine an age, but McDonald (2010) found organic deposits extending back to 14,934 years ago in one site, and Shafer (1986) found organic material back to 3300 years. Most of these wetlands now appear tied to rare site configurations where water input and drainage are appropriate. As with High Elevation Rocky Summits, the most distinctive species may once have occurred in a more widespread landscape of alpine tundra during the coldest parts of the Pleistocene.

Similar to bogs and fens in other regions, our communities appear to result from a process of paludification, where saturation and anaerobic soils lead to inhibited decomposition and organic matter buildup, organic matter buildup enhances saturation, limited recycling of nutrients promotes bog vegetation, and bog vegetation produces nutrient-poor refractory litter that further contributes to organic matter buildup. *Sphagnum* in particular is widely known to acidify soil, compete successfully for nutrients with other plants, and to be slow to decompose. This process is most pronounced in ombrotrophic bogs, without groundwater input, but similar processes happen even in rich fens, where cations may be abundant but nitrogen and phosphorous are still scarce.

In boreal mires, there is a general belief in a succession from fen to bog hydrology and vegetation as organic matter buildup raises the surface above groundwater discharge (e.g., Zobel 1988). Change is greater in fens, while, when bog vegetation prevails, vegetation is likely to be more stable (Pedrotti et al. 2014). Many sites show mosaics, with hummocks supporting bog vegetation while hollows and water tracks continue to support fen vegetation for a longer time. The transition appears to be driven by proliferation and widening of the hummocks, whose tops are out of reach of the ground water table. This transition is considered autogenic and slow, a kind of primary succession that followed deglaciation. However, there is also evidence that it can reverse or take different courses if ground water levels change naturally or artificially (e.g., Hughes and Dumyme-Peaty 2002) and that it can sometimes happen rapidly (Tahvanainen 2011) with altered hydrology. This version of primary succession is more applicable to Southern Appalachian systems than is the often-cited succession in glacial ponds. However, succession from open water may have occurred in a few cases, in abandoned stream channel segments or in short-lived Pleistocene lakes.

It is unclear how similar wetland development in this theme is to either scenario. The course of paludification in Mountain Bogs and Fens is less extreme than in the pocosins of the Coastal Plain and in boreal sites, where it has led to the spread of large peatlands. However, McDonald (2010) found evidence of it in his site, where organic matter accumulated first in stream channel segments, then spread over the adjacent area, and ultimately produced a surface having no relationship with the underlying alluvial topography. If paludification is less extreme in mountain bogs, it may be

because natural disturbances have interrupted it. Although bog sites do not regularly flood, McDonald (2010) found evidence of episodes of alluvial deposition that suggest river flooding, with gaps in the peat record. Many sites also occur in settings where beaver ponds can flood them. It may be noted that most potential natural disturbances, including stream flooding, beavers, fire, and native grazing animals, are likely to have also occurred in the Coastal Plain as much deeper organic deposits and extensive peatlands were developing. However, the lower topographic gradients may have been important there.

Regardless of their past development, of greatest concern for the dynamics of Mountain Bogs and Fens is the present ecological instability of the vegetation. Many of the communities show a tendency for rapid proliferation of native shrubs and trees, and woody cover can increase to a density that threatens the survival of characteristic herbaceous species, sometimes in the space of only a few years. The most characteristic bog species do not survive in heavy shade. What is regarded as the most characteristic bog animal, *Glyptemys muhlenbergii*, also requires open herbaceous vegetation. Communities that appear to have persisted for thousands of years at a site appear ready to disappear in the space of a few decades or less. Many of the most highly regarded conservation sites have been maintained by cutting of shrubs and trees, sometimes for many years, with sprouting and re-seeding beginning again immediately. Communities that appear most analogous, such as northern bogs and fens, do not show this tendency. They exclude native forest and shrubland vegetation, apparently by a combination of wetness, low nutrient levels, and perhaps competitiveness of the established vegetation.

This ecological instability has generated several views on the nature of bogs. Most focus on disturbance, either viewing open bogs as shifting ephemeral communities or believing that some kind of periodic or chronic disturbance once "reset succession" by removing invading woody plants and thus maintained the open vegetation. The most common kind of shifting ephemeral community hypothesis is that bogs represent a stage of succession following drainage of beaver ponds. However, no ephemeral community hypothesis accords with the conservative flora nor with the tie of bogs to distinctive sites with groundwater discharge. Beavers, once extirpated in the region, have returned and numerous beaver pond are now being created and abandoned, yet there is no known case of a bog developing where it did not exist before.

The other category of disturbance hypotheses, that of maintenance in their particular sites by periodic or chronic disturbance, could also involve beavers. Other ideas include large herbivores and fire.

A diverse fauna of large grazing and browsing animals was present until the end of the Pleistocene and may well have affected the landscape then, but only elk and bison persisted into the current climate that shaped our present bogs. These species could have had important effects on bogs until they were extirpated early in European settlement. The habitats and behavior of the local races of elk and bison are not well known. Bogs were too small a part of the recent landscape to have been a major food source for them, but a visit by a herd could be a major physical disturbance. It is unclear if they would choose to frequent bogs. Bogs have abundant grassy food, but hamper movement in the wet ground would have increased their risk of predators. The native large herbivore well adapted to wetlands, moose, was not present in this region. Bison also disturbed areas by wallowing; however, if bison wallows in tallgrass prairie farther west are an indication,

they chose upland flats rather than wetlands. It should be noted that domestic livestock are not native to the region and that their behavior is very different from native large herbivores.

Fire is known to have been abundant in the region since the Pleistocene, both before and after a widespread human presence. However, the setting of bogs, at the base of slopes and near streams, surrounded by mesic vegetation, would limit natural fire spread into them. It appears that most bog vegetation is not very flammable; graminoids are sometimes abundant, but forbs, bryophytes, and saturated litter would limit fire spread and intensity.

Beavers have flooded a number of bogs in recent years, as their populations continue to recover in the region, and the majority of known bogs appear to have potential for being flooded. Bog vegetation can survive on the edges of ponds, and for a time under very shallow water, but dies out in deeper water. Crucial aspects of natural beaver dynamics in the region — duration of ponds, frequency of return to former ponds, and how much of the floodplain landscape was affected by ponds over time — are completely unknown. Several bogs that have been impounded by beaver ponds or artificial lakes and subsequently drained can be observed to have well-developed bog vegetation in the former lake bed. All that I have carefully observed have bog vegetation extending beyond the pond edge, generally clearly older outside of the pond, indicating that the plants spread from a local source rather than recolonizing from a different site or persisting in the standing water.

It is unclear how often bogs would naturally have been subject to disturbances, and whether those disturbances functioned to maintain their character or disrupted it until they recovered. Very frequent, low-intensity disturbances to which the biota were resilient, such as the role of fire in many upland communities, do not appear to have been likely, given the plausible processes. Additional important evidence for the effect of disturbance comes from vegetation analysis by Wichmann (2009). She found a distinct type of vegetation that was associated with disturbed bogs across the full range of bog environments, while less disturbed bogs were differentiated into several distinct communities with particular location, elevation, and environment. This suggests that the disturbances, including impoundment, grazing, and even heavy shrub clearing, were replacing the characteristic vegetation of several communities with a homogenized successional vegetation of more generalist plants. It suggests that such disturbances are not processes that maintain bogs, but rather are disruptions that the community has to recover from. Such disruptions would be detrimental if they occur too frequently. Additional evidence comes from a study of seed banks in a bog, which found seeds with limited diversity and primarily consisting of generalist and ruderal species rather than the most characteristic bog species. It thus appears that the bog flora is not adapted to surviving catastrophic disturbance in a seed bank.

A more likely alternative hypothesis for the instability of bogs is that they, like their northern counterparts, were naturally maintained by site conditions and competitiveness of vegetation, and that these conditions have been disrupted. As noted above, changes in ground water levels can chance the presence of bog or fen conditions in northern mires. Many remaining examples of mountain bogs, including some of the most intact, have had drainage ditches dug in the past. Near many, the stream has been channelized or has become entrenched as a result of land use in its watershed. Given the low levels of available nutrients, bogs are very sensitive to addition of nutrients. Artificial drainage, input of surface runoff or sediment, and physical disturbance of the soil increase nutrient levels either directly or indirectly by increasing decomposition. This

presumably is part of why many kinds of disturbances lead to homogenized vegetation and dominance by more generalist species. Additional possible enrichment of nutrients may have come from atmospheric deposition. Nitrates have been an important component of the acid rain in the region, and though their levels have been reduced, much input has already occurred. Atmospheric nitrogen enrichment in boreal bogs is considered a potential disruptor, one that must be accounted for before studying other drivers (e.g., Schultheis et al. 2010; Tahvanainen 2011; Pedrotti et al. 2014). The effects of added nitrogen can be complex rather than straightforward (e.g. Wieder et al. 2019, who found that it stimulated growth in some species but not others, was partly compensated for by reducing nitrogen fixing, but that expected changes in herb and moss production were reduced by increased growth of shrubs and trees).

A history of such disturbances in the last century may be the cause of the present instability of many bogs and the invasion by woody plants. Grazing within the bogs may have been particularly important. While they help eliminate seedlings of trees and shrubs, cattle would also disrupt *Sphagnum* mats, destroy any hummock structure that existed, enhance decomposition by breaking up and stirring organic matter, more directly increase nutrient levels by concentrating them in their excretions, and create bare sites where seedlings of ruderal species, both herbaceous and woody, could establish. Clearing of adjacent areas for pasture or cultivation would increase runoff and flow of surface water, sediment, and nutrients into bogs, while soil compaction would also reduce infiltration. The open area would increase the seed rain of ruderal and generalist species into the bog. The few bogs that apparently did not have substantial grazing appear to not show as substantial woody invasion, but this question needs further study. The fact that woody invasion did not become evident until the cessation of grazing does not make it less likely that the alteration caused by the grazing is contributing to the current instability.

While a definitive answer to any of these views of bog dynamics is lacking, the question is extremely important for determining appropriate management for bogs. It is unclear whether arrival of beavers at a given bog is beneficial or harmful. Otherwise, current management is usually based on maintaining a general vegetation structure, with a focus on the needs of particular species. Extensive experience and a growing literature exist on using cattle grazing to create conditions optimal to bog turtles (e.g., Travis et al. 2018). Such management maintains the homogenized vegetation of disturbed bogs, and it is not a plausible return to natural conditions even if the hypothesis of maintenance by native large herbivores is accepted. Bogs that are managed with a focus on plants generally are managed by periodic hand cutting of shrubs and trees. This too is not an analogue of any natural process. Sites where heavy cutting has followed heavy woody cover contain the homogenized vegetation of disturbed bogs, at least at first. Nevertheless, it is believed to have been the only thing that prevented the elimination of rare species and herbaceous flora for the last several decades. Sites with ongoing maintenance by cutting do have characteristic herbaceous flora and support rare plants.

True restoration of bogs is particularly difficult if nutrient enrichment or hydrologic alteration are important factors. Once present, nutrients are retained and cycled on the site, and there is no quick way to remove them. Reversal of artificial drainage has been tried at a few sites, sometimes with apparent success, but without knowledge of pre-alteration baseline conditions. The literature on the reversible succession from fens to bogs in boreal settings suggests the possibility of unexpected consequences: making the site wetter, if it raises the water table close enough to the surface, will

increase nutrient levels and bring a return to fen conditions. While less attention has been paid to nutrients, it is plausible that, if nutrient addition is stopped, removal of biomass in the form of woody vegetation will slowly reduce levels. It is plausible that, if the soil and herbaceous layer are left undisturbed, growth of *Sphagnum* and accumulation of organic matter will sequester nutrients and create less favorable conditions for trees and shrubs, making the system more stable over time.

The effect of anticipated changes in the climate are also of concern for mountain bogs, with much uncertainty about what to expect. Processes reviewed for West Virginia bogs by Schultheis et al. (2010) likely also apply to North Carolina bogs. A warming climate would lead to increased *Sphagnum* growth to a point, increasing nutrient stress on other plants, but this would only occur if precipitation remained high enough to maintain saturation. It would also only occur if increased woody growth did not prevent it. Increased drought would harm *Sphagnum*, increase decomposition and nutrient levels, and exacerbate woody invasion. Conversely, in increase in extreme rainfall and flooding could bring more overland runoff, stream flooding, and sediment input.

Comments: The classification of mires into bogs or fens based on the role of ground water does not appear to work as well in the Southern Appalachians as it does in northern latitudes. Additionally, the intermixture of bog and fen conditions in so many northern mires may occur at a scale too fine to separate in the smaller patches of our mountain wetlands. By the standard classification of mires, all the communities in this theme are fens, because all have significant ground water input. However, most do not show the minerotrophic character expected of fens, and their vegetation more closely resembles bogs than fens. The ground water emerging from acidic igneous and metamorphic rocks subject to millions of years of chemical weathering and leaching remains acidic and low in cations, much more so than even acidic glacial till. Given the lack of fit of flora and vegetation to bogs and fens in other regions, I have retained the tradition of calling most of these communities bogs, retaining the name fen for the very rare examples that have higher pH, base-rich ground water.

Mountain Bogs and Fens are difficult to study with standard plot methods such as those used by CVS because of their structural and vegetational heterogeneity, as well as because even the least altered examples have been affected by woody encroachment and variable management for, as well as being affected by past, grazing. Bogs are most often sampled with 10x10 meter plots, and this is most often appropriate. However, Swamp Forest–Bog Complex communities are not well represented by 10x10 meter plots. Boggy openings are smaller than this, but plots centered on them look deceptively much more open than the community as a whole. Conversely, 10x10 meter plots placed in edges or in tree patches in open Southern Appalachian Bogs appear deceptively forested, and analysis often places them with Swamp Forest–Bog Complex plots. Quantitative analysis without being cognizant of these structural issues can give misleading results.

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KEY TO MOUNTAIN BOGS AND FENS

1. Community predominantly forested in natural condition, generally a mosaic of saturated wetland patches in a mesic matrix; wetland patches individually less than 1 acre in size; bog flora in wetland patches generally limited in diversity.
   2. Forest matrix containing abundant *Picea rubens*, sometimes in combination with abundant *Tsuga canadensis* or *Tsuga caroliniana*; occurring at higher elevation, generally above 3500 feet. ..... **Swamp Forest–Bog Complex (Spruce Subtype)**
   2. Forest matrix not containing appreciable *Picea rubens*, dominated by *Tsuga canadensis, Acer rubrum, Liriodendron tulipifera*, or other mesophytic species; potentially occurring at elevations above 3500 feet but usually lower ..... **Swamp Forest–Bog Complex (Typic Subtype)**

1. Community vegetation structure not as above, either predominantly herbaceous or a mosaic of herb, shrub, and tree patches or zones.
   3. Community a rich fen containing abundant calciphilic species such as *Muhlenbergia glomerata, Cladium mariscoides, Triantha glutinosa*, *Parnassia grandifolia,* and *Sphagnum subsecundum*; extremely rare community associated with seepage from mafic or ultramafic rock; occurring in Ashe or Alleghany County.
      4. Extremely rare community known only at Bluff Mountain; vegetation with zones dominated by *Muhlenbergia glomerata* and *Cladium mariscoides*. ..... **Southern Appalachian Fen (Bluff Mountain Subtype)**
      4. Extremely rare community known only at The Glades, known only in degraded form in North Carolina; vegetation including abundant *Schizachyrium scoparium* and *Panicum virgatum*, as well as *Muhlenbergia glomerata* and several *Rhynchospora* spp..... **Southern Appalachian Fen (Glades Subtype)**
   3. Community a poor fen; vegetation consisting primarily of acid-tolerant species, though small numbers of more calciphilic species may occasionally be present; underlying rock various but rarely mafic or ultramafic; potentially occurring anything in the Mountains.
      5. Community on a distinct slope, with saturated subsoil but seldom saturated at the surface; flora containing a distinctive set of species of Coastal Plain affinities shared with fire-maintained savannas, including *Cinna arundinacea, Eryngium integrifolium, Andropogon glomeratus, Fuirena squarrosa, Helianthus angustifolius, Rhynchospora gracilenta, Rhynchospora rariflora, Scleria ciliata, Scleria muehlenbergii, Gratiola pilosa, Xyris jupicai, Polygala cruciata, Drosera capillaris, Erianthus giganteus,* and *Eupatorium pilosum*; extremely rare community known only in Clay County..... **Low Mountain Seepage Bog**
      5. Community generally flat or nearly so, on a stream bottom or very gentle slope; if species of Coastal Plain affinities are present, they are a different suite; potentially occurring throughout the Mountains.
         6. Community containing a distinct suite of species, many of Coastal Plain affinities, including *Smilax laurifolia, Eubotrys racemosa, Viburnum nudum, Rhododendron viscosum, Dulichium arundinaceum, Carex collinsii, Anchistea virginica*, *Lorinseria areolata, Myrica gale, Chamaedaphne calyculata, Gaylussacia orocola*, and *Sarracenia jonesii*; very rare community known only from the upper French Broad River valley around Hendersonville and Cedar Mountain. ..... **French Broad Valley Bog**
         6. Community lacking the above suite of species, but distinguished by a different suite of bog species, many with northern affinities, such as *Carex trisperma, Carex buxbaumii, Rhynchospora alba, Filipendula rubra, Dryopteris cristata, Coryphopteris (Thelypteris) simulata, Spiraea alba, Schizachyrium scoparium, Lilium grayi, Pogonia ophioglossoides, Juncus subcaudatus, Ilex collina,*

Picea rubens, Vaccinium macrocarpon, and *Micranthes* (*Saxifraga) pensylvanica*; collectively widespread in the Mountains and potentially present in the foothills.

7. Very rare community occurring in high elevation valleys, above 4000 feet, in Ashe and Watauga County; characterized by a suite of species that includes *Taxus canadensis, Menyanthes trifoliata, Lonicera canadensis, Lonicera dioica*, and *Ilex collina*. ....**Southern Appalachian Bog (Long Hope Valley Subtype)**

7. Community generally at middle or lower elevations, or if rarely at elevations above 4000 feet, lacking the above suite of species.

8. Community at middle or rarely higher elevations, above 3000 feet; characterized by a suite of species that includes *Epilobium leptophyllum, Houstonia serpyllifolia, Chelone glabra, Dryopteris cristata, Picea rubens, Betula alleghaniensis*, and *Salix sericea*, and often having zones dominated by *Carex echinata*. .....**Southern Appalachian Bog (Typic Subtype)**

8. Community at lower elevations, below 3500 feet; largely lacking the above species and instead characterized by species such as *Rhynchospora capitellata, Osmunda spectabilis, Carex folliculata, Eriocaulon decangulare*, *Dichanthelium lucidum*, *Pogonia ophioglossoides*, *Aronia arbutifolia*, and *Rhododendron viscosum*, and often having zones dominated by *Carex atlantica*.

9. Community with abundant *Symplocarpus foetidus* and containing *Toxicodendron vernix*, potentially containing *Kalmia carolina* or *Viburnum nudum* (but lacking the other characteristic species of French Broad Valley Bogs); extremely rare community known from Alleghany County..... **Southern Appalachian Bog (Skunk Cabbage Subtype)**

9. Community lacking *Symplocarpus foetidus, Toxicodendron vernix, Kalmia carolina,* and *Viburnum nudum*; potentially anywhere in the Mountains or foothills .... **Southern Appalachian Bog (Low Elevation Subtype)**

SWAMP FOREST–BOG COMPLEX (TYPIC SUBTYPE)

Concept: Swamp Forests–Bog Complexes are stream bottom complexes of mesic to wet forest with small, wetter, bog-like open areas, or occasionally uniformly wet forests. The ground surface is usually irregular, so that wetness varies substantially on a fine scale, but occasionally is uniformly wet. Herb-dominated boggy openings are usually a minority of the area, in a matrix of closed or open tree canopy, usually with a dense shrub layer. The Typic Subtype covers most North Carolina examples, at low to moderate elevations, excluding only higher elevation examples that have significant *Picea rubens* in the canopy.

Distinguishing Features: Swamp Forest–Bog Complexes are distinguished from other Mountain Bogs and Fens communities by the combination of a well-developed canopy with small boggy openings containing wetland plants characteristic of bogs, such as *Sphagnum*, *Carex folliculata,* and *Osmundastrum cinnamomeum*. Boggy openings are small and floristically depauperate compared to Southern Appalachian Bog and French Broad Valley Bog communities. Openings as large as one acre, or smaller openings that have a diverse and characteristic bog flora, should be classified as an embedded bog community. Forested wetlands that represent invasion of open bogs, and forest patches on edges or within open bogs should not be classified as Swamp Forest–Bog Complex but should be treated as part of the open bog mosaic, unless they are notably more extensive than the open bog. Floodplain Pools may be distinguished by the composition of the herbaceous vegetation, which does not include most of the characteristic bog species.

The matrix of Swamp Forest–Bog Complexes may be indistinguishable from Acidic Cove Forest, with only the presence of numerous boggy openings distinguishing it. Often, however, the canopy contains at least some individuals of species not typical of Acidic Cove Forest, such as *Pinus rigida* or *Nyssa sylvatica*. Some also contain wetland shrubs such as *Viburnum cassinoides* or *Alnus serrulata* in the matrix as well as in the boggy openings.

The Typic Subtype is distinguished from the Spruce Subtype by lacking *Picea rubens* as a significant component.

Synonyms: *Tsuga canadensis - Acer rubrum - (Liriodendron tulipifera, Nyssa sylvatica) / Rhododendron maximum / Sphagnum* spp. Forest (CEGL007565).
Ecological Systems: Southern and Central Appalachian Bog and Fen (CES202.300).
Forest Gap Bog Complex (Gaddy 1981).

Sites: Swamp Forest–Bog Complexes occur on bottomlands of medium to large streams or rivers, or occasionally on flats at heads of valleys. They generally have substantial microtopography consisting of ridges and swales or a flat with numerous small depressions. Most of the microtopography appears to be relict stream channels and alluvial features, but a few sites have features of unknown origin. As with other bogs, some sites have small amphitheater-like basins on the upland edge, apparently resulting from sapping by groundwater discharge, and some have mucky rivulets flowing through parts. Most examples are at elevations of 2000-3000 feet, but occurrences may range down to near 1000 feet or to 4500 feet or higher.

Soils: Swamp Forest–Bog Complexes have alluvial soils with local or frequent wet inclusions. They are generally Inceptisols and Entisols with indicators of wetness (Fluvaquents, Humaquepts, Fluvaquentic Dystrochrepts, or Humic Haplumbrepts). Frequently mapped series are Nikwasi, Toxaway, Hatboro, Codorus, Hatboro, and Rosman.

Hydrology: Boggy openings are permanently or semipermanently saturated, occasionally holding shallow surface water. The forest matrix usually is visibly higher and at least moderately well drained, but occasionally is saturated throughout. The overall community may be flooded in large flood events but not routinely. Seepage may be evident locally, but most openings appear to be kept wet only by rainwater and a high water table.

Vegetation: Swamp Forest–Bog Complexes generally have a typical dense forest canopy over most of their extent, with open areas frequent but small. Most of the typical canopy trees are shared with Acidic Cove Forest. Analysis of plots by Wichmann (2009) found *Acer rubrum*, *Pinus strobus*, *Nyssa sylvatica*, *Quercus alba*, *Tsuga canadensis*, *Quercus rubra*, and *Pinus rigida* the most frequent canopy species, in that order of abundance. Also frequent in other site descriptions are *Liriodendron tulipifera* and *Betula lenta*. The understory is usually not extensive, and consists of the canopy species, though *Amelanchier arborea* was frequent in plots. The shrub layer is usually dense. The most frequent shrubs in plots are *Kalmia latifolia*, *Viburnum cassinoides*, *Rhododendron maximum*, *Alnus serrulata*, *Ilex verticillata*, *Vaccinium corymbosum*, *Aronia arbutifolia*, and *Lyonia ligustrina*. *Leucothoe fontanesiana* has also been observed to dominate sizeable areas. The wetland shrubs generally are confined to in or near the boggy openings in most examples, while *Rhododendron*, *Kalmia*, and *Leucothoe* are widespread in the forest matrix. The herb layer in boggy openings consists of species shared with many boggy wetlands, though with fewer species. Frequent species reported by Wichmann (2009) in plots and observed to be frequent elsewhere are *Osmundastrum cinnamomeum*, *Carex folliculata*, *Parathelypteris noveboracensis, Galium tinctorium*, *Impatiens capensis*, *Lycopus virginicus*, *Mitchella repens*, *Carex intumescens*, *Houstonia serpyllifolia*, and *Viola cucullata*. *Dalibarda repens* and *Symplocarpus foetidus* were also frequent in the plots but not as widespread in other occurrences. Other species frequent in site descriptions include *Carex gynandra*, *Carex leptalea*, *Osmunda spectabilis, Glyceria melicaria*, *Oxypolis rigidior*, *Symphyotrichum puniceum*, and *Solidago patula*. *Sarracenia purpurea* var. *montana* and *Drosera rotundifolia* occur occasionally. Herbs in the forest matrix are sparse or patchy. Besides the generalist species also in the boggy openings, frequent species include *Galax urceolata*, *Athyrium asplenioides*, *Polystichum acrostichoides*, *Hexastylis heterophylla*, *Hexastylis rhombiformis*, *Medeola virginiana*, and *Maianthemum canadense*.

Range and Abundance: Ranked G2. The equivalent association is described with a range from Georgia to Kentucky and Pennsylvania. This may represent an overly broadly defined association, compared to others in the NVC. If defined that broadly, it probably is not as rare as G2. North Carolina alone has 50 good to fair quality occurrences, scattered throughout the Mountain region. However, the distinctive mosaic wetland sites are inherently uncommon. Their occurrence in accessible, low elevation sites that have long been subject to draining, impoundment, and clearing for pasture, has made them increasingly rare. Many occurrences of “meadow bogs”, disturbed boggy wetlands in pastures, are believed to have been Swamp Forest–Bog Complex areas that were cleared, but this is somewhat uncertain.

Associations and Patterns: Swamp Forest–Bog Complexes are large patch communities, with natural occurrences often 10-50 acres, though many others are only a few acres. This community typically grades to Acidic Cove Forests on adjacent bottomlands, less commonly to Rich Cove Forest. It may contain embedded patches of Southern Appalachian Bog or French Broad Valley Bog. Various upland oak forests may border it on adjacent slopes.

Variation: The Typic Subtype is variable from site to site, but the variation is not well enough sorted out to recognize distinct variants. Most distinctive are the few examples in the upper French Broad valley that are uniformly wet rather than with boggy openings. They may represent a distinct community type of such large valleys, but the few examples are too altered and too little studied to be sure what they represent. Otherwise, examples vary in canopy composition and shrub layer, but the significance of such variation is unknown. Wichmann (2009) linked her equivalent grouping to three other NVC associations rather than the one synonymized here, and she noted the variability but noted the need for more data to sort the variation.

Dynamics: The dynamics of Swamp Forest–Bog Complexes are different from other Mountain Bogs and Fens. Their structure appears to be stable, with boggy openings generally not showing a tendency to be invaded by shrubs or trees. While they are sometimes equated with an end point of the invasion of trees into open Southern Appalachian Bogs, this is unlikely; most sites are distinctly different.

With their substantial tree canopy, gap processes similar to those in most forests are important in a way they are not in other Mountain Bogs and Fens. Most canopy trees regenerate in small to medium size gaps created by wind, lightning, or disease. It may be that the variable canopy composition represents variable time since disturbance, with *Liriodendron* and *Pinus* giving way to *Tsuga* over time, but this is far from clear. Examples with abundant *Tsuga* have recently suffered extensive mortality caused by hemlock woolly adelgid. The dense shrub layer in most examples raises questions of how canopy trees can regenerate in their shade, but, as with Acidic Cove Forests, examples do not appear to be losing canopy density.

The environmental factors that lead to formation of Swamp Forest–Bog Complex, rather than to the Acidic Cove Forest, Rich Cove Forest, or Montane Alluvial Forest that might occur in similar sites, need further study. A high water table, combined with microtopography, would appear to be necessary. Other communities likely have a deeper water table, perhaps because of greater depth to an impermeable layer or less subsurface ground water flow from adjacent uplands. Gaddy (1981), apparently the first to recognize this community, suggested the boggy openings were caused by paludification following tree blowdown or logging in wet alluvial forests. However, boggy openings do not resemble wind throw pits, and sites do not appear more widely windthrown nor more recently logged than those of other communities. Canopy gaps away from boggy openings appear to have normal tree regeneration. Additionally, regrowth and maturation of the forest does not appear to lead to drying and closure of the boggy openings. Though not clearly documented, they may be vulnerable to actions such as ditching, stream channelization, or extensive development in the watershed, which would lower water tables or reduce groundwater recharge.

The frequency and role of flooding in these communities is not known. They usually occur on

alluvial soils with microtopography created by flood scouring. However, these features likely are relict from the Pleistocene, as none show evidence of recent reworking. Major floods must inundate sites, but their effects may be short lived. No significant alterations of examples were reported after extensive major flooding caused by multiple hurricanes in 2004. Boggy vegetation in the sloughs would not be expected to survive frequent flooding. More frequent flooding can be expected to result in vegetation as seen in Floodplain Pools.

Fire dynamics likely are similar to those in Acidic Cove Forests. Fire may penetrate these communities, but at low intensity and generally without much effect. The boggy openings would not burn, and might inhibit fire spread, but are not usually continuous enough to be a significant fire barrier.

Comments: Swamp Forest–Bog Complexes illustrate one of the conceptual difficulties of addressing spatial scale in community classification. They could be regarded as a mosaic of two communities. However, because of the small size of the boggy openings compared to free-standing community types, and because the openings are usually widely distributed, they have been treated as a single complex community throughout the history of North Carolina community classification. The concept was described in an early Natural Heritage Program inventory of bogs (Gaddy 1981), where they were called forest gap bog complex. They are, however, difficult to study with typical vegetation plot approaches because of their mosaic structure. Standard 1/10 hectare plots are wider than typical boggy openings, though openings may be longer. Small plots centered on openings give a false impression of the openness, while randomly located plots, if not numerous, may miss most of the openings.

Besides Wichmann (2009), there is at least one published study of an example of this community (Warren et al. 2004). Numerous whole-site descriptions provide good background on its characteristics.

Wichmann's (2009) Low Elevation Saturated Forests (*Acer rubrum var. rubrum / Viburnum cassinoides / Osmunda cinnamomea var. cinnamomea*) type fits this well, but she synonymized it also with CEGL008438 and two other associations not reported from North Carolina. She also noted that it is heterogeneous and might be subdivided with more data. *Glyceria striata - Carex gynandra - Chelone glabra - Symphyotrichum puniceum / Sphagnum* spp. Herbaceous Vegetation (CEGL008438), a "poorly developed bog" has been attributed to North Carolina and synonymized to Swamp Forest–Bog Complex. It may represent the vegetation of boggy openings, separated form the matrix.

Rare species:
Vascular plants: *Hexastylis rhombiformis, Caltha palustris, Carex bullata, Carex cristatella, Dalibarda repens, Filipendula rubra, Galium asprellum, Glyceria laxa, Helonias bullata, Platanthera peramoena, Rhododendron vaseyi, Sagittaria fasciculata,* and *Thalictrum macrostylum.*
Vertebrate animals: *Glyptermys muhlenbergii*.

References:

Gaddy, L.L. 1981. The bogs of the southwestern mountains of North Carolina. Report to N.C. Natural Heritage Program.

Warren, R.J. III., J.D. Pittillo, and I.M Rossell. 2004. Vascular flora of a Southern Appalachian Bog and Floodplain Complex. Castanea 69:116-124.

Wichmann, B.L. 2009. Vegetation of geographically isolated montane non-alluvial wetlands of the southern Blue Ridge of North Carolina. M.S. Thesis, NC State University.

SWAMP FOREST–BOG COMPLEX (SPRUCE SUBTYPE)

Concept: Swamp Forests–Bog Complexes are stream bottom complexes of mesic to wet forest with small, wetter, bog-like open areas, or less often, uniformly wet forested areas. The ground surface is usually irregular, so that wetness varies substantially on a fine scale, but occasionally is uniformly wet. Herb-dominated boggy openings are usually a minority of the area, in a matrix of closed or open tree canopy, usually with a dense shrub layer. The Spruce Subtype covers the rare examples that have *Picea rubens* dominant or codominant. They generally have a larger component of northern species and a minimal component of species shared with the Coastal Plain.

Distinguishing Features: Swamp Forest–Bog Complexes are distinguished from other Mountain Bogs and Fens communities by the combination of a well-developed canopy with small boggy openings containing wetland plants characteristic of bogs, such as *Sphagnum*, *Carex folliculata,* and *Osmundastrum cinnamomeum*. Boggy openings are small and floristically depauperate compared to Southern Appalachian Bog and French Broad Valley Bog communities. Openings as large as one acre, or smaller openings that have a diverse and characteristic bog flora, should be classified as an embedded bog community. Forested wetlands that represent invasion of open bogs, and forest patches on edges or within open bogs should not be classified as Swamp Forest–Bog Complex but should be treated as part of the open bog mosaic, unless they are notably more extensive than the open bog.

The Spruce Subtype is distinguished from the Typic Subtype by having *Picea rubens* as a canopy dominant or codominant. Some examples have additional distinctive species of northern affinities, such as *Taxus canadensis*. The combination of *Picea rubens* canopy with wetland conditions in a flat setting distinguishes the Spruce Subtype from all other communities. Though at higher elevation than the Typic Subtype, they often are at lower elevation than Red Spruce–Fraser Fir Forest.

Synonyms: *Picea rubens - (Tsuga canadensis) / Rhododendron maximum* Saturated Forest (CEGL006277).
Ecological Systems: Southern and Central Appalachian Bog and Fen (CES202.300).

Sites: The Spruce Subtype occurs on bottomlands of medium to large streams on flats at heads of valleys. The sites are unusually flat for their elevation, and often appear as “hanging valleys” (though they are not the glacial valley that term is generally used for). Cold air drainage and pooling may be an important influence in this community. Elevations range from 3600 to 5400 feet. A few sites are uniformly wet, but most have substantial microtopography. This sometimes appears to be fluvial features such as sloughs or abandoned channels, but elsewhere consists of a series of small parallel channels and intervening small ridges. Given the small size and limited watershed of most examples, the substantial microrelief is surprising. As with other bogs, some sites have small amphitheater-like basins on the upland edge, apparently resulting from sapping by groundwater discharge, and some have mucky rivulets flowing through parts.

Soils: Soils of the Spruce Subtype are variable or not well understood. Each occurrence is mapped as a different series of Dystrochrepts, Humaquepts, or Hapludults.

Hydrology: Boggy openings are permanently or semipermanently saturated, occasionally holding shallow surface water. The forest matrix usually is visibly higher and at least moderately well drained, but occasionally is saturated throughout. The overall community may be flooded in large flood events but not routinely. Seepage may be evident locally, but most openings appear to be kept wet only by rainwater and a high water table.

Vegetation: Swamp Forest–Bog Complexes generally have a typical dense forest canopy over most of their extent, with open areas frequent but small. The canopy of the Spruce Subtype is dominated or codominated by *Picea rubens*. Codominant trees are *Acer rubrum, Tsuga canadensis*, or in one case, *Tsuga caroliniana*. Often associated is *Betula alleghaniensis*, while *Betula lenta* and other species shared with the Typic Subtype are occasional. The sparse understory consists primarily of the same species but may include *Amelanchier arborea*. The shrub layer is generally dense, most often with *Rhododendron maximum* dominant. *Kalmia latifolia* is frequent. Other wetland and high elevation shrubs may occur in boggy openings or scattered through the matrix. Frequent species include *Viburnum cassinoides, Sambucus canadensis, Aronia melanocarpa, Clethra acuminata, Ilex verticillata*, while less frequent but notable species include *Ilex collina, Taxus canadensis, Sambucus pubens, Rhododendron catawabiense, Viburnum lantanoides*, *Vaccinium corymbosum*, and *Lyonia ligustrina*. *Sphagnum* spp. dominates patches, at least in boggy openings and often elsewhere. The only herbs frequent in site descriptions are *Osmundastrum cinnamomeum, Glyceria melicaria, Osmunda spectabilis, Solidago patula,* and *Viola* sp. A variety of additional species may be present at low frequency, including *Carex* spp., *Chelone glabra, Chelone lyonii, Juncus gymnocarpus, Symphyotrichum puniceum, Trillium undulatum, Dryopteris cristata, Platanthera psychodes, Platanthera peramoena*, and *Neottia (Listera) smallii*.

Range and Abundance: Ranked G2? This community is very rare in North Carolina, with only seven examples scattered throughout the Mountain Region. The flat valley bottoms in which they occur are inherently rare at high elevation. The synonymized NVC association is defined as ranging from New York southward to North Carolina. It may be too broadly defined. If the community is as wide-ranging as it implies, it is probably more common than the G2 rank would imply.

Associations and Patterns: The Spruce Subtype generally is a large patch community. Large examples are 20 to perhaps more than 100 acres. However, some examples function as small patch communities, being naturally bounded in areas of only a few acres. Though examples tend to be at higher elevations than the Typic Subtype, most are at lower elevations that Red Spruce–Fraser Fir Forest. They are generally surrounded by Northern Hardwood Forest but could be associated with Acidic Cove Forest, especially the High Elevation Subtype. The largest example has embedded Southern Appalachian Bog (Long Hope Valley Subtype) patches.

Variation: Examples vary in the canopy species associated with the spruce, with some examples having little else, some having *Tsuga canadensis*, and one example having *Tsuga caroliniana*. No variants are formally recognized.

Dynamics: Regeneration patterns and dynamics are virtually unknown in this community. Like the Typic Subtype, it appears to be stable in its vegetation structure. However, several examples

had extensive mortality of *Picea* caused by an anomalous southern pine beetle attack and have not shown significant tree regeneration after 10-20 years. Examples with abundant *Tsuga* have suffered widespread canopy mortality in recent years, caused by hemlock woolly adelgid, and their future is unclear. At least one other example has only sparse trees, for reasons that are unknown. The dense evergreen shrub layer may inhibit tree regeneration, but there is no reason to believe that this by itself would do so more effectively than in the Typic Subtype or other communities, which seem to retain tree canopies despite dense shrub layers.

The occurrence of *Picea rubens* in the Spruce Subtype is presumably relictual from a time in the Pleistocene when the species was widespread at its elevations. It is notable that the southernmost as well as the lowest elevation populations of *Picea rubens* occur in this community rather than in Red Spruce–Fraser Fir Forest, and that others are disjunct some distance from larger populations. Their future in a warmer climate is unclear. They are already surviving in a presumed climate outside what is generally considered suitable for the species, presumably thanks to some combination of cold air drainage and limited competition. However, they also apparently survived warmer climatic periods since the end of the Ice Age.

Comments: Most of the comments about the Typic Subtype also apply to the Spruce Subtype. This subtype is very little studied in North Carolina. Wichmann (2009) appears to be the only formal study to address them. This study illustrates the difficulties of plot data analysis in Mountain Bogs and Fens. In the grouping that represented this subtype, small plots in woody portions of Southern Appalachian Bogs greatly outnumbered Swamp Forest–Bog Complex plots, resulting in misleading summary data. For this reason, the vegetation description above is based on site reports instead.

Rare species:
Vascular plants: *Chelone cuthbertii, Filipendula rubra, Ilex collina, Lilium grayi, Menyanthes trifoliata,* and *Taxus canadensis*.

References:
Wichmann, B.L. 2009. Vegetation of geographically isolated montane non-alluvial wetlands of the southern Blue Ridge of North Carolina. M.S. Thesis, NC State University.

SOUTHERN APPALACHIAN BOG (TYPIC SUBTYPE)

Concept: Southern Appalachian Bogs are naturally open, acidic, permanently saturated wetlands of flat stream bottoms or gentle slopes containing a distinctive bog flora. They lack the additional distinctive southern and Coastal Plain flora characteristic of French Broad Valley Bog and Low Mountain Seepage Bog, and often have some members of a distinctive set of species shared with northern bogs and poor fens. Physiognomy is generally mixed, with varying amounts of shrubs and sometimes with moderate amounts of tree cover, but with a well-developed, dense herbaceous layer and, generally, extensive *Sphagnum* cover. Though traditionally known as bogs, these wetlands generally appear to have a substantial amount of ground water input, and therefore would be considered poor fens in classifications of northern mires.

The Typic Subtype covers Southern Appalachian Bogs that occur at middle elevations, generally above 3000 feet, containing many species of northern affinities but lacking the distinctive flora of the Long Hope Valley Subtype. They are thus in the middle of the elevational range of North Carolina's mountain bogs.

Distinguishing Features: Southern Appalachian Bogs in general are distinguished from other kinds of wetlands, such as Upland Seepages and Spray Cliffs or floodplain communities, by the combination of permanently saturated soils with a distinctive flora. Bogs generally, though not always, have extensive *Sphagnum* and, often, carnivorous plants, while these are uncommon in most other wetlands. Species typical of bogs and not of other wetlands include *Carex folliculata, C. leptalea*, *C. atlantica, C. echinata*, *Chelone cuthbertii*, *Symphyotrichum puniceum*, *Eriophorum virginicum*, *Juncus gymnocarpus*, *Eriocaulon decangulare*, *Vaccinium macrocarpon*, *Rosa palustris*, and *Toxicodendron vernix*. Species of less acidic wetlands and not typical of bogs include *Saururus cernuus*, *Onoclea sensibilis*, *Lobelia cardinalis*, *Thalictrum clavatum*, *Glyceria striata*, *Monarda didyma*, *Rudbeckia laciniata, Micranthes micranthidifolia*, *Diphylleia cymosa*, and *Lindera benzoin*. Many additional species, such as *Osmundastrum cinnamomeum*, *Osmunda spectabilis*, *Carex intumescens*, *Carex gigantea*, *Oxypolis rigidior*, *Impatiens capensis*, *Viburnum nudum*, *Aronia arbutifolia*, *Persicaria hastata*, *Persicaria sagittata*, and *Juncus effusus* are often abundant in bogs, sometimes more if they are altered, but also occur in other kinds of saturated wetlands.

High Elevation Boggy Seeps may share bog flora with Southern Appalachian Bogs. They are distinguished by structural and floristic differences: seeps are moderately to steeply sloped and have a mixture of plants of bogs and of more fertile wetlands. They may, however, contain extensive cover of *Sphagnum* and populations of *Vaccinium macrocarpon*.

Southern Appalachian Bogs are distinguished from Swamp Forest–Bog Complex by structure and corresponding floristic differences. Swamp Forest–Bog Complexes are naturally forested over most of their area, with boggy herbaceous vegetation generally permanently confined to small patches that are in distinctly wetter microsites. The herbaceous vegetation in these openings is a subset of the flora of bogs, much lower in species richness. Large boggy areas within Swamp Forest–Bog Complex may be treated as Southern Appalachian Bogs if they reach one acre in size, if they are known to have once been larger open bogs, or if they contain or once contained a more

diverse flora of bog species. Because Southern Appalachian Bogs are prone to invasion by woody vegetation, more heavily invaded and altered examples may be difficult to distinguish.

Southern Appalachian Bogs are distinguished from French Broad Valley Bogs and Low Mountain Seepage Bogs by substantial floristic differences. Species largely or completely lacking in Southern Appalachian Bogs but present in these other communities, many of them shared with Coastal Plain wetlands, include *Sarracenia* spp., *Smilax laurifolia, Eubotrys racemosa, Viburnum nudum, Rhododendron viscosum, Dulichium arundinaceum, Carex collinsii, Helonias bullata, Anchistea virginica, Lorinseria areolata, Cinna arundinacea, Eryngium integrifolium, Andropogon glomeratus, Fuirena squarrosa, Helianthus angustifolius*, *Rhynchospora gracilenta, Rhynchospora rariflora, Scleria ciliata, Scleria muehlenbergii, Gratiola pilosa, Xyris jupicai, Polygala cruciata, Drosera capillaris, Erianthus giganteus, Eupatorium pilosum, Juncus canadensis*, and *Panicum virgatum*. Species typical of Southern Appalachian Bogs and generally lacking in the other bogs, many of them northern species, include *Carex trisperma, Carex buxbaumii, Rhynchospora alba, Filipendula rubra, Dryopteris cristata, Thelypteris simulata, Spiraea alba, Schizachyrium scoparium* var. *scoparium, Lilium grayi, Pogonia ophioglossoides, Juncus subcaudatus, Picea rubens, Vaccinium macrocarpon*, and *Micranthes (Saxifraga) pensylvanica*.

Southern Appalachian Fens are distinguished from Southern Appalachian Bogs by containing species needing higher pH and base saturation, such as *Muhlenbergia glomerata, Triantha (Tofieldia) glutinosa*, and *Sphagnum subsecundum*. Only a single Southern Appalachian Fen is known in North Carolina, at Bluff Mountain.

The Typic Subtype of Southern Appalachian Bog is distinguished from the Low Elevation Subtype by occurrence at higher elevation, generally 3000 feet north of Asheville, somewhat higher farther south, and by floristic differences that include a greater number and abundance of northern species. Species Wichmann (2009) found more abundant in the Typic Subtype than in the Low Elevation Subtype include *Epilobium leptophyllum, Houstonia serpyllifolia, Chelone glabra, Dryopteris cristata, Picea rubens, Betula alleghaniensis*, and *Salix sericea*. *Carex echinata*, while present in both, often is dominant in the Typic Subtype but not in the Low Elevation Subtype. Species more common in the Low Elevation Subtype include *Rhynchospora capitellata, Osmunda spectabilis, Carex folliculata, Eriocaulon decangulare*, *Dichanthelium lucidum*, *Pogonia ophioglossoides*, *Aronia arbutifolia*, and *Rhododendron viscosum*. *Carex atlantica* is often dominant in patches. The Skunk Cabbage Subtype also occurs at elevations below 3000 feet, and contains abundant *Symplocarpus foetidus*, as well as containing *Toxicodendron vernix*.

The Typic Subtype is distinguished from the Long Hope Valley Subtype by a smaller component of northern species and by the absence of characteristic species such as *Taxus canadensis, Menyanthes trifoliata, Lonicera canadensis, Lonicera dioica*, and *Ilex collina*. All but one example are in Long Hope Valley, but not all bogs in lower Long Hope Valley may represent that subtype.

Synonyms: *Carex atlantica - Solidago patula var. patula - Lilium grayi / Sphagnum bartlettianum* Herbaceous Vegetation (CEGL004158).
Acidic Bog – *Lyonia ligustrina* var. *ligustrina – Viburnum cassinoides* / *Carex echinata* var. *echinata – Scirpus expansus* / *Sphagnum* spp. (2.3); High Elevation Mosaic Bog – *Vaccinium*

simulatum / *Osmunda cinnamomea* var. *cinnamomea – Oclemena acuminata* / *Sphagnum* spp. – *Polytrichum* spp. (2.4); Mosaic bog – *Salix sericea* / *Osmunda cinnamomea* var. *cinnamomea – Carex echinata* ssp. *echinata* / *Sphagnum* spp. (2.5) (Wichmann 2009).
Ecological Systems: Southern and Central Appalachian Bog and Fen (CES202.300).

Sites: Southern Appalachian Bogs occur in flat or slightly sloped areas near streams, but generally are at the base of the upland slope, separated from the principal stream by a natural levee or higher area. They occur at moderate to fairly high elevation. They are generally above 3000 feet in elevation, somewhat higher in the southern part of the state.

Soils: Mountain bog soils are generally saturated and high in organic matter but rarely are true Histosols. They often include layers of gravel or other alluvial material at the base, sometimes also embedded within the organic-rich material. The Typic Subtype is often mapped as Nikwasi (Cumulic Humaquept), sometime as Toxaway (Cumulic Humaquept), Cullowhee (Fluvaquentic Humadept), or Rosman (Fluventic Humadept).

Hydrology: Southern Appalachian Bogs are permanently saturated. More properly, they are fens, where much of the wetness comes from groundwater seepage, though the groundwater chemistry is oligotrophic. Groundwater sources are usually visible on the edge of the wetland, but study by Jeff Wilcox (UNC-Asheville, personal communication) has shown that discharge can also occur in other portions. Some limitation on drainage of water away from the site likely also is needed to create the bog-like conditions. Stream flooding is a minor influence under natural conditions, but inundation can occur occasionally. Though bogs are separated from the principal stream in the valley, small rivulets may carry the discharged water through them and out of them.

Vegetation: Southern Appalachian Bog vegetation is extremely variable in structure and dominance, among examples, within sites, and, at least in recent decades, over time. The natural structure is not known in detail, though it is clear that it characteristically has a dense herbaceous layer and only partial woody cover. In the least altered examples, trees are sparse or confined to the edges, while shrubs are patchy or scattered in the interior and may form a dense edge zone. Trees are often small and appear stunted. Characteristic trees species include *Acer rubrum*, *Tsuga canadensis, Picea rubens*, *Betula alleghaniensis*, and *Pinus strobus*. Shrub zones and patches are most often dominated by *Rhododendron maximum* or *Alnus serrulata*, but may also be dominated by *Kalmia latifolia, Spiraea alba, Spiraea tomentosa, Salix sericea*, or other species. Other highly constant or frequent shrubs include *Lyonia ligustrina, Hypericum densiflorum, Viburnum cassinoides, Vaccinium corymbosum, Aronia melanocarpa, Rosa palustris, Kalmia carolina*, and *Xanthorhiza simplicissima*. *Rubus hispidus* or *trivialis* is sometimes abundant on the ground.

The herb layer is generally patchy, with much fine-scale variation. Beds of *Sphagnum* spp. are often present, at least in part of the bog. Species that are highly constant and dominate patches in plots (Wichmann 2009) are *Carex echinata* var. *echinata, Osmundastrum cinnamomeum,* and *Solidago patula*. Other frequent species that dominate patches include *Carex leptalea* var. *leptalea*, *Carex atlantica, Carex gynandra, Scirpus expansus,* and *Lycopus uniflorus.* Less frequent in plots but sometimes dominant are *Vaccinium macrocarpon, Thelypteris palustris,* and *Chelone glabra*. In bogs that have been disturbed, *Persicaria sagittata, Persicaria hastata, Juncus effusus, Eupatorium perfoliatum*, or other species may dominate. Few species are highly constant, but

many are frequent in plots, including *Galium tinctorium, Drosera rotundifolia, Houstonia serpyllifolia, Symphyotrichum puniceum* var. *puniceum*, *Platanthera clavellata, Carex lurida, Hypericum punctatum, Hypericum mutilum, Oxypolis rigidior, Viola cucullata, Glyceria striata, Sphenopholis pensylvanica, Rhynchospora capitellata,* and *Lycopus virginicus*. Species less frequent in plots but characteristic in the Typic Subtype include *Carex baileyi, Dryopteris cristata, Rhynchospora alba, Impatiens capensis, Impatiens pallida, Glyceria melicaria, Juncus gymnocarpus, Eleocharis tenuis, Lilium grayi*, and *Chamaenerion* (*Epilobium*) *angustifolium*.

Range and Abundance: Ranked G1G2. There are about 25 occurrences in North Carolina, scattered throughout the interior of the Mountain region. It is unclear if this community occurs in any other state. The NVC association is questionably attributed to Virginia and Tennessee. Given the lower elevations in Tennessee, any bogs shared with North Carolina there are likely to be the Low Elevation Subtype. The number of occurrences would suggest a G rank of G2, but the many threats to this community make its rank less certain.

Associations and Patterns: Southern Appalachian Bogs are small patch communities. Most occurrences are a few acres in size. They are sometimes associated with Swamp Forest–Bog Complex communities but more often are bordered by Acidic Cove Forest within the bottomland and on the adjacent slopes.

Variation: The Typic Subtype is one of the mountain bog communities that is notorious for its variability. Variation includes different dominants and different collections of species in different bogs, different parts of the same bog, and, apparently, at different times. Bogs exhibit a tendency common to many small patch communities with conservative flora, that each site appears unique, presumably because of limited dispersal of species. Additionally, some of the larger bogs have several separate patches that differ substantially in dominant vegetation and total flora. The author has repeatedly had the experience of visiting a bog several times and forming drastically different impressions because a different portion was visited or because the aspect of the vegetation had changed.

Dynamics: The dynamics described for the Mountain Bogs and Fens theme in general fit the Typic Subtype well in all their complexity.

Comments: Southern Appalachian Bogs are among the most difficult communities to classify. Part of this is due to the extreme variability of their vegetation, as described above. Both site descriptions and plots can give a limited picture of a complex site. Plots are more difficult to interpret than in most kinds of vegetation. Plots are generally small, usually 100 square meters rather than 1000, because of small size of open patches and of homogeneous vegetation. This gives different impressions of constancy of species and of species richness. Plot placement is generally biased toward the most open part of bogs. Nevertheless, because of the strongly zoned or patchy vegetation, small differences in plot location, deliberate or accidental, can result in very different data on species cover. Understanding of bog vegetation is also complicated by the nearly universal history of alteration that is greater than in the reference examples of most communities.

Though bogs have been of great interest to the conservation community and Natural Heritage Program throughout its existence, there is very little published literature on their vegetation.

Moorehead et al., (2000) describe several sites briefly. Wichmann (2009) conducted the only thorough quantitative study on a broad set of bog communities. She found the most distinctive vegetation groupings to be those associated with alteration. Vegetation disturbed by clearing, grazing, and beaver impoundment, vegetation heavily dominated by shrubs, once-open bogs now dominated by trees, and a depauperate herbaceous type formed strong groups that were not well associated with differences in environment or biogeography. The large number of plots in these categories left a much smaller set to identify underlying characteristic natural patterns that would be more appropriate for classification for conservation purposes. However, groups that are equivalent to the three subtypes recognized here also emerged, and these are the basis for much of the description of vegetation and floristic distinctions in the 4th Approximation. These subtypes also correspond fairly well to those recognized in Weakley and Schafale (1994).

Earlier drafts of the 4th approximation, and the NVC, recognized separate herbaceous and shrub subtypes within what is now treated as the Typic Subtype. These were conceived as zones. Given the reality of the variation and rapid change in shrub cover, this distinction is problematic, impossible to apply meaningfully, and potentially misleading for conservation action. It has been dropped. *Alnus serrulata - Kalmia carolina - Rhododendron catawbiense - Spiraea alba / Carex folliculata - Lilium grayi* Shrubland (CEGL003915) and *Rhododendron maximum / Sphagnum* spp. Shrubland (CEGL003849) were the shrub-dominated typic bog associations.

Carex (atlantica, echinata, leptalea, lurida) - Solidago patula Herbaceous Vegetation (CEGL004156) is a broadly defined, apparently more depauperate bog association attributed to all of the states neighboring North Carolina. Its concept may overlap several North Carolina subtypes, but it is not considered to occur here.

Rare species:
Vascular plants: *Arethusa bulbosa, Carex baileyi, Carex trisperma, Chamerion angustifolium, Chelone cuthbertii, Coryphopteris simulata, Epilobium ciliatum, Lilium grayi, Lonicera canadensis, Lycopodiella inundata, Oenothera perennis, Veronica americana,* and *Vaccinium macrocarpon*.
Nonvascular plants: *Dicranum undulatum, Sphagnum fallax,* and *Splacnum pensylvanicum*.
Vertebrate animals: *Empidonax alnorum* and *Glyptemys muhlenbergii*.

References:
Moorhead, K.K., R.E. Moynihan, and S.L. Simpson. 2000. Soil characteristics of four Southern Appalachian fens in North Carolina, U.S.A. Society for Wetland Scientists 20:560-564.

Weakley, A.S., and M.P. Schafale. 1994. Non-alluvial wetlands of the Southern Blue Ridge – diversity in a threatened ecosystem. Water, Air, and Soil Pollution 77:359-383.

Wichmann, B.L. 2009. Vegetation of geographically isolated montane non-alluvial wetlands of the southern Blue Ridge of North Carolina. M.S. Thesis, NC State University.

SOUTHERN APPALACHIAN BOG (LOW ELEVATION SUBTYPE)

Concept: Southern Appalachian Bogs are naturally open, acidic, permanently saturated wetlands of flat stream bottoms or gentle slopes containing a distinctive bog flora. They lack the additional distinctive southern and Coastal Plain flora characteristic of French Broad Valley Bog and Low Mountain Seepage Bog, and often have some members of a distinctive set of species shared with northern bogs and poor fens. Physiognomy is generally mixed, with varying amounts of shrubs and sometimes with moderate amounts of tree cover, but with a well-developed, dense herbaceous layer and, generally, extensive *Sphagnum* cover. Though traditionally known as bogs, these wetlands generally appear to have a substantial amount of ground water input, and therefore would be considered poor fens in classifications of northern mires.

The Low Elevation Subtype covers bogs of lower elevations, generally below 3000 feet, with relatively few species of northern affinities.

Distinguishing Features: Southern Appalachian Bogs in general are distinguished from other kinds of wetlands, such as Upland Seepages and Spray Cliffs or floodplain communities, by the combination of permanently saturated soils with a distinctive flora. Bogs generally, though not always, have extensive *Sphagnum* and, often, carnivorous plants, while these are uncommon in most other wetlands. Other species typical of bogs and not of other wetlands include *Carex folliculata, C. leptalea*, *C. atlantica, C. echinata*, *Chelone cuthbertii*, *Symphyotrichum puniceum*, *Eriophorum virginicum*, *Juncus gymnocarpus*, *Eriocaulon decangulare*, *Vaccinium macrocarpon*, *Rosa palustris*, and *Toxicodendron vernix*. Species of less acidic wetlands and not typical of bogs include *Saururus cernuus*, *Onoclea sensibilis*, *Lobelia cardinalis*, *Thalictrum clavatum*, *Glyceria striata*, *Monarda didyma*, *Rudbeckia laciniata, Micranthes micranthidifolia*, *Diphylleia cymosa*, and *Lindera benzoin*. Many additional species, such as *Osmundastrum cinnamomeum*, *Osmunda spectabilis*, *Carex intumescens*, *Carex gigantea*, *Oxypolis rigidior*, *Impatiens capensis*, *Viburnum nudum*, *Aronia arbutifolia*, *Persicaria hastata*, *Persicaria sagittata*, and *Juncus effusus* are often abundant in bogs, sometimes more if they are altered, but also occur in other kinds of saturated wetlands.

Southern Appalachian Bogs are distinguished from Swamp Forest–Bog Complex by structure and corresponding floristic differences. Swamp Forest–Bog Complexes are naturally forested over most of their area, with boggy herbaceous vegetation generally permanently confined to small patches that are in distinctly wetter microsites. The herbaceous vegetation in these openings is a subset of the flora of bogs, much lower in species richness. Large boggy areas within Swamp Forest–Bog Complex may be treated as Southern Appalachian Bogs if they reach one acre in size, if they are known to have once been larger open bogs, or if they contain or once contained a more diverse flora of bog species. Because Southern Appalachian Bogs are prone to invasion by woody vegetation, more heavily invaded and altered examples may be difficult to distinguish.

Southern Appalachian Bogs are distinguished from French Broad Valley Bogs and Low Mountain Seepage Bogs by substantial floristic differences. Species largely or completely lacking in Southern Appalachian Bogs but present in these other communities, many of them shared with Coastal Plain wetlands, include *Sarracenia* spp., *Smilax laurifolia, Eubotrys racemosa, Viburnum nudum, Rhododendron viscosum, Dulichium arundinaceum, Carex collinsii, Helonias bullata,*

Anchistea virginica, Lorinseria areolata, Cinna arundinacea, Eryngium integrifolium, Andropogon glomeratus, Fuirena squarrosa, Helianthus angustifolius, *Rhynchospora gracilenta, Rhynchospora rariflora, Scleria ciliata, Scleria muehlenbergii, Gratiola pilosa, Xyris jupicai, Polygala cruciata, Drosera capillaris, Erianthus giganteus, Eupatorium pilosum, Juncus canadensis*, and *Panicum virgatum*. Species typical of Southern Appalachian Bogs and generally lacking in the other bogs, many of them northern species, include *Carex trisperma, Carex buxbaumii, Rhynchospora alba, Filipendula rubra, Dryopteris cristata, Thelypteris simulata, Spiraea alba, Schizachyrium scoparium var. scoparium, Lilium grayi, Pogonia ophioglossoides, Juncus subcaudatus, Picea rubens, Vaccinium macrocarpon*, and *Micranthes (Saxifraga) pensylvanica*.

The Low Elevation Subtype is distinguished from the Typic Subtype by occurrence at lower elevation, generally below 3500 feet, and by floristic differences that include a smaller number and abundance of northern species. Species Wichmann (2009) found more abundant in the Typic Subtype than in the Low Elevation Subtype include *Epilobium leptophyllum, Houstonia serpyllifolia, Chelone glabra, Dryopteris cristata, Picea rubens, Betula alleghaniensis*, and *Salix sericea*. *Carex echinata*, while present in both, often is dominant in the Typic Subtype but not in the Low Elevation Subtype. Species more common in the Low Elevation Subtype include *Rhynchospora capitellata, Osmunda spectabilis, Carex folliculata, Eriocaulon decangulare*, *Dichanthelium lucidum*, *Pogonia ophioglossoides*, *Aronia arbutifolia*, and *Rhododendron viscosum*. *Carex atlantica* is often dominant in patches. The Skunk Cabbage Subtype also occurs at elevations below 3000 feet, and contains abundant *Symplocarpus foetidus*, as well as containing *Toxicodendron vernix*.

Synonyms: *Alnus serrulata - Rhododendron viscosum - Rhododendron maximum / Juncus gymnocarpus - Chelone cuthbertii* Shrubland (CEGL003916). Southern Appalachian Bog (Southern Floodplain Variant), (Southern Appalachian Bog (Low Elevation Variant) (Third Approximation).
Low Elevation Bog – *Lyonia ligustrina* var. *ligustrina – Aronia arbutifolia* / *Eriophorum virginicum – Solidago patula* var. *patula / Sphagnum spp.* (2.7) (Wichmann 2009).
Ecological Systems: Southern and Central Appalachian Bog and Fen (CES202.300).

Sites: Southern Appalachian Bogs occur in flat or slightly sloped area near streams, but generally are at the base of the upland slope, separated from the principal stream by a natural levee or higher area. The Low Elevation Subtype generally occurs below 3500 feet elevation, reaching somewhat higher in the southern part of the state.

Soils: Mountain bog soils are generally saturated and high in organic matter but rarely are true Histosols. They often include layers of gravel or other alluvial material at the base, sometimes also embedded within the organic-rich material. The Typic Subtype is often mapped as Nikwasi (Cumulic Humaquept), sometime as Toxaway (Cumulic Humaquept), Cullowhee (Fluvaquentic Humadept), or Rosman (Fluventic Humadept).

Hydrology: Southern Appalachian Bogs are permanently saturated. More properly, they are fens, where much of the wetness comes from groundwater seepage, though the groundwater chemistry is oligotrophic. Groundwater sources are usually visible on the edge of the wetland, but study by

Jeff Wilcox (UNC-Asheville, personal communication) has shown that discharge can also occur in other portions. Some limitation on drainage of water away from the site likely also is needed to create the bog-like conditions. Stream flooding is a minor influence under natural conditions, but inundation can occur occasionally. Though bogs are separated from the principal stream in the valley, small rivulets may carry the discharged water through them and out of them.

Vegetation: Southern Appalachian Bog vegetation is extremely variable in structure and dominance, among examples, within sites, and, at least in recent decades, over time. The natural structure is not known in detail, though it is clear that it characteristically has a dense herbaceous layer and only partial woody cover. In the least altered examples, trees are sparse or confined to the edges, while shrubs are patchy or scattered in the interior and may form a dense edge zone. Trees are often small and appear stunted. Characteristic trees species include *Acer rubrum, Tsuga canadensis, Pinus strobus*, *Liriodendron tulipifera*, and *Oxydendrum arboreum*. Shrub zones and patches are most often dominated by *Rhododendron maximum* or *Alnus serrulata*. Other frequent shrubs include *Rosa palustris, Aronia arbutifolia, Aronia melanocarpa, Spiraea tomentosa, Rhododendron viscosum*, *Kalmia latifolia, Ilex verticillata, Vaccinium corymbosum*, and *Kalmia carolina*. *Rubus hispidus* or *trivialis* is highly constant and sometimes dominates patches.

The herb layer is generally patchy, with much fine-scale variation. Beds of *Sphagnum* spp. are often present, at least in part of the bog. In CVS plots (Wichmann 2009), there are no highly constant herbs that dominate. Frequent species that may dominate patches include *Carex leptalea* var. *leptalea, Carex echinata* ssp. *echinata*, *Carex atlantica, Osmundastrum cinnamomeum, Rhynchospora capitellata, Andropogon glomeratus, Juncus effusus*, and *Vaccinium macrocarpon*. In disturbed bogs, *Persicaria sagittata, Persicaria hastata, Juncus effusus, Eupatorium perfoliatum*, *Scirpus cyperinus*, or other species may dominate. Though less dominant, highly constant species in plots include *Eriophorum virginicum, Solidago patula*, *Juncus* sp., *Vernonia noveboracensis, Dichanthelium lucidum,* and *Drosera rotundifolia*. Other frequent species include *Viola primulifolia, Viola pallens, Scirpus expansus, Eriocaulon decangulare, Pogonia ophioglossoides, Platanthera clavellata, Symphyotrichum puniceum* var. *puniceum, Lycopus uniflora, Oxypolis rigidior, Carex folliculata, Carex buxbaumii, Chelone cuthbertii, Eleocharis tenuis, Galium tinctorium, Linum striatum, Packera crawfordii, Polygala sanguinea, Schizachyrium scoparium, Carex intumescens, Eutrochium fistulosum, Hypericum canadense, Rhynchospora alba, Rhynchospora gracilenta, Eupatorium rotundifolium, Juncus biflorus,* and *Solidago speciosa*. Less frequent species that are characteristic include *Carex ruthii, Lysimachia terrestris, Pteridium latiusculum, Sanguisorba canadensis,* and *Calopogon tuberosus*.

Range and Abundance: Ranked G1G2 but probably more appropriately G2 or G3. More than 40 occurrences are known, but, even more than most bogs, a substantial number of them are in poor condition. They are scattered through the interior of the Mountain region with a few also occurring in the foothills. This community apparently also occurs in South Carolina, Georgia, and Tennessee.

Associations and Patterns: Southern Appalachian Bogs are small patch communities. Most occurrences are a few acres in size. They are sometimes associated with Swamp Forest–Bog Complex communities but more often are bordered by Acidic Cove Forest within the bottomland and on the adjacent slopes.

Variation: The Low Elevation Subtype, like the Typic Subtype, is one of the mountain bog communities that is notorious for its variability. Variation includes different dominants and different collections of species in different bogs, different parts of the same bog, and also, apparently, at different times. Bogs exhibit a tendency common to many small patch communities with conservative flora, that each site appears unique, presumably because of limited dispersal of species. Additionally, some of the larger bogs have several separate patches which differ substantially in dominant vegetation and total flora.

Dynamics: The dynamics described for the Mountain Bogs and Fens theme in general fit the Low Elevation Subtype well in all their complexity.

Comments: The extreme difficulty of classifying bog vegetation, discussed for the Typic Subtype, applies equally well to the Low Elevation Subtype, which is similarly variable and often even more altered by land use in and near the bog.

Published literature is equally scarce. McLeod (1983) and McLeod and Croom (1983) describe the floristics and vegetation zones of one example, and some of the examples described by Moorhead et al. (2000) are of the Low Elevation Subtype.

Weakley and Schafale (1994) recognized a Southern Floodplain subtype. It is not recognized in the 4th approximation. Wichmann (2009) did not find a grouping corresponding to it. Because all southern bogs she sampled fell into one of the categories of altered vegetation, this is not definitive. However, examination of whole-site floristics failed to find any differences related to biogeography or distinctive environmental factors. Almost all southern bogs are at lower elevations and fit this subtype. However, the substantial distance and moderate disjunction of the southern examples makes it possible that biogeographic differences will be found that warrant a distinct subtype.

Earlier drafts of the 4th approximation, and the NVC, recognized separate herbaceous and shrub subtypes within what is now treated as the Typic Subtype. These were conceived as zones, but ones that might be associated with several different bog subtypes. Given the reality of the variation and rapid change in shrub cover, this distinction is problematic, impossible to apply meaningfully, and potentially misleading for conservation action. It has been dropped. *Alnus serrulata - Kalmia carolina - Rhododendron catawbiense - Spiraea alba / Carex folliculata - Lilium grayi* Shrubland (CEGL003915) and *Rhododendron maximum / Sphagnum* spp. Shrubland (CEGL003849) were the shrub-dominated typic bog associations.

Carex (atlantica, echinata, leptalea, lurida) - Solidago patula Herbaceous Vegetation (CEGL004156) is a broadly defined, apparently more depauperate bog association attributed to all of the states neighboring North Carolina. Its concept may overlap several North Carolina subtypes, probably most extensively the Low Elevation Subtype, but it is not considered to occur here.

Rare species:
Vascular plants: *Arethusa bulbosa, Calamagrostis canadensis, Carex buxbaumii, Carex utriculata, Carex vesicaria, Chelone cuthbertii, Chelone obliqua* var. *erwiniae, Coryphopteris simulata, Dalibarda repens, Dryopteris cristata, Epilobium ciliatum, Filipendula rubra, Glyceria*

laxa, Helenium brevifolium, Helonias bullata, Hexastylis rhombiformis, Lilium grayi, Liparis loeselii, Oenothera perennis, Packera crawfordii, Platanthera herbiola, Platanthera grandiflora, Rhynchospora alba, Solidago uliginosa, Spiraea alba, Thalictrum macrostylum, Vaccinium macrocarpon, and *Veronica americana*.
Nonvascular plants: *Entodon sullivantii* and *Sphagnum fallax*.
Vertebrate animals: *Aneides aeneus, Glyptemys muhlenbergii,* and *Hemidactylium scutatum*.
Invertebrate animals: *Euphydryas phaeton*.

References:

McLeod, D. 1983. The vascular flora of a small Southern Appalachian bog-fen. Association of Southeastern Biologists Bulletin 30:70-71 (abstract).

McLeod, D., and J.A. Croom. 1983. Vegetation patterns and habitat types in a small Southern Appalachian bog-fen. Association of Southeastern Biologists Bulletin 30:71 (abstract).

Moorhead, K.K., R.E. Moynihan, and S.L. Simpson. 2000. Soil characteristics of four Southern Appalachian fends in North Carolina, U.S.A. Society for Wetland Scientists 20:560-564.

Weakley, A.S., and M.P. Schafale. 1994. Non-alluvial wetlands of the Southern Blue Ridge – diversity in a threatened ecosystem. Water, Air, and Soil Pollution 77:359-383.

Wichmann, B.L. 2009. Vegetation of geographically isolated montane non-alluvial wetlands of the southern Blue Ridge of North Carolina. M.S. Thesis, NC State University.

SOUTHERN APPALACHIAN BOG (LONG HOPE VALLEY SUBTYPE)

Concept: Southern Appalachian Bogs are naturally open, acidic, permanently saturated wetlands of flat stream bottoms or gentle slopes containing a distinctive bog flora. They lack the additional distinctive southern and Coastal Plain flora characteristic of French Broad Valley Bog and Low Mountain Seepage Bog, and often have some members of a distinctive set of species shared with northern bogs and poor fens. Physiognomy is generally mixed, with varying amounts of shrubs and sometimes with moderate amounts of tree cover, but with a well-developed, dense herbaceous layer and, generally, extensive *Sphagnum* cover. Though traditionally known as bogs, these wetlands generally appear to have a substantial amount of ground water input, and therefore would be considered poor fens in classifications of northern mires.

The Long Hope Valley Subtype covers bogs of Long Hope Valley and related high elevation bogs, with a distinctive set of northern disjunct flora that includes species such as *Menyanthes trifoliata, Ilex collina,* and *Taxus canadensis* in addition to the larger set of species of northern affinities shared with the Typic Subtype.

Distinguishing Features: Southern Appalachian Bogs in general are distinguished from other kinds of wetlands, such as Upland Seepages and Spray Cliffs or floodplain communities, by the combination of permanently saturated soils with a distinctive flora.

The Long Hope Valley Subtype is distinguished from other subtypes by a characteristic set of northern disjunct plant species, including *Taxus canadensis, Menyanthes trifoliata, Lonicera canadensis, Lonicera dioica*, and *Ilex collina*, as well as many of the broader set of species with northern affinities. It lacks many species of mid to lower elevations.

Synonyms: *Carex atlantica - Rhynchospora alba - Parnassia asarifolia / Sphagnum warnstorfii* Herbaceous Vegetation (CEGL004157).
High Elevation Valley Fen – *Lyonia ligustrina* var. *ligustrina – Aronia arbutifolia* / *Eriophorum virginicum – Solidago patula* var. *patula / Sphagnum spp.* (2.8) (Wichmann 2009).
Ecological Systems: Southern and Central Appalachian Bog and Fen (CES202.300).

Sites: The primary location for the Long Hope Valley Subtype is a distinctive high elevation, low-gradient valley, at around 3900-4600 feet. A cold microclimate produced by sheltering, slope aspect, and cold air drainage may be an important part of the setting, as the valley is surrounded by high peaks and runs northward. The bogs are in discrete spots scattered through the valley, with some on gentle lower slopes and side valleys. The only other known example is in a smaller valley at 4100 feet.

Soils: Soils in the primary occurrence of the Long Hope Valley Subtype are mapped broadly as a newer series called Longhope (Terric Haplohemist with a frigid temperature regime). This suggests a deeper organic layer than most examples of other subtypes, but soils may be more heterogeneous than this implies. The other known example is mapped as Nikwasi (Cumulic Humaquept).

Hydrology: The Long Hope Valley Subtype occurs in permanently saturated sites with groundwater seepage, similar to other subtypes.

Vegetation: As with other Southern Appalachian Bogs, the Long Hope Valley Subtype is variable in vegetation structure and dominance. Some bogs there seem less altered than any Southern Appalachian Bogs elsewhere. These have a dense herb layer with only sparse shrubs and small trees in the interior, with a zone of dense shrubs and sparse trees on the edge. *Picea rubens* is the primary tree. Shrubs include *Rhododendron maximum, Salix sericea, Ilex collina*, and *Rosa palustris*. Other trees and shrubs frequent in CVS and Wichmann (2009) data include *Acer rubrum, Lyonia ligustrina, Aronia melanocarpa, Viburnum cassinoides*, and *Lonicera dioica*. Highly constant and sometimes dominant herb layer species in Wichmann (2009) are *Sphagnum* spp., *Carex echinata* var. *echinata, Schizachyrium scoparium, Houstonia serpyllifolia, Solidago patula,* and *Vaccinium macrocarpon*. Other species that are less constant but sometimes locally dominant in plots include *Rhynchospora alba, Rhynchospora capitellata, Carex leptalea* spp. *leptalea, Carex buxbaumii, Scirpus expansus*, and *Juncus* sp. Several less dominant species are highly constant in plots: *Packera aurea, Drosera rotundifolia, Juncus effusus* and *Oxypolis rigidior*. Other frequent species in plot data include: *Eriophorum virginicum, Parnassia asarifolia, Thelypteris palustris, Pogonia ophioglossoides, Viola cucullata, Galium asprellum, Epilobium leptophyllum, Linum striatum, Eleocharis tenuis, Hypericum mutilum, Luzula echinata, Platanthera lacera, Viola pallens, Osmundastrum cinnamomeum, Lycopodioides apodum, Cirsium muticum*, and *Rubus hispidus* or *trivialis*. Also notable as distinct to this subtype is *Menyanthes trifoliata*.

Range and Abundance: Ranked G1. The Long Hope Valley Subtype is a narrow endemic community, confined to one large and one small site in Watauga and Ashe County.

Associations and Patterns: The Long Hope Valley Subtype is a small patch community, with individual patches each a few acres or less. Many patches are associated with Swamp Forest–Bog Complex (Spruce Subtype). Others are surrounded by upland communities, including Northern Hardwood Forest and unusual lower slope stands of *Picea rubens*. Though not well known, it appears that some bog patches in the lower part Long Hope Valley represent the Typic Subtype rather than the Long Hope Valley Subtype.

Variation: Little is known about the variation among the few examples.

Dynamics: Dynamics of the Long Hope Valley Subtype are presumed to be generally similar to those of other Southern Appalachian Bog Subtypes. However, some of the bogs in upper Long Hope Valley appear not to show rapid invasion by shrubs and trees, and perhaps are more stable. This area is remote from the pastures in the site and may not have been grazed. This needs further study. The other occurrence of the Long Hope Valley Subtype is also notable for its dynamic setting. Most of the bog was inundated by an artificial lake, which was later drained. It is clear that bog vegetation persisted above the level of the lake, and that it spread into nearby parts of the drained lake bed. More recently, beavers have impounded part of the bog within the lake bed.

Comments: The Long Hope Valley Subtype conceptually represents a higher elevation equivalent to the Low Elevation and Typic subtypes, with the effects of its elevation perhaps enhanced by its

occurrence in a "hanging" valley where cold air drainage and accumulation may be important. However, some other aspects of its vegetation, such as the importance of *Schizachyrium scoparium*, are less explicable. Additionally, though Long Hope Valley is higher than most Southern Appalachian Bogs, at least a couple occur at similar elevations but better resemble the Typic Subtype.

The bogs of Long Hope Valley have long been regarded as unique, and this subtype has been assumed to be confined to that site. However, analysis by Wichmann (2009) showed that one other bog was similar, and that some of the bogs in lower Long Hope Valley were more like the Typic Subtype.

Earlier drafts of the 4th approximation, and the NVC, recognized separate herb and shrub subtypes for Long Hope Valley bogs. These have been combined in both the 4th Approximation and the NVC. *Rhododendron (maximum, catawbiense) - Ilex collina - Salix sericea / Carex trisperma - Eriophorum virginicum* Shrubland (CEGL003913) was the Long Hope Valley shrub association.

Rare species:
Vascular plants: *Carex buxbaumii, Carex oligosperma, Carex trisperma, Ilex collina, Lilium grayi, Lonicera canadensis, Menyanthes trifoliata, Rhynchospora alba, Micranthes pensylvanica, Taxus canadensis, Utricularia cornuta,* and *Vaccinium macrocarpon*.
Nonvascular plants: *Sphagnum subsecundum*.

References:
Wichmann, B.L. 2009. Vegetation of geographically isolated montane non-alluvial wetlands of the southern Blue Ridge of North Carolina. M.S. Thesis, NC State University.

SOUTHERN APPALACHIAN BOG (SKUNK CABBAGE SUBTYPE)

Concept: The Skunk Cabbage Subtype is a very rare bog community resembling the Low Elevation Subtype but with floristic vegetational differences that include abundant *Symplocarpus foetidus* and the presence of several other species not found in the Low Elevation Subtype.

Distinguishing Features: Southern Appalachian Bogs in general are distinguished from other kinds of wetlands, such as Upland Seepages and Spray Cliffs or floodplain communities, by the combination of permanently saturated soils with a distinctive flora.

Southern Appalachian Bogs are distinguished from French Broad Valley Bogs and Low Mountain Seepage Bogs by substantial floristic differences. Species largely or completely lacking in Southern Appalachian Bogs but present in these other communities, many of them shared with Coastal Plain wetlands, include *Sarracenia* spp., *Smilax laurifolia, Eubotrys racemosa, Viburnum nudum, Rhododendron viscosum, Dulichium arundinaceum, Carex collinsii, Helonias bullata, Anchistea virginica, Lorinseria areolata, Cinna arundinacea, Eryngium integrifolium, Andropogon glomeratus, Fuirena squarrosa, Helianthus angustifolius*, *Rhynchospora gracilenta, Rhynchospora rariflora, Scleria ciliata, Scleria muehlenbergii, Gratiola pilosa, Xyris jupicai, Polygala cruciata, Drosera capillaris, Erianthus giganteus, Eupatorium pilosum, Juncus canadensis*, and *Panicum virgatum*. Species typical of Southern Appalachian Bogs and generally lacking in the other bogs, many of them northern species, include *Carex trisperma, Carex buxbaumii, Rhynchospora alba, Filipendula rubra, Dryopteris cristata, Thelypteris simulata, Spiraea alba, Schizachyrium scoparium var. scoparium, Lilium grayi, Pogonia ophioglossoides, Juncus subcaudatus, Picea rubens, Vaccinium macrocarpon*, and *Micranthes (Saxifraga) pensylvanica*.

Southern Appalachian Bogs are distinguished from Swamp Forest–Bog Complex by structure and corresponding floristic differences. Swamp Forest–Bog Complexes are naturally forested over most of their area, with boggy herbaceous vegetation generally permanently confined to small patches that are in distinctly wetter microsites. The herbaceous vegetation in these openings is a subset of the flora of bogs, much lower in species richness. Large boggy areas within Swamp Forest–Bog Complex may be treated as Southern Appalachian Bogs if they reach one acre in size, if they are known to have once been larger open bogs, or if they contain or once contained a more diverse flora of bog species. Because Southern Appalachian Bogs are prone to invasion by woody vegetation, more heavily invaded and altered examples may be difficult to distinguish.

The Skunk Cabbage Subtype is distinguished from other subtypes by having *Symplocarpus foetidus* present in more than trivial amounts. This subtype is extremely rare, with only several examples known in North Carolina. The examples are more forested than most Southern Appalachian Bogs, but their flora is more bog-like than a typical Swamp Forest–Bog Complex.

Synonyms: *Pinus rigida / Toxicodendron vernix / Gaylussacia baccata / Symplocarpus foetidus* Woodland (CEGL003667).
Ecological Systems: Southern and Central Appalachian Bog and Fen (CES202.300).

Sites: Southern Appalachian Bogs occur in flat or slightly sloped areas near streams, but generally are at the base of the upland slope, separated from the principal stream by a natural levee or higher area. The known examples of the Skunk Cabbage Subtype occur around 2600-2700 feet elevation.

Soils: The soils of the Skunk Cabbage Subtype are similar to other subtypes in being saturated and high in organic matter. The known examples are mapped simply as "alluvial land – wet" but presumably belong to a series such as Nikwasi (Cumulic Humaquept), Toxaway (Cumulic Humaquept), or Cullowhee (Fluvaquentic Humadept),

Hydrology: Southern Appalachian Bogs are permanently saturated. More properly, they are fens, where much of the wetness comes from groundwater seepage, though the groundwater chemistry is oligotrophic. Some limitation on drainage of water away from the site likely also is needed to create the bog-like conditions. Stream flooding is a minor influence under natural conditions, but inundation can occur occasionally. Though bogs are separated from the principal stream in the valley, small rivulets may carry the discharged water through them and out of them.

Vegetation: The natural vegetation structure and dominance of the Skunk Cabbage Subtype is even more uncertain than most Southern Appalachian Bogs. Both Wichmann (2009) and the NVC description emphasized a tendency to have substantial tree cover. The couple of known examples are dominated by *Pinus rigida* and *Acer rubrum* in an open but substantial canopy, with *Pinus strobus* and *Nyssa sylvatica* also having substantial cover. Constant or frequent shrubs with high cover in CVS plot data include *Alnus serrulata, Ilex verticillata, Lyonia ligustrina, Rhododendron maximum, Kalmia carolina,* and reportedly, *Viburnum nudum* as well as *Viburnum cassinoides*. Less abundant in plots but highly constant are *Aronia arbutifolia* and *Vaccinium corymbosum*, while *Toxicodendron vernix, Viburnum cassinoides, Aronia melanocarpa*, *Hypericum densiflorum, Hypericum prolificum, Kalmia latifolia, Rosa palustris, Spiraea tomentosa, Vaccinium fuscatum, Cornus amomum, Gaylussacia baccata, Sambucus canadensis,* and *Lindera benzoin* are also frequent. With the denser woody cover, the herb layer is patchy. Frequent herbs that sometimes dominate patches in CVS plots include *Carex baileyi, Osmundastrum cinnamomeum, Glyceria striata, Glyceria laxa, Carex stricta,* and *Coryphopteris (Thelypteris*) *simulata*. Other frequent herbs in plots include *Carex folliculata, Viola pallens, Viola cucullata, Impatiens capensis, Carex atlantica, Carex intumescens, Carex echinata* spp. *echinata, Chelone cuthbertii, Houstonia serpyllifolia, Lycopus virginicus, Rubus (Dalibarda) repens, Symphyotrichum puniceum* var. *puniceum, Symphyotrichum dumosum, Bartonia virginica, Juncus effusus, Juncus subcaudatus, Dichanthelium lucidum, Hypericum mutilum,* and *Persicaria sagittata*.

Range and Abundance: Ranked G1. The Skunk Cabbage Subtype is known in North Carolina only in two closely associated sites in Alleghany County. The NVC association is also attributed to Georgia. However, *Symplocarpus foetidus* does not occur in or near Georgia, and it is unclear if the community there is really similar.

Associations and Patterns: The Skunk Cabbage Subtype is a small patch community, with the known occurrences covering at most a few acres. It is associated with Swamp Forest–Bog Complex (Typic Subtype) and may be associated with Southern Appalachian Bog (Low Elevation

Subtype). The surrounding uplands are heavily altered, but it likely was surrounded by Acidic Cove Forest.

Variation: Little is known about the range of natural variation. The known examples are similar to other bogs in being extremely heterogeneous.

Dynamics: The dynamics described for the Mountain Bogs and Fens theme in general fit the Skunk Cabbage Subtype well in all their complexity. The factors that lead to the formation this subtype rather than the Low Elevation Subtype are not well known. *Symplocarpus foetidus* is at the southern limit of its large contiguous range where this subtype occurs. *Toxicodendron vernix* has a widely scattered range, with a small cluster of counties of occurrences in the vicinity.

Comments: The Skunk Cabbage Subtype is accepted provisionally but much uncertainty remains about its natural character and distinctiveness. It is also unclear where it best fits within the 4th Approximation. Because only a couple of examples are known and they are substantially altered, it is less clear than usual which aspects of the vegetation result from alteration and which are part of the natural character. All descriptions have emphasized the amount of tree cover, which may be greater than indicated in the plots that were placed in the most open areas. Wichmann's (2009) analysis grouped it with Swamp Forest–Bog Complex sites. It is treated as a subtype of Southern Appalachian Bog instead because it includes a diverse herbaceous flora more typical of that type. Given the number of tree stems that have been cut out of the most highly regarded examples of the Typic Subtype and Low Elevation Subtype in recent decades to maintain open conditions, it is unclear how much weight to give tree cover. Nevertheless, it must be noted that the *Pinus rigida* trees that dominate in the primary example of the Skunk Cabbage Subtype are large and appear to be old.

It is unclear what interpretation to give to *Symplocarpus foetidus*, the most abundant species distinct to this subtype. The species does not extend further south in North Carolina, at least in mountain bogs. In states to the north, it occurs in a wide range of wetlands and is not characteristic of bogs. Most of its habitat is more similar to Low Elevation Seeps. Its abundance in this community may be coincidental. Nevertheless, the vegetation of the Skunk Cabbage Subtype differs from the Low Elevation Subtype in containing abundant *Toxicodendron vernix*, *Kalmia carolina*, and perhaps *Viburnum nudum*, species that are shared with French Broad Valley Bogs as well as with wetlands outside the mountains.

Rare species:
Vascular plants: *Carex buxbaumii, Coryphopteris simulata, Dalibarda repens, Glyceria laxa, Helenium brevifolium, Lilium grayi, Platanthera grandifolia,* and *Vaccinium macrocarpon*.
Vertebrate animals: *Empidonax alnorum* and *Glyptemys muhlenbergii*.

References:
Wichmann, B.L. 2009. Vegetation of geographically isolated montane non-alluvial wetlands of the southern Blue Ridge of North Carolina. M.S. Thesis, NC State University.

FRENCH BROAD VALLEY BOG

Concept: French Broad Valley Bogs are open herb- and shrub-rich acidic wetlands of flat stream bottoms or gentle slopes, containing a distinctive flora that includes species shared with Southern Appalachian Bog, species of Coastal Plain affinities, and some additional species that are scarce or absent in the Southern Appalachian Bog and Low Mountain Seepage Bog types. Such bogs are known only from the upper French Broad River valley in the vicinity of Hendersonville, but do not include all bogs in the French Broad basin. They are generally nonforested, but contain trees on edges, in patches, and where trees have invaded formerly open areas.

Distinguishing Features: The French Broad Valley Bog community is distinguished from Southern Appalachian Bog by floristic differences. A suite of species, many but not all having affinities with the Coastal Plain, are present in French Broad Valley Bogs but rarely or never elsewhere, including *Smilax laurifolia, Eubotrys racemosa, Viburnum nudum, Rhododendron viscosum, Dulichium arundinaceum, Carex collinsii, Anchistea virginica*, *Lorinseria areolata, Myrica gale, Chamaedaphne calyculata, Gaylussacia orocola* (*dumosa var. bigeloviana)*, and *Sarracenia jonesii*. Plants present in Southern Appalachian Bogs but not in French Broad Valley Bogs include *Carex trisperma, Carex buxbaumii, Rhynchospora alba, Filipendula rubra, Dryopteris cristata, Coryphopteris (Thelypteris) simulata, Spiraea alba, Schizachyrium scoparium, Lilium grayi, Pogonia ophioglossoides, Juncus subcaudatus, Ilex collina, Picea rubens, Vaccinium macrocarpon*, and *Micranthes* (*Saxifraga) pensylvanica*.

French Broad Valley Bogs are distinguished from the Low Mountain Seepage Bog by floristic differences as well as by differences in environment and biogeography. Both contain a number of species of Coastal Plain affinities, but the suite of species is quite different. Besides the species mentioned above that are distinct only to French Broad Valley Bogs, the following species occur only in Low Mountain Seepage Bogs: *Sarracenia oreophila, Cinna arundinacea, Eryngium integrifolium, Andropogon glomeratus, Fuirena squarrosa, Helianthus angustifolius*, *Rhynchospora gracilenta, Rhynchospora rariflora, Scleria ciliata, Scleria muehlenbergii, Gratiola pilosa, Xyris jupicai, Polygala cruciata, Drosera capillaris, Erianthus giganteus, Eupatorium pilosum, Juncus canadensis*, and *Panicum virgatum*.

Synonyms: *Alnus serrulata - Viburnum nudum var. nudum - Chamaedaphne calyculata / Woodwardia areolata - Sarracenia rubra ssp. jonesii* Shrubland (CEGL003918).
Ecological Systems: Southern and Central Appalachian Bog and Fen (CES202.300).

Sites: French Broad Valley Bogs occur in flat or gently sloping bottoms of small to large streams, at the base of upland slopes where seepage water can be discharged. Elevations are around 2000-3000 feet.

Soils: Mapped series are Hatboro (Typic Fluvaquent), Tate (Typic Hapludult), and Toxaway (Cumulic Humaquept). The bogs presumably represent inclusions in all of these units except possibly Toxaway.

Hydrology: French Broad Valley Bogs, like Southern Appalachian Bogs, are permanently saturated. More properly, they are fens, where much of the wetness comes from groundwater

seepage, though the groundwater chemistry is oligotrophic. Groundwater sources are usually visible on the edge of the wetland, but study by Jeff Wilcox (UNC-Asheville, personal communication) has shown that discharge can also occur in other portions. Some limitation on drainage of water away from the site likely also is needed to create the bog-like conditions. Stream flooding is a minor influence under natural conditions, but inundation can occur occasionally. Though bogs are separated from the principal stream in the valley, small rivulets may carry the discharged water through them and out of them.

Vegetation: The natural vegetation structure of French Broad Valley Bogs is not known. They likely existed as mosaics of shrub and herb dominance with scattered trees, as is observed in the least altered examples. Characteristic trees are *Nyssa sylvatica*, *Pinus rigida*, *Pinus strobus,* and *Acer rubrum*. A tremendous variety of shrubs may be present. Most frequent are *Alnus serrulata, Rhododendron maximum, Toxicodendron vernix, Rosa palustris, Rhododendron viscosum, Cornus amomum, and Gaylussacia orocola*. Other fairly frequent shrubs include *Lyonia ligustrina, Aronia arbutifolia, Aronia melanocarpa, Viburnum nudum, Viburnum cassinoides, Ilex verticillata, Viburnum dentatum*, and *Leucothoe fontanesiana*, along with *Smilax laurifolia*. Though not frequent, notable disjunct shrub species, including *Chamaedaphne calyculata*, *Kalmia carolina*, and *Gale palustris,* occur in some examples. The herb layer is characteristically dense and is usually dominated by sedges or ferns. *Osmundastrum cinnamomeum* and sometimes *Lorinseria areolata* are abundant. *Sphagnum* forms a dense layer beneath the herbs in sizeable patches. A tremendous range of sedges has been found in these bogs, differing substantially among examples. *Carex folliculata*, *C. collinsii*, *C. intumescens, C. radiata*, and *Carex schweinitzii* have been found in multiple bogs, and many more species were present only in one. *Rhynchospora* spp., *Eleocharis* sp., and *Scirpus* spp. increase the sedge diversity. *Juncus effusus, Juncus gymnocarpus, and Calamagrostis coarctata (cinnoides)* also occur in multiple examples. Frequent among forbs are *Sarracenia purpurea* var. *montana*, *Sarracenia jonesii*, *Chelone cuthbertii, Persicaria sagittata, Eupatorium fistulosum*, and *Eupatorium perfoliatum* occur in multiple examples. Other notable herbs found in a few examples include *Xerophyllum asphodeloides, Rhexia* sp., *Epilobium ciliatum, Helonias bullata*, *Arethusa bulbosa* and *Juncus caesariensis*.

Range and Abundance: Ranked G1. This community is endemic to North Carolina. All remaining examples are in Henderson and nearby Transylvania County. Numerous examples are believed to have been destroyed, but this community is unlikely to have ranged much beyond its current range.

Associations and Patterns: French Broad Valley Bogs are small patch communities. Most examples are now surrounded by heavily altered lands. Naturally, they likely were bordered by Acidic Cove Forests, possibly occasionally by oak forests.

Variation: No variants are recognized, but each remaining example is somewhat different in flora and structure.

Dynamics: The dynamics described for the Mountain Bogs and Fens theme in general appear to fit French Broad Valley Bogs, to the extent that it is known. The French Broad Valley Bogs differ from the Southern Appalachian Bogs probably primarily due to biogeography, rather than a difference in environment or dynamics. The southern location and occurrence in a large valley that once had more extensive bogs probably are the crucial factors.

Comments: The concept of French Broad Valley Bog has been narrowed from that in early drafts of the 4th Approximation and that implied in Weakley and Schafale (1994). Bogs in the Mills River drainage and most bogs upstream of the Hendersonville valley share some limited flora but are floristically more similar to Southern Appalachian Bog (Low Elevation Subtype), so they are now treated as that community.

French Broad Valley Bogs were not recognized in Wichmann (2009). This appears to be a result of inadequate sampling rather than evidence that they are not distinct. The only plots from a French Broad Valley Bog (under the new, narrowed definition) were classified in the altered vegetation types and included few of the distinctive plants.

Rare species:
Vascular plants: *Arethusa bulbosa, Carex utriculata, Dalibarda repens, Epilobium ciliatum* var. *ciliatum, Gaylussacia orocola, Helonias bullata, Hexastylis rhombiformis, Juncus caesariensis, Neottia australis, Myrica gale, Sarracenia jonesii, Sarracenia purpurea* var. *montana,* and *Thalictrum macrostylum.*
Vertebrate animals: *Glyptemys muhlenbergii*.

References:
Weakley, A.S., and M.P. Schafale. 1994. Non-alluvial wetlands of the Southern Blue Ridge – diversity in a threatened ecosystem. Water, Air, and Soil Pollution 77:359-383.

Wichmann, B.L. 2009. Vegetation of geographically isolated montane non-alluvial wetlands of the southern Blue Ridge of North Carolina. M.S. Thesis, NC State University.

LOW MOUNTAIN SEEPAGE BOG

Concept: The Low Mountain Seepage Bog community type is a nonforested, shrub- or herb-dominated acidic wetland of low elevation, gentle, seepage-fed slopes, containing a distinct suite of plants that includes numerous Coastal Plain disjuncts but is floristically different from the French Broad Valley Bog type.

Distinguishing Features: Low Mountain Seepage Bog is distinguished from French Broad Valley Bogs and Southern Appalachian Bogs by substantial floristic differences. Low Mountain Seepage Bogs contain a suite of primarily Coastal Plain disjunct species not found in other mountain wetlands. These include *Sarracenia oreophila, Cinna arundinacea, Eryngium integrifolium, Andropogon glomeratus, Fuirena squarrosa, Helianthus angustifolius, Rhynchospora gracilenta, Rhynchospora rariflora, Scleria ciliata, Scleria muehlenbergii, Gratiola pilosa, Xyris jupicai, Polygala cruciata, Drosera capillaris, Erianthus giganteus, Eupatorium pilosum, Juncus canadensis*, and *Panicum virgatum*.

Synonyms: *Alnus serrulata - Rhododendron arborescens / Sarracenia oreophila - Rhynchospora rariflora* Shrubland (CEGL003914).
Ecological Systems: Southern and Central Appalachian Bog and Fen (CES202.300).

Sites: The Low Mountain Seepage Bog community occurs on gentle slopes with seepage at low elevation — about 1900 feet. A shallow rock ledge may be important in producing the seepage.

Soils: Soils are mapped as Dillard (Aquic Hapludult) and Nikwasi (Cumulic Humaquept).

Hydrology: A hydrologic study of the most intact example (Wilcox et al. 2020) described it as a hypocrene spring-fed fen, where ground water frequently approaches the surface but rarely reaches it. Ground water is perched atop bedrock and a dense sloping clay layer. The authors believed that evapotranspiration was important to keeping ground water levels lower than the surface and noted that after at least one fire, which substantially reduced woody vegetation, ground water levels rose more than observed with similar rainfall in other years.

Vegetation: All examples are substantially altered, so that it is difficult to know the natural vegetation structure. The most intact remaining example is a mix of shrub and herb zones, blending into a cleared pasture. Shrubs include *Alnus serrulata, Lyonia ligustrina, Aronia arbutifolia, Aronia melanocarpa, Rhododendron arborescens, Rosa palustris,* and *Sambucus canadensis*. Abundant herb species include *Osmundastrum cinnamomeum, Rhynchospora rariflora, Sarracenia oreophila, Eriocaulon decangulare, Parathelypteris noveboracensis, Sagittaria latifolia, Eupatorium perfoliatum, Eupatorium pilosum, Eupatorium fistulosum, Rhexia virginica, Rhexia mariana, Eryngium integrifolium, Helianthus angustifolia, Eriophorum virginicum, Sanguisorba canadensis*, and *Juncus caesariensis*.

Range and Abundance: Ranked G1, Low Mountain Seepage Bog is one of the rarest of natural communities in North Carolina, with only one remaining good quality example, itself significantly altered. Another, more altered example is present in nearby Georgia, and historical examples are present nearby. The equivalent association is also attributed to Tennessee and Georgia.

Associations and Patterns: Low Mountain Seepage Bog is a small patch community. Natural surroundings are uncertain. The occurrence in a low elevation valley makes it likely that it was naturally surrounded by a dry oak forest or perhaps Low Mountain Pine Forest.

Variation: Natural variation among examples is uncertain.

Dynamics: This community shares with many Mountain Bogs and Fens communities the tendency of shrubs to invade and to threaten the distinctive herbaceous flora. Otherwise, the dynamics of this community appear different from most communities in the theme. Fire appears to be an important ecological process in this community, with its occurrence in a dry, low-elevation valley and its tendency for the soil surface to be dry. Recent prescribed burning appears to have reduced the invading woody vegetation and benefitted *Sarracenia*, though it is unclear what fire regime is natural or is most beneficial to the community as a whole.

Comments: This community was not treated by Wichmann (2009) because of a lack of sufficient plot data. This community is different enough from other Mountain Bogs and Fens that its inclusion in this theme is provisional. It shares some characteristics with Low Elevation Seeps and even with Sandhill Seeps.

Rare species:
Vascular plants: *Juncus caesariensis* and *Sarracenia oreophila*.

References:
Weakley, A.S., and M.P. Schafale 1994. Non-alluvial wetlands of the southern Blue Ridge – Diversity in a threatened ecosystem. Water, Air, and Soil Pollution 77:359-383.

Wichmann, B.L. 2009. Vegetation of geographically isolated montane non-alluvial wetlands of the southern Blue Ridge of North Carolina. M.S. Thesis, NC State University.

Wilcox, J., E.B. Marino, A. Warwick, and M. Sutton. 2020. Hydrology of a Southern Appalachian hypocrene spring-fed fen. Environmental and Engineering Geoscience 26:359-366.

SOUTHERN APPALACHIAN FEN (BLUFF MOUNTAIN SUBTYPE)

Concept: Southern Appalachian Fens are primarily herb-dominated wetlands fed by base-rich waters seeping from amphibolite or ultramafic rocks. The Bluff Mountain Subtype covers the floristically distinct example known only from Bluff Mountain.

Distinguishing Features: Southern Appalachian Fens are distinguished by the presence or abundance of a suite of calciphilic species of northern affinities, such as *Muhlenbergia glomerata, Cladium mariscoides, Triantha (Tofieldia) glutinosa*, and *Sphagnum subsecundum,* which are absent or scare in more acidic mountain herbaceous or shrubby wetlands. The Bluff Mountain Subtype is distinguished from the Glades Subtype by floristic differences and by its higher elevation. While many species are shared, *Cladium mariscoides*, *Carex torta*, and *Triantha glutinosa* are abundant and frequent in the Bluff Mountain Subtype and are scarce or absent in the Glades Subtype, and *Thelypteris palustris, Glyceria striata, Helenium brevifolium*, and a number of shrubs are among the many species in the Glades Subtype but absent at Bluff Mountain.

Synonyms: *Cladium mariscoides - Sanguisorba canadensis / Sphagnum subsecundum* Herbaceous Vegetation (CEGL004167).
Ecological Systems: Southern and Central Appalachian Bog and Fen (CES202.300).

Sites: The one example occurs in a small, high elevation, low-gradient "perched" valley at about 4300 feet elevation. The underlying rock is amphibolite.

Soils: The soil is a shallow muck overlying amphibolite bedrock. It is mapped as the Toxaway series, a Cumulic Humaquept.

Hydrology: The fen is permanently saturated by ground water seeping from amphibolite. Unlike the Southern Appalachian Bogs, it is high in dissolved cations such as calcium and magnesium and has a circumneutral pH.

Vegetation: The vegetation is a complex of herbaceous zones responding to soil depth and wetness. Species dominant in zones include *Rhynchospora alba, Rhynchospora capitellata, Juncus subcaudatus, Cladium mariscoides, Carex stricta, Helenium autumnale, Schizachyrium scoparium, Sanguisorba canadensis, Solidago uliginosa* var. *uliginosa*, and *Osmunda spectabilis*. Other characteristic species include *Huperzia appalachiana, Eriophorum virginicum, Houstonia cerulean, Utricularia cornuta, Osmundastrum cinnamomeum, Liatris aspera, Muhlenbergia glomerata, Triantha glutinosa, Carex conoidea, Carex buxbaumii*, and *Parnassia grandiflora* (Weakley and Schafale 1994). Other species found in the plot reported by Wichmann (2009) include *Drosera rotundifolia* var. *rotundifolia*, *Carex atlantica, Linum striatum, Lycopus uniflorus, Sanguinaria canadensis, Xyris torta, Carex leptalea* var. *leptalea*, *Houstonia serpyllifolia*, *Viola cucullate*, *Packera aurea*, and *Eleocharis tenuis*. A suite of characteristic bryophytes is also present, including *Sphagnum subsecundum, Rhytidium rugosum, Hypnum pratense, Campylium stellatum, Calliergon cordifolium*, and *Calliergonella cuspidata*.

Range and Abundance: Ranked G1. Only a single occurrence is known. No more are likely to be found, as the site is unique.

Associations and Patterns: The fen is closely associated with the High Elevation Mafic Glade (Bluff Mountain Subtype) community and is otherwise largely surrounded by Montane Oak–Hickory Forest (Basic Subtype).

Variation: Only a single site exists.

Dynamics: The fen is apparently maintained by the saturated and shallow soil and shows little sign of the encroachment by woody plants seen in most Mountain Bogs and Fens.

Comments: In broader classifications of mires in glaciated regions farther north, this type would likely be considered an intermediate, possibly a rich, fen, while Southern Appalachian Bog and French Broad Valley Bog, which appear to be fed by acidic ground water, would be considered poor fens.

Carex leptalea - Parnassia grandifolia - Rhynchospora alba Herbaceous Vegetation (CEGL004997) is defined from Buffalo Mountain, Virginia, but said to "probably" occur at Bluff Mountain. The basis for this is unclear, though the nominal species are all abundant at Bluff Mountain.

Rare species:
Vascular plants: *Bromus ciliatus, Calamagrostis canadensis* var. *canadensis, Carex aquatilis* var. *substricta*, *Carex buxbaumii, Carex conoidea, Cladium mariscoides, Crocanthemum bicknellii, Crocanthemum propinquum, Gentianopsis crinita, Huperzia appalachiana, Lilium grayi, Muhlenbergia glomerata, Oenothera perennis, Parnassia grandifolia, Rhynchospora alba*, *Solidago uliginosa, Stenanthium leimanthoides, Symphyotrichum laeve, Thalictrum macrostylum, Triantha glutinosa,* and *Utricularia cornuta.*
Nonvascular plants: *Campylium stellatum* and *Sphagnum subsecundum*.
Vertebrate animals: *Glyptemys muhlenbergii*.

References:
Weakley, A.S., and M.P. Schafale. 1994. Non-alluvial wetlands of the Southern Blue Ridge – diversity in a threatened ecosystem. Water, Air, and Soil Pollution 77:359-383.

Wichmann, B.L. 2009. Vegetation of geographically isolated montane non-alluvial wetlands of the southern Blue Ridge of North Carolina. M.S. Thesis, NC State University.

SOUTHERN APPALACHIAN FEN (GLADES SUBTYPE)

Concept: Southern Appalachian Fens are primarily herb-dominated wetlands fed by base-rich waters seeping from amphibolite or ultramafic rocks. The Glades Subtype covers the floristically distinct examples from The Glades in Virginia, and adjacent areas in Alleghany County. Only a very altered area possibly representing this subtype occurs in North Carolina, and more intact examples are unlikely to be found.

Distinguishing Features: The Glades Subtype is distinguished from the Bluff Mountain Subtype by floristic differences, but these need further clarification.

Synonyms: *Alnus serrulata / Sanguisorba canadensis - Parnassia grandifolia - Helenium brevifolium* Shrubland (CEGL003917). *Alnus serrulata / Sanguisorba canadensis - Calamagrostis canadensis* Shrubland (CEGL004252).
Ecological Systems: Southern and Central Appalachian Bog and Fen (CES202.300).

Sites: Examples occur on nearly flat areas where seepage emerges from hornblende gneiss or amphibolite, at 2400-3500 feet in elevation.

Soils: No details are known about the soil, but it likely would be classified as the Toxaway series, a Cumulic Humaquept.

Hydrology: The fen is permanently saturated by ground water seeping from amphibolite.

Vegetation: No intact examples are known in North Carolina. In the Virginia occurrence (as described in the NVC), the community is a mosaic of herb and shrub zones, with only sparse trees such as *Pinus strobus* and *Acer rubrum*. Predominant shrubs are *Alnus serrulata, Spiraea latifolia* (*alba), Spiraea tomentosa*, and *Lyonia ligustrina* var. *ligustrina* the predominant species. Herb species include *Glyceria striata, Juncus subcaudatus, Osmunda regalis, Oxypolis rigidior, Viola cucullata, Eleocharis tenuis, Cirsium muticum, Dichanthelium dichotomum, Houstonia caerulea, Oenothera perennis, Sanguisorba canadensis, Parnassia grandifolia, Symphyotrichum novi-belgii, Carex atlantica, Helenium brevifolium, Solidago uliginosa, Calopogon tuberosus, Muhlenbergia glomerata, Schizachyrium scoparium, Xyris torta, Panicum virgatum, Rhynchospora capitellata, Rhynchospora alba*, and *Lycopodioides apodum (Selaginella apoda*).

Range and Abundance: Ranked G1. Only one uncertain example, too highly altered to be certain, is known from North Carolina. Well-developed examples occur in Virginia within a few miles of the state line.

Associations and Patterns: The Glades Subtype is a small patch community. It probably naturally graded to Montane Oak–Hickory Forest (Basic Subtype) or Rich Cove Forest (Montane Rich Subtype).

Variation: Nothing is known of variation.

Dynamics: Little is known of the natural dynamics of this subtype. It is unclear to what extent the shrubbiness of the current vegetation is a result of shrub encroachment, as happens in most Mountain Bogs and Fens.

Comments: This subtype is perhaps best regarded as an extirpated community in North Carolina. However, the possibility remains of an attempt at restoring it.

Rare species:

References: