NON-ALLUVIAL WETLANDS OF THE SOUTHERN BLUE RIDGE -- DIVERSITY IN A THREATENED ECOSYSTEM

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Abstract. The generally steep landscape of the Southern Blue Ridge is not conducive to the formation of extensive wetlands, but wetlands do occur. Wetlands in this region are mostly small in size (< 10 ha), and are found in locations where topography is unusually gentle or where seepage is unusually strong or constant. Despite their rarity and small size, such wetlands show great species and community diversity, and are one of the most important habitats for rare (endemic and disjunct) plants and animals in the region. Community species composition seems to vary primarily in relation to elevation, topographic position, hydrology, underlying bedrock composition, recent land use, and biogeographic history. Based on differences in vegetation structure and composition, landscape position, and hydrology, we recognize nine groups of non-alluvial wetlands in the Southern Blue Ridge. An inventory of non-alluvial wetlands in the mountains of North Carolina revealed that the majority of these naturally rare communities are now destroyed or severely altered. Bogs and fens of the North Carolina mountains have been reduced nearly six-fold from an original extent of about 2000 ha, so that only about 300 ha remain in reasonably intact condition, and most of the remnants are compromised by hydrologic alteration and nutrient inputs. Because wetlands tend to be concentrated in valley bottoms and at low elevations where most land is privately owned, efforts to assure their long-term viability will require innovative protection and restoration tools.

1. Introduction

Wetlands of the Southern Blue Ridge of North Carolina have been classified by Schafale & Weakley (1990) into 15 natural community types, based on differences in vegetation composition and physiognomy, topography, substrate, hydrology, soils, and other abiotic factors. Of these, eight types may be called "boggy" or non-alluvial wetlands. They can be differentiated from the other, more alluvial, wetlands by the substantial to dominant *Sphagnum* (versus little or no *Sphagnum*), as well as their non-alluvial hydrology dominated by seepage, spray, high water table, or paludification, with flooding by rivers or streams rare or nonexistent. Except for Spray Cliffs, they are also distinguished by occurring as more-or-less isolated wetlands, surrounded by terrestrial communities, and usually occurring on slopes or outer edges of stream valleys. Most of these communities have been commonly referred to as "bogs." This term will be retained here, though in many classifications of mire types, these wetlands would be considered fens (see discussion below). Although some occur along the floodplains of streams and small rivers, they occur away from the stream and above the normal reach of flooding and alluvial deposition. We here recognize an additional category, subdividing the Southern Appalachian Bog (Southern Subtype) into two types, French Broad Valley Bog and Low Mountain Seepage Bog, based on strong differences in vegetation structure and composition.

Despite the great scientific interest and conservation importance of these wetland communities, only a few isolated examples have been studied (Schafale & Weakley 1990, Richardson & Gibbons 1993, Stewart & Nilsen 1993). The rarity of these wetland types and their concentration of rare species found in them has led the North Carolina Natural Heritage Program (Division of Parks and Recreation) to make the identification prioritization, and protection of remaining sites a focus of its activity since 1985 (Weakley 1993, LeGrand 1993, Murdock, this volume). Field work conducted during the last decade has provided us with a more comprehensive listing of remaining sites, an improved understanding of the diversity of these wetland types, and the information needed to direct conservation efforts. Many questions remain, however. Quantitative vegetation data are essentially non-existent; many sites have received only a cursory survey, focused on

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dominant species and rare species of special conservation concern. Information on soils and hydrology is poor or absent. Studies of the dynamics and successional patterns of these wetland types are non-existent. Information on potential impacts of grazing, nutrient input from atmospheric deposition and run-off from surrounding fields, and alteration of hydrology is anecdotal, yet effective management and stewardship of these ecosystems depends on an understanding of these forces.

This paper summarizes the available information on these interesting ecosystems. Its focus is on North Carolina, though much of its content applies to non-alluvial wetlands in the Southern Blue Ridge of northwestern South Carolina, northeastern Georgia, eastern Tennessee, and southwestern Virginia, as well. Bogs, fens, and other non-alluvial wetlands in the sedimentary rock provinces (Ridge and Valley, Alleghany Plateau) of the Central Appalachians of western Virginia and West Virginia show some similarities to the communities discussed here, but also differ in many ways (Walbridge, this volume). They have received more detailed study, much of it published in McDonald (1982). Non-alluvial wetlands north of the glacial boundary are much more extensive and have received much greater scientific attention, with numerous papers published on the successional dynamics of bogs and fens in New England. Despite the tendency to consider southern "bogs" and fens as essentially similar to (or poor cousins of) northern wetland types, non-alluvial wetlands of the southern mountains are not analogous to those of the northeastern United States in either floristics, climate, biogeochemistry, successional dynamics, or biogeographic history.

Most of the information on which this discussion is based is either in the form of unpublished reports and site survey forms in the files of the N.C. Natural Heritage Program, or unpublished observations by the authors. We acknowledge here the use of numerous reports and field forms prepared by a number of workers; only the more comprehensive of the unpublished reports will be cited (such as Gaddy 1981a and Smith 1993). Taxonomy and nomenclature of vascular plant species generally follow Kartesz (1994). Taxonomy and nomenclature of mosses generally follow Anderson, Crum, & Buck (1990) and Anderson (1990). Taxonomy and nomenclature of liverworts generally follow Hicks (1992). We present a discussion of broad-scale classification issues, followed by our classification of the community types of non-alluvial wetlands of the southern Blue Ridge. Type descriptions include physical characteristics, vegetation, range, distinguishing features, and examples. Following the classification we discuss distribution and abundance, biogeographic affinities, factors influencing compositional variation, natural dynamics and disturbance, and conservation status for these wetlands.

2. Broad Scale Classification

The word "bog" has been historically and traditionally applied to various non-alluvial wetlands in the Southern Appalachians, especially those with apparent *Sphagnum* and either herb- or shrub-dominated vegetation. Usage of this terminology has been nearly universal in popular, conservation, and scientific literature, and has been retained in recent scientific discussions of these communities (such as Schafale & Weakley 1990, Richardson & Gibbons 1993, Stewart & Nilsen 1993, and this paper). The term "fen" has also been used, but has usually been limited to the most minerotrophic examples, which contain some species characteristic of northern fens (Schafale & Weakley 1990, Richardson & Gibbons 1993).

Most international classifications of "mires" have emphasized a dichotomy into fens and bogs, a dichotomy which "reflects the historical lead of northwest continental Europe in peatland investigations" (Gore 1983). For instance, Gore (1983) follows an extensive and complex discussion of mire terminology with "a satisfactory definition of fens and bogs: fens are mires influenced by water derived predominantly from outside their own immediate limits; bogs are influenced solely by water that falls directly on to them as rain and snow." This definition is indicative of some conceptual problems in the simple dichotomy, since it leaves unaccounted for wetlands which receive some (but not predominant) flow from outside. Ingram (1983) states that "hydrologically, mires can be divided into two categories according to the nature of their water supply. Fens are mires developing in valleys or topographic basins. Part of their water recharge comes from atmospheric precipitation, but the remainder is telluric and it is this part which has the greater ecological effect.... Most bogs, by contrast, are recharged mainly by meteoric water and their surface vegetation is largely isolated from telluric influence."

Non-alluvial wetlands of the southern Blue Ridge vary considerably in the relative influence of seepage and precipitation. The relative influence can vary substantially even along a transect within a single small wetland. Even when telluric water (derived from surrounding rocks and soils) dominates the hydrology of a wetland in the southern Blue Ridge, there is considerable question about the chemical effect that it has. In the southern Blue Ridge, most wetlands are situated over nutrient-poor, felsic, metamorphic or igneous rocks. In general contrast to wetlands of northern Europe and northern North America, the Southern Appalachian landscape is an old one, with soils surrounding wetlands generally consisting of highly-leached, acidic Ultisols, often developed under vegetation dominated by soil-acidifying conifers and heaths. Seepage water is acidic and nutrient-poor.

Some workers have also questioned whether these wetlands have organic soils, and therefore whether they should indeed be considered mires or peatlands at all (Browning, this volume, T. Rawinski, pers. comm.). None of the named soil series for the southern Blue Ridge are classified as Histosols; soil series applied to these wetlands are classified as Inceptisols and Entisols (Browning, this volume). While it is true that the majority of non-alluvial wetlands of the southern Blue Ridge have soils which do not have enough organic carbon to meet the definition of Histosols, some sites, particularly those at medium to high elevations on flat valley bottoms in the northern portion of the southern Blue Ridge, do have soils which should apparently be classified as Histosols (Soil Survey Staff 1975, Soil Management Support Services 1985). For instance, Stewart & Nilsen (1993) studied one of only a few bogs in the mountains of east Tennessee and found 42 % soil organic matter in the top 20 centimeters; this would likely be a Histosol, depending on other factors such as depth of organic layer, whether the organic layer is over a lithic or paralithic contact or over fragmental material (Soil Management Support Services 1985). Based on our experience (but very little data), we believe that non-alluvial wetlands in the southern Blue Ridge span the distinction between organic and mineral soils, with most examples having shallow, organic-rich, mineral soils overlying bedrock.

Very few studies have touched on hydrology, soil chemistry, and water chemistry of non-alluvial wetlands in the southern Blue Ridge. In Mowbray and Schlesinger (1988), the only site studied was the Bluff Mountain Fen, the most minerotrophic mire in the southern Blue Ridge. In Stewart & Nilsen (1993), a single Blue Ridge site (impacted by cattle grazing and nearby agriculture) was compared to four sites on sedimentary rocks in West Virginia. Based on the very few measurements made (reported in published literature and unpublished information), some of these with questionable methods and accuracy, the documented pH's of bog soils in the southern Blue Ridge range from about 4.5 to about 6.5. Given that we lack substantial knowledge about the hydrology and chemistry of these wetlands, and that they do not appear to be closely analogous (in hydrology, chemistry, soils, history, or vegetation) to the better studied wetlands of northern Europe and northern North America, there seems little to be gained scientifically by forcing them into an artificial hierarchy.

All of these wetlands, however, are to one degree or another seepage-fed, and thus would be classified as fens in most mire classifications. The only strictly ombrotrophic wetlands (and therefore the only bogs, according to many mire classifications) in the southeastern United States are the remarkable peat-dome pocosins, primarily of eastern North Carolina. Lacking a better set of terminology (based on studies of the systems themselves), we here continue the use traditional for the region, using "bog" informally to refer to a wide range of moss-, herb-, and shrub-dominated wetlands with extensive *Sphagnum*, and restricting the term "fen" (in the phrase "Southern Appalachian Fen") to the most minerotrophic wetlands.

The most frequently used classification of wetlands in the United States is Cowardin et al. (1979). Non-alluvial wetlands of the southern Blue Ridge all belong to the Palustrine System. Within the Palustrine System, the following subclasses are represented in the southern Blue Ridge: Moss-Lichen Wetlands, Persistent Emergent Wetlands, Nonpersistent Emergent Wetlands, Broad-leaved Deciduous Scrub-Shrub Wetlands, Broad-leaved Evergreen Scrub-Shrub Wetlands, Needle-leaved Evergreen Scrub-Shrub Wetlands, Broad-leaved Deciduous Forested Wetlands, and Needle-leaved Evergreen Forested Wetlands. This classification, like many hierarchical classifications employing vegetation physiognomy at a high level in the hierarchy, is not very satisfying or useful for Southern Appalachian bogs and other systems which consist of a complex of zones dominated by mosses, lichens, herbs, shrubs (deciduous and evergreen), and trees (deciduous and evergreen). Some wetlands, only a few hectares in size, would have all or nearly all of these subclasses represented. At the scale of mapping employed by the U.S. Fish and Wildlife Service in National Wetland Inventory maps, most non-alluvial wetlands in the southern Blue Ridge should probably be generalized as Palustrine Broad-leaved Deciduous Scrub-Shrub Wetlands, Palustrine Needle-leaved Evergreen Forested Wetlands, or Palustrine Broad-leaved Deciduous Forested Wetlands. Spray Cliffs, vertical wetlands hydrologically maintained by constant mist aerosol from waterfalls, are not explicitly accounted for in the Cowardin classification. Presumably, they would be considered Palustrine Moss-Lichen Wetlands.

3. Community Type Classification

In developing a classification of the diversity of non-alluvial wetlands in the southern Blue Ridge, we have chosen to emphasize a number of characteristics -- vegetational composition, vegetational structure, landscape position, elevation, and oligotrophy/minerotrophy. We believe that such a classification provides a framework for understanding the diversity of non-alluvial wetlands present in the southern Blue Ridge and is useful for conservation planning. A classification based more strictly on vegetation dominants or indicator species, in the tradition of European phytosociology (e.g. Rodwell 1991), would likely recognize many additional types, even in some individual bogs of a hectare or less. Similarly, classifications emphasizing physiognomy of vegetation would recognize numerous communities in many bogs. While such classifications are valid and valuable approaches, they are not as useful for our primary purposes. The classification presented here reflects fairly minor changes from that in Schafale & Weakley (1990), and is based primarily on vegetation data and considerations of landscape position. Statistical analyses of new data (in progress) suggest that further modifications will be needed to best reflect the range of variation of these communities. The Southern Appalachian Bog category (see below) is particularly broad and heterogeneous; further subdivisions would probably help clarify our understanding of the variation among these wetlands. Additional vegetation data, in conjunction with studies of the hydrology and chemistry of these wetlands, would greatly augment our understanding of these communities and would allow development of a more definitive classification.

3.1. SOUTHERN APPALACHIAN FEN

3.1.1. *Physical Characteristics*: The only known example occurs on a nearly flat plateau at an elevation of 1300 meters. Wetland hydrology is maintained by a series of seepages upslope, which provide relatively nutrient-rich waters of circumneutral pH (from percolation through soils derived from amphibolite, a mafic, metamorphic rock). The soils are shallow, organic-rich mineral soils overlying amphibolite bedrock. Although mapped as Toxaway series (a Cumulic Humaquept), they are almost certainly a different, undefined series.

3.1.2. *Vegetation*: Complex zonation of herbaceous vegetation appears to depend on small variations in hydrology and substrate. Species dominant in one or more of the zones include: *Rhynchospora alba, R. capitellata, Juncus subcaudatus, Cladium mariscoides, Carex stricta, Helenium autumnale, Schizachyrium scoparium, Sanguisorba canadensis, Solidago uliginosa*, and *Osmunda regalis* var. *spectabilis*. Other characteristic species include *Huperzia appalachiana, Eriophorum virginicum, Houstonia caerulea, Utricularia cornuta, Osmunda cinnamomea, Liatris aspera, Muhlenbergia glomerata, Tofieldia glutinosa, Carex conoidea, C. buxbaumii*, and *Parnassia grandifolia*. Occasional *Alnus serrulata* and other wetland shrubs occur. Characteristic bryophytes include *Sphagnum subsecundum, Rhytidium rugosum, Hypnum pratense, Campylium stellatum, Calliergon* *cordifolium*, and *Calliergonella cuspidata*.

3.1.3. *Range*: The only known well-developed example is on Bluff Mountain, Ashe County, North Carolina. A site recently discovered in Grayson County, Virginia has some similarities (T. Rawinski, pers. comm.)

3.1.4. *Distinguishing Features*: The Southern Appalachian Fen is distinguished from Southern Appalachian Bogs by the species composition including numerous northern calciphilic species such as *Muhlenbergia glomerata*, *Tofieldia glutinosa*, and *Sphagnum subsecundum*. A few bogs, occurring over hornblende-rich rocks, have fen-like zones in the center, but the bulk of the area is bog-like.

3.1.5. *Discussion*: Southern Appalachian Fens appear to result from the seepage of nutrient-rich, circumneutral waters, a situation rare in the southern Blue Ridge. Since this type is demonstrably seepage-fed and minerotrophic, it is the most fen-like of Southern Blue Ridge wetland communities. Bluff Mountain is the only well-developed example of the type here called Southern Appalachian Fen, but several other sites, particularly the bogs in Long Hope Valley, the Celo Bog, and fens in "The Glades" of Grayson County, Virginia, show some relationship to the Bluff Mountain Fen in nutrient status and species composition. Undiscovered small fens may exist, but none as large as Bluff Mountain are likely. Fens in other parts of the United States may be similar in some ways, but should not be considered the same natural community type because of their different climate, origins, and composition.

3.1.6. *Examples*: Bluff Mountain, Ashe County, North Carolina (Weakley et al. 1979, Tucker 1967, Mowbray & Schlesinger 1988).

3.2. SOUTHERN APPALACHIAN BOG

3.2.1. *Physical characteristics*: This type occurs at a variety of sites. Some are in flat areas, in portions of valley bottoms that are not subject to flooding. These sites receive little seepage and are presumably largely maintained hydrologically by rainwater and high water table. Others bogs of this type are in the upper portions of stream watersheds, on slight to moderate slopes, hydrologically maintained by very nutrient-poor to nutrient-rich seepage. Soils are organic or organic-rich mineral soils, presumably very acidic to slightly acidic or even circumneutral. In the northern part of the range, sites occur at elevations from 800-1400 m. In the southern part of the range, sites occur at elevations from 1000 to 1800 m.

3.2.2. *Vegetation*: The vegetation generally consists of a mosaic or zoned pattern of shrub thickets and herb-dominated areas, much of it underlain by *Sphagnum* mats. Trees such as *Acer rubrum, Pinus strobus, Tsuga canadensis, Pinus rigida*, and *Picea rubens* may be scattered throughout or may dominate in patches or on the edges. Shrubs may include *Alnus serrulata, Rosa palustris, Salix sericea, Aronia arbutifolia, A. melanocarpa, Rhododendron maximum, R. viscosum, R. catawbiense, Kalmia latifolia, K. carolina, Hypericum densiflorum, Lyonia ligustrina* var. *ligustrina, Ilex verticillata, I. collina, Spiraea tomentosa, S. alba*, and *Menziesia pilosa*. The herb layer may include *Carex leptalea, C. folliculata, C. gynandra, C. atlantica, C. echinata, Rhynchospora alba, R. capitellata, Scirpus expansus, S. cyperinus, S. polyphyllus, S. atrovirens, Osmunda cinnamomea, O. regalis* var. *spectabilis, Solidago patula, Senecio aureus, Thelypteris palustris* var. *pubescens, Juncus effusus, Juncus subcaudatus, Lilium grayi, Lysimachia terrestris, Vaccinium macrocarpon, Eriophorum virginianum, Oxypolis rigidior, Parnassia asarifolia, Saxifraga pensylvanica, Sagittaria latifolia* var. *pubescens*, and *Orontium aquaticum*. *Sphagnum* species include *S. palustre, S. affine, S. bartlettianum, S. recurvum*, and, rarely, northern disjuncts such as *S. warnstorfii, S. fallax, S. fuscum, S. subsecundum, S. angustifolium, S. capillifolium, S. subtile*, and *S. flexuosum*. Other important bryophytes include *Polytrichum commune, Rhizomnium appalachianum, Aulacomnium palustre*, and *Bazzania trilobata*.

3.2.3. *Range*: This type is scattered from southwestern Virginia and northeastern Tennessee south through the southern Blue Ridge to southwestern North Carolina. Most examples are north of the Asheville basin; some sites at moderate to high elevations south of the Asheville Basin are included in this type.

3.2.4. *Distinguishing Features*: Southern Appalachian Bogs are distinguished from Swamp Forest-Bog Complexes by their structure. Southern Appalachian Bogs are concentrically or patchily zoned, with herbs or shrubs dominating in the interior. Swamp Forest-Bog Complexes contain small areas of boggy vegetation in a matrix of forest. When both types occur together, *Sphagnum*-dominated areas greater than one acre in size should be considered Southern Appalachian Bogs. Southern Appalachian Bogs are distinguished from Southern Appalachian Fens by species composition, which is apparently correlated with Ph. Distinguishing species include several northern fen indicators such as *Muhlenbergia glomerata*, *Tofieldia glutinosa*, and *Sphagnum subsecundum*. As defined, the only known example of Southern Appalachian Fen is at Bluff Mountain. A few Southern Appalachian Bogs, occurring over hornblende-rich rocks, have fen-like zones along seepage rivulets, but the bulk of the area is more sphagnous and (apparently) more oligotrophic. The distinction between Southern Appalachian Bogs and High Elevation Seeps is not well defined. In general, High Elevation Seeps occur on upper slopes or ridgetops, while Southern Appalachian Bogs occur on non-flooded bottomlands or slope bases. Southern Appalachian Bogs tend to be larger, have well-developed *Sphagnum* mats, and have soils with more organic matter. Seeps tend to be dominated more by forbs, rather than by graminoids and shrubs. Southern Appalachian Bogs are distinguished from French Broad Valley Bogs and Low Mountain Seepage Bogs by floristic differences that correlate with geography and elevation. Southern Appalachian Bogs have a large component of species with northern affinities, including long-distance disjuncts, while French Broad Valley Bogs and Low Mountain Seepage Bogs contain many species more typical of the Coastal Plain (see Table 1). Species which occur in Southern Appalachian Bogs but are absent in French Broad Valley Bogs and Low Mountain Seepage Bogs include *Carex trisperma*, *C. buxbaumii*, *C. oligosperma*, *Rhynchospora alba*, *Ilex collina*, *Vaccinium macrocarpon*, *Saxifraga pensylvanica*. Species which occur in French Broad Valley Bogs and Low Mountain Seepage Bogs but are absent in Southern Appalachian Bogs include *Sarracenia jonesii*, *Sarracenia purpurea*, *Sarracenia oreophila*, *Smilax laurifolia*, *Viburnum nudum*, *Rhododendron arborescens*, *Dulichium arundinaceum*, *Carex collinsii*, *Helonias bullata*, *Gaylussacia dumosa* var. *bigeloviana*, *Chamaedaphne calyculata*, *Myrica gale*, *Juncus caesariensis*, *Rhynchospora rariflora*, *Woodwardia virginica*, and *Woodwardia areolata*.

3.2.5. *Variation*: Southern Appalachian Bogs vary with wetness and amount of organic matter accumulation, both within and among sites. Open areas tend to be more diverse than shrub-dominated areas. Some high elevation sites have northern bog species such as *Vaccinium macrocarpon* and the northern *Sphagnum* species listed above. Nutrient status also modifies species composition and aspect, with some Southern Appalachian Bogs (such as the Celo Bog and the Long Hope Valley bogs) approaching the Southern Appalachian Fen category in nutrients and species composition.

This remains a heterogeneous grouping, with examples occurring on a wide range of rock types, at various elevations, in most parts of the southern Blue Ridge, and in a variety of landscape positions. Some of the more distinctive variants are described below.

Long Hope Valley Variant. Long Hope Valley has at least twenty-three individual bogs, at elevations of 1250-1450 m, developed over amphibolite, a mafic metamorphic rock. They occur on slight to fairly steep slopes, are slightly to strongly seepage fed, generally have shallow soils over bedrock, and are surrounded by Swamp Forest-Bog Complex (Spruce Subtype), Northern Hardwoods Forests, or land cleared from one of these two communities. While they differ from one another considerably in size, slope, landscape position, and physiognomy, they are united by a very northern floristic assemblage. Some of them show a relationship to the Bluff Mountain Fen (also on amphibolite and less than 10 km distant) in their central zones, where rivulets carry relatively nutrient-rich seepage water. Species which are restricted to this variant are

Table 1. Biogeographic affinities of the flora of selected Southern Appalachian Bogs of the Southern Blue Ridge, by percentage of total flora at each site.

	Northern Species	Southern Appalachian Species	Widespread Species	Coastal Plain Species
Long Hope Valley Bogs (Southern Appalachian Bog)	56.6	12.1	31.3	0.0
Bluff Mountain Fen (Southern Appalachian Fen)	43.1	17.2	39.7	0.0
Sugar Mountain Bog (Southern Appalachian Bog)	46.8	19.1	34.1	0.0
Pineola Bog (Southern Appalachian Bog)	48.3	5.2	32.7	13.8
Big Pine Creek Bog (Southern Appalachian Bog)	46.4	10.7	37.5	5.4
Whiteoak Bottoms Bog (Southern Appalachian Bog)	39.1	19.6	35.9	5.4
Panthertown Valley Bog (Southern Appalachian Bog)	33.3	7.8	52.2	6.7
King Creek Bog (French Broad Valley Bog)	17.6	13.2	41.2	28.0
Eller Seepage Bog (Low Mountain Seepage Bog)	19.2	4.8	41.6	34.4

Lonicera canadensis, L. dioica, Menyanthes trifoliata, Taxus canadensis, Utricularia minor, Carex oligosperma, and *Ilex collina*. Other typical species of this variant which are found less frequently in other variants or types include *Cladium mariscoides, Betula allegheniensis, Carex trisperma, Rhynchospora alba, Utricularia cornuta, Hierochloe odorata, Picea rubens, Galium asprellum,* and *Parnassia asarifolia*.

Typic Variant. Bogs of this variant occur at relatively high elevations (from about 1000 to 1250 m) in the northern part of the southern Blue Ridge. Characteristic examples include Pineola Bog (Avery County, North Carolina), Sugar Mountain Bog (Avery

County, North Carolina), Invershiel Bog (Avery County, North Carolina), Beech Creek Bog (Watauga County, North Carolina). A few examples at very high elevations (ca. 1800 m) south of the Asheville Basin, such as the Flat Laurel Gap Bog, are tentatively placed here, though they may be better considered among the boggier examples of High Elevation Seep (see below). Rock types are usually felsic gneisses or schists, and seepage is acidic and nutrient-poor. Many examples are nearly flat and occur in the higher (rarely or never flooded) portions of the floodplains of creeks or small rivers, while others are on gentle slopes and are fed by oligotrophic seepage. Tree species occurring around the bog margin and as scattered, stunted individuals in the bog are characteristically *Picea rubens*, *Pinus strobus, Acer rubrum*, and *P. rigida*. At these sites *Picea rubens* occurs below its usual elevational range as an "elevational disjunct." While the flora is not as northern in its affinities as the flora of the Long Hope Variant, it is still a flora dominated by northern species (Table 1). Some examples, especially those with deeper peat (Pineola Bog), have a number of Coastal Plain species, while others (Sugar Mountain Bog) lack Coastal Plain species entirely. Possibly the deeper peat more closely resembles Coastal Plain habitats, or, alternatively, it may reflect a longer and more stable history more favorable for relictual distributions.

Low Elevation Variant. Bogs of this variant occur at lower elevations than the previous two variants (from about 750 to 950 m), in the northern part of the southern Blue Ridge, primarily in Alleghany and Ashe counties, North Carolina. They occur primarily in floodplain situations with little seepage. Their floristic composition is intermediate between the Typic Variant and the Southern Floodplain Variant.

Southern Floodplain Variant. Bogs of this variant occur south of the Asheville Basin at elevations of about 900 to 1200 m. Characteristic examples include Panthertown Bog, Greenland Creek Bog, Horsepasture River Bog, and the several Nantahala River Bogs. All or nearly all examples are nearly flat and occur in the higher (rarely or never flooded) portions of the floodplains of creeks or small rivers, and receive minimal seepage. Tree species occurring around the bog margin and as scattered, stunted individuals in the bog are characteristically *Pinus strobus, Acer rubrum, Liriodendron tulipifera*, and *P. rigida*; *Picea rubens* is never present.

3.2.6. *Examples*: Long Hope Valley bogs (23 bogs known), Watauga and Ashe counties, North Carolina (Weakley 1993b); Invershiel (Linville Gap) Bog, Avery County, North Carolina; Pineola Bog, Avery County, North Carolina; Celo Bog, Yancey County, North Carolina (McLeod 1983, McLeod & Croom 1983, McLeod 1988); Flat Laurel Gap Bog, Haywood County, North Carolina (Horton & Hotaling 1981, Shafer 1984, Shafer 1986); Quebec Branch Bog, Grayson County, Virginia; Big Wilson Creek Bog, Grayson County, Virginia; Panthertown Bog, Jackson County, North Carolina; Horsepasture River Bog, Jackson County, North Carolina (Smith 1993); Whiteoak Bottoms, Macon County, North Carolina (Gaddy 1981a); Sparta Bog, Alleghany County, North Carolina (Smith 1993).

3.3. FRENCH BROAD VALLEY BOG

3.3.1. *Physical characteristics*: This type occurs in flat or gently sloping areas, generally in valley bottoms that are not subject to flooding. Soils have not been carefully studied, but are likely to be acidic, organic-rich mineral soils developed over gravelly floodplain deposits. Most bog soils are mapped as Toxaway (Cumulic Humaquept), Wehadkee (Typic Fluvaquent), or Hatboro (Typic Fluvaquent) series. The hydrology is palustrine, permanently saturated to intermittently dry. Sites are generally in flat to slightly sloping areas near streams, and receive some seepage from adjacent slopes. The hydrology of this type appears to be less dominated by seepage than are Southern Appalachian Fens, Low Mountain Seepage Bogs, High Elevation Seeps, and most variants of Southern Appalachian Bogs. This type ranges from 500 meters to 700 meters in elevation.

3.3.2. *Vegetation*: This type supports a mosaic or zoned pattern of shrub thickets and herb-dominated areas, much of it underlain by *Sphagnum* mats. Trees such as *Acer rubrum, Pinus strobus, P. rigida, Nyssa sylvatica, Liriodendron tulipifera*, and *Tsuga canadensis* may be scattered throughout or may dominate on the edges. Shrubs may include *Alnus serrulata, Rosa palustris, Salix sericea, Aronia arbutifolia, Myrica gale,* *Gaylussacia dumosa* var. *bigeloviana, Rhododendron maximum, R. viscosum, R. arborescens, Viburnum nudum, V. cassinoides, Kalmia latifolia, K. carolina, Hypericum densiflorum, Lyonia ligustrina* var. *ligustrina, Ilex verticillata,* and *Menziesia pilosa*. The woody vine *Smilax laurifolia* is often present, climbing high into the shrubs and trees. The herb layer may include *Carex leptalea, C. echinata, C. folliculata, C. gynandra, C. collinsii, Scirpus cyperinus, Osmunda cinnamomea, O. regalis* var. *spectabilis, Solidago patula, Senecio aureus, Thelypteris palustris* var. *pubescens, Isoetes caroliniana, Juncus effusus, J. caesariensis, Drosera rotundifolia, Woodwardia virginica, Woodwardia areolata, Dulichium arundinaceum, Sarracenia purpurea, S. jonesii, Sagittaria fasciculata, Eriophorum virginianum,* and *Parnassia asarifolia*. *Sphagnum* species include *S. palustre, S. affine, S. bartlettianum,* and *S. recurvum*.

3.3.3. *Range*: French Broad Valley Bogs are found at low elevations in the broad basin of the French Broad River in southern Buncombe, Henderson, and eastern Transylvania Counties, North Carolina. A concentration formerly occurred in Henderson County, North Carolina, but nearly all of these bogs have been destroyed by drainage.

3.3.4. *Distinguishing Features*: French Broad Valley Bogs are distinguished from Swamp Forest-Bog Complexes by their structure. French Broad Valley Bogs, like Southern Appalachian Bogs, are concentrically or patchily zoned, with herbs or shrubs dominating in the interior, though zonation is usually less well developed and overall this type is shrubbier. Swamp Forest-Bog Complexes contain small areas of boggy vegetation in a matrix of forest.

French Broad Valley Bogs are distinguished on the one hand from Southern Appalachian Bogs and on the other hand from Low Mountain Seepage Bogs by floristic differences that correlate with geography and elevation. Southern Appalachian Bogs have a number of northern disjunct species, while this French Broad Valley Bogs often contain species typical of the Coastal Plain (see Table 1). Species which occur in Southern Appalachian Fens and Southern Appalachian Bogs but are absent in French Broad Valley Bogs include *Carex trisperma, C. buxbaumii, Rhynchospora alba, Filipendula rubra, Dryopteris cristata, Thelypteris simulata, Spiraea alba, Schizachyrium scoparium, Lilium grayi, Pogonia ophioglossoides, Juncus subcaudatus, Ilex collina, Picea rubens, Vaccinium macrocarpon,* and *Saxifraga pensylvanica*. Species which occur in the French Broad Valley Bogs but are absent in Southern Appalachian Bogs and Southern Appalachian Fens include *Sarracenia jonesii, S. purpurea, Smilax laurifolia, Leucothoe racemosa, Viburnum nudum, Rhododendron arborescens, Dulichium arundinaceum, Carex collinsii, Helonias bullata, Woodwardia virginica,* and *W. areolata*. Species which occur in French Broad Valley Bogs but not in Low Mountain Seepage Bogs include *Carex collinsii, Chamaedaphne calyculata, Eleocharis tortilis, Gaylussacia dumosa var. bigeloviana, Myrica gale, Sarracenia jonesii,* and *Viburnum nudum*. See Low Mountain Seepage Bog for a list of species which occur in it alone.

3.3.5. *Discussion*: One of the most interesting features of French Broad Valley Bogs is the presence of a suite of species that are disjunct from a more northern Coastal Plain distribution. Most of these species do not occur at all in other bog types, though a few have limited occurrence in other bog types. These species include *Myrica gale, Chamaedaphne calyculata, Gaylussacia dumosa* var. *bigeloviana, Helonias bullata, Juncus caesariensis, Carex collinsii, C. barrattii, Narthecium americanum, Xerophyllum asphodeloides, Sarracenia purpurea,* and *Triadenum virginicum*.

3.3.6. *Examples*: King Creek Bog, Henderson County, North Carolina; Etowah Bog, Henderson County, North Carolina; East Flat Rock Bog, Henderson County, North Carolina (formerly the best example, now essentially destroyed).

3.4. LOW MOUNTAIN SEEPAGE BOG

3.4.1. *Physical characteristics*: Known examples occur on shallow slopes, at about 500 meters elevation, and have a palustrine hydrology, fed by acidic seepage.

3.4.2. *Vegetation*: Owing to disturbance of the only known examples, the original vegetation structure of this community type is unknown, but was probably primarily shrubby. Shrub species include *Alnus serrulata, Lyonia ligustrina, Aronia arbutifolia, A. melanocarpa, Rhododendron arborescens, Rosa palustris,* and *Sambucus canadensis*. Typical herb species include *Osmunda cinnamomea, Rhynchospora rariflora, Sarracenia oreophila, Eriocaulon decangulare, Thelypteris palustris* var. *pubescens, Sagittaria latifolia* var. *pubescens, Rhexia virginica, R. mariana, Eryngium integrifolium, Helianthus angustifolius, Eupatorium perfoliatum, E. pilosum, E. pubescens, E. fistulosum, Eriophorum virginicum, Sanguisorba canadensis,* and *Juncus caesariensis*.

3.4.3. *Range*: This type is known only from Clay County, North Carolina and Towns County, Georgia. It should be sought in nearby counties.

3.4.4. *Distinguishing features:* This type has numerous species which do not occur in other bog types in the southern Blue Ridge. Most of these species are more typical of Coastal Plain wetlands: *Sarracenia oreophila, Andropogon glomeratus, Aster dumosus, Cinna arundinacea, Eryngium integrifolium, Fuirena squarrosa, Helianthus angustifolius, Rhynchospora gracilenta, R. rariflora, Scleria ciliata, S. muhlenbergii, Gratiola pilosa, Xyris jupicai, Polygala cruciata, Drosera capillaris, Erianthus giganteus, Eupatorium pilosum, Juncus canadensis,* and *Panicum virgatum*. Many additional species occur in other bog types only very rarely or atypically, such as *Eriocaulon decangulare, Eleocharis tuberculosa*, and *Betula nigra*. While it shares some species with French Broad Valley Bogs, this type is not closely related.

3.4.5. *Discussion*: Fire may have been a natural disturbance in this community type. This is suggested by the large suite of species more typical of fire-maintained communities of the Coastal Plain. It is also possible that this suite of species is present in this community because of its low elevation and phytogeographic history.

3.4.6. *Examples*: Eller Seepage Bog, Clay County, North Carolina (Govus 1985, Govus 1987); Reed Creek Seepage Bog, Towns County, Georgia (Dennis 1980).

3.5. HIGH ELEVATION SEEP

3.5.1. *Physical characteristics:* High elevation seeps occur at a range of high elevation sites, in generally sloping areas, and receive nearly constant (or at least, regular) seepage. Soils are generally rocky, gravelly, or (less commonly) mucky soils. Their hydrology is palustrine, permanently saturated to intermittently dry, and varies in chemistry depending on the rock type. These communities occur at elevations from about 1200 m to about 2000 m.

3.5.2. *Vegetation*: The vegetation consists generally of an open to dense bed of wetland herbs. Seeps are often small enough that they may be substantially shaded by trees rooted in adjacent communities, but some are extensive and open, with trees scattered or absent. Herbs include *Chelone lyonii, Chelone cuthbertii, Veronica americana, Diphylleia cymosa, Saxifraga micranthidifolia, S. careyana, Cardamine clematitis, Parnassia asarifolia, Helenium autumnale, Chrysosplenium americanum, Boykinia aconitifolia, Polygonum sagittatum, Drosera rotundifolia, Cicuta maculata, Rhynchospora capitellata, Juncus subcaudatus, Carex leptalea, C. gynandra, Houstonia serpyllifolia, Aster puniceus, Impatiens pallida, Impatiens capensis, Hypericum prolificum, H. buckleyi, H. mitchellianum, H. graveolens, Viola cucullata, V. macloskeyi* ssp. *pallens, Hydrocotyle americana, Aconitum reclinatum, Hydrophyllum canadense, Monarda didyma, Solidago patula, Lycopus uniflorus, Rudbeckia laciniata, Houstonia serpyllifolia, Veratrum viride, Lilium grayi, Thalictrum clavatum, T. dioicum,* and *Trautvetteria carolinensis*. *Sphagnum* is often present and may occasionally have significant cover. Woody species include *Rhododendron maximum, Kalmia latifolia, Viburnum cassinoides, Lyonia ligustrina* var. *ligustrina*, and *Vaccinium corymbosum*. *Acer rubrum, Betula alleghaniensis, Picea rubens,* and *Amelanchier arborea* are common trees.

3.5.3. *Range*: High Elevation Seeps are scattered in small occurrences throughout the mountains at high elevations; they are fairly common, but never extensive. Presence is related to strike and dip of metamorphic foliation or fractures in the rocks.

3.5.4. *Distinguishing Features*: The distinction between High Elevation Seeps and Southern Appalachian Bogs is not well defined. In general, High Elevation Seeps occur on upper slopes or ridgetops, while Southern Appalachian Bogs occur on non-flooded bottomlands or slope bases (though sometimes at high elevations in hanging valleys). Southern Appalachian Bogs tend to be larger, to have well-developed *Sphagnum* mats, and to have a definite organic layer. Seeps tend to be more dominated by forbs, rather than by graminoids and shrubs, and to have bedrock or broken rock substrates which make microsite conditions heterogeneous. Seeps are less often strongly zoned.

3.5.5. *Variation*: This is currently a very diverse grouping, including a wide variety of small upland wetlands occurring within high elevation mountain communities. Division into subtypes is probably desirable, but further study will be required. Examples vary with underlying rock, topographic position, regularity and amount of seepage, elevation (climate), and soil development. Some examples show gradation to Southern Appalachian Bog.

3.5.6. *Discussion*: The classification of mountain wetlands is still somewhat tentative, because of their variable vegetation and because little is known about their hydrology and nutrient dynamics. High Elevation Seeps and Southern Appalachian Bogs grade conceptually into each other, although they are seldom associated at the same site and are very distinct at their extremes.

3.5.7. *Examples*: Roan Mountain, Mitchell County, North Carolina; Big Yellow Mountain, Avery County, North Carolina; Grandfather Mountain, Avery and Watauga counties, North Carolina; Bluff Mountain, Ashe County, North Carolina; Andrews Bald, Swain County, North Carolina; Long Hope Valley, Ashe and Watauga counties, North Carolina (Weakley 1993b); Ivestor Gap Cranberry Seep, Haywood County, North Carolina; Fork Ridge Balds and Seeps, Haywood County, North Carolina (Gaddy 1981b).

3.6. SWAMP FOREST-BOG COMPLEX (TYPIC SUBTYPE)

3.6.1. *Physical Characteristics*: This community type occurs in poorly drained bottomlands, generally with visible microtopography of ridges and sloughs or depressions. The soils show an alluvial origin, but are now removed from regular flooding. They are, however, seasonally to semipermanently saturated, apparently primarily from a high water table. Some examples also receive seepage from adjacent slopes.

3.6.2. *Vegetation*: Most sites are primarily forested, with a closed or open canopy and an open or dense shrub layer, interspersed with small boggy openings in depressions. *Tsuga canadensis* or *Acer rubrum* are usually the dominant trees. Other trees include *Salix nigra*, *Betula lenta*, *B. alleghaniensis*, *Quercus alba*, *Pinus strobus*, and various other alluvial species. The dominant shrubs are usually *Rhododendron maximum*, *Kalmia latifolia*, and *Leucothoe fontanesiana*. Common shrubs include *Salix sericea*, *Alnus serrulata*, *Ilex montana*, *Cornus amomum*, *Viburnum cassinoides*, and *Toxicodendron vernix*. Herbs in boggy openings include *Solidago patula*, *Aster novae-angliae*, *Dalibarda repens*, *Osmunda cinnamomea*, *Carex folliculata*, *C. gynandra*, *C. scabrata*, *C. leptalea*, *C. stricta*, *Sarracenia purpurea*, *Sagittaria latifolia* var. *pubescens*, and *Leersia virginica*. Herbs in the forest include *Glyceria melicaria*, *Lycopodium obscurum*, *Onoclea sensibilis*, *Maianthemum canadense*, *Thelypteris noveboracensis*, and *Osmunda regalis* var. *spectabilis*.

3.6.3. *Range*: This type is scattered throughout the southern Blue Ridge, sometimes associated with more open bogs, but often not.

3.6.4. *Distinguishing Features*: Swamp Forest-Bog Complexes are distinguished from

Southern Appalachian Bogs by their structure, which consists primarily of forested thickets with only small boggy openings. Boggy areas in Swamp Forest-Bog Complexes are less than one acre in size. Swamp Forest-Bog Complexes are distinguished from Montane Alluvial Forests and Acidic Cove Forests by being wetter, having open boggy vegetation in small depressions, and having scattered *Sphagnum* mats. The Floodplain Pool type occurs in deeper bottomland depressions, containing standing water for much or all of the year, and lacking dense boggy vegetation. The Typic Subtype may be distinguished from the Spruce Subtype by the composition of the forest canopy, which consists of *Tsuga canadensis*, *Acer rubrum*, and other lower elevation trees but not of *Picea rubens*.

3.6.5. *Variation*: Examples of this type vary with elevation and hydrology. Sites vary especially in the relative amounts of closed forest, shrubby openings, and boggy openings. Examples at lower elevations (especially south of the Asheville Basin) tend to be dominated by *Acer rubrum*, *Liriodendron tulipifera*, or *Nyssa sylvatica*, while examples at higher elevations (especially north of the Asheville Basin) are usually dominated by *Tsuga canadensis*. Such differences suggest that additional types, subtypes or variants should be recognized to better describe variation within this group. These communities have received almost no study -- even less than the more herbaceous bog and fen communities. More information is needed for a better understanding of these communities.

3.6.6. *Discussion*: The factors responsible for creating and maintaining these communities are not well known. Gaddy (1981a) suggested they were caused by paludification following tree blowdown or logging in wet alluvial forests. Some examples appear to be very old, however, and most logged bottomlands do not contain boggy vegetation. The boggy openings are generally associated with small depressions. They may be successional remnants of once more extensive bog areas. As in some Southern Appalachian Bogs, beaver activities may be a significant factor in these communities. The frequency and role of flooding in these communities is not known. They often occur near streams and undoubtedly are occasionally flooded. Some occur near the outer edge of floodplains and also receive seepage water from adjacent slopes. Others may receive seepage water flowing through Southern Appalachian Bogs.

3.6.7. *Examples*: Nantahala and Big Indian Creek Bogs, Macon County, North Carolina (Gaddy 1981a); Tulula Bog, Graham County, North Carolina (Gaddy 1981a); Etowah Swamp, Henderson County, North Carolina (Wickland & Horton 1977); Ochlawaha Bog, Henderson County, North Carolina; Panthertown Valley, Jackson County, North Carolina.

3.7. SWAMP FOREST-BOG COMPLEX (SPRUCE SUBTYPE)

3.7.1. *Physical Characteristics*: This community type occurs on poorly drained bottomlands of small streams at high elevations. The soils have been mapped as the Toxaway series (Cumulic Humaquept), but that classification should be considered preliminary. Soils are seasonally to semipermanently saturated. The frequency of flooding is not known, but appears to be very rare. Some areas also receive groundwater seepage from adjacent slopes. The best examples, in the hanging valley of Long Hope Creek, are at 1300 to 1400 m elevation.

3.7.2. *Vegetation*: This type supports forest with a closed or open canopy and open or dense shrub layer, interspersed with small, open, boggy patches in slight depressions. *Picea rubens* is the dominant tree, with *Tsuga canadensis*, *Betula alleghaniensis*, *Acer rubrum*, *Amelanchier arborea*, and other species sometimes present. A dense shrub layer of *Rhododendron maximum* and *Kalmia latifolia* is usually present. Other shrubs may include *Ilex verticillata*, *I. collina*, *Taxus canadensis*, *Viburnum cassinoides*, *Aronia melanocarpa*, and *Vaccinium* spp. Herbs are generally sparse under the canopy but may be dense in openings. Herb species include *Glyceria melicaria*, *Osmunda cinnamomea*, *O. regalis* var. *spectabilis*, *Maianthemum canadense*, *Carex trisperma*, *C. folliculata*, *Listera smallii*, and various species of the Southern Appalachian Bog type. *Sphagnum* patches may occur scattered beneath the canopy as well as in small depressions.

3.7.3. *Range*: Several examples of this type are scattered in the Southern Blue Ridge.

3.7.4. *Distinguishing Features*: Swamp Forest-Bog Complexes are distinguished from Southern Appalachian Bogs by their structure, which consists primarily of forested thickets with only small boggy openings. Boggy areas are less than one acre in size. They are distinguished from Red Spruce Forests (Schafale & Weakley 1990) by being wetter and having boggy openings and scattered *Sphagnum* mats. They also are generally at somewhat lower elevation than Red Spruce Forest. The Spruce subtype may be distinguished from the Typic Subtype by the composition of the forest, with *Picea rubens* as the dominant tree.

3.7.5. *Discussion*: The factors responsible for creating and maintaining these communities are not well known. Occurrence of spruce at unusually low elevations and the occurrence of northern disjunct species suggests that they are relicts from the Pleistocene glacial period, persisting in specialized environments. They may, however, represent a late stage of primary succession from more extensive open bogs.

3.7.6. *Examples*: Long Hope Valley, Ashe and Watauga counties, North Carolina (Weakley 1993b); Alarka Laurel, Swain County, North Carolina.

3.8. SPRAY CLIFF

3.8.1. *Physical Characteristics*: Spray cliffs occur on vertical to gently sloping rock faces that are constantly wet from the spray of waterfalls. Small pockets or mats of mineral or organic matter are interspersed with bare rock. These sites are palustrine, permanently saturated by spray, with or without seepage water.

3.8.2. *Vegetation*: Vegetation consists of a variable collection of mosses, liverworts, algae, vascular herbs, and occasional shrubs, most of them requiring constantly moist substrate and very high relative humidity. Many of the typical species of this community are bryophytes and ferns disjunct from tropical regions (Anderson & Zander 1973). There are also many endemic bryophytes. Vascular species include *Huperzia porophila, Asplenium montanum, A. trichomanes, A. rhizophyllum, A. monanthes, Cystopteris protrusa, Polypodium virginianum, Trichomanes boschianum, T. intricatum, Grammitis nimbata, Vittaria appalachiana, Hymenophyllum tayloriae*, *Phegopteris connectilis*, *Adiantum pedatum, Saxifraga careyana, S. caroliniana, Heuchera parviflora, Circaea alpina, Impatiens capensis, Houstonia serpyllifolia, Hydrocotyle americana*, *Thalictrum* spp., *Oxalis montana*, *Carex biltmoreana*, *Galax urceolata*, *Tsuga canadensis, Rhododendron maximum*, and *Kalmia latifolia*. Bryophyte species, many of them nearly or entirely limited to this community, include *Sphagnum quinquefarium, S. girgensohnii, Plagiomnium carolinianum, Mnium affine, M. marginatum, Isopterygium distichaceum, Bryocrumia vivicolor, Flakea papillosa, Hookeria acutifolia, Thamnobryum alleghaniense, Oncophorus raui, Hyophila involuta, Dichodontium pellucidum, Radula* spp., *Plagiochila sharpii, P. caduciloba, P. sullivantii, P. austinii, Fissidens osmundioides, Bazzania denudata, Conocephalum conicum, Pellia epiphylla, P. neesiana*, and *Riccardia multifida*.

3.8.3. *Range*: This type is scattered throughout the mountains, and is rare in the upper Piedmont. Spray Cliffs are most frequent and best-developed in the southern Blue Ridge Escarpment region of Transylvania and Jackson counties, North Carolina and adjacent portions of Oconee and Pickens counties, South Carolina and Rabun County, Georgia.

3.8.4. *Distinguishing Features*: Spray Cliffs are distinguished from other cliff communities by their association with waterfalls and their constant or near-constant wetness. Other cliff communities may have seepage areas, but the cliff as a whole is dry, is not subject to spray, and is frequently exposed to low humidity. Spray Cliffs are distinguished from forest communities by being steep, rocky, or wet enough to lack a closed tree canopy.

3.8.5. *Variation*: Examples of this type vary considerably, depending on amount and dependability of spray, elevation, rock type, orientation of rocks, degree of shading, and past and present climate. Some examples have well developed herb or bryophyte mats, while others are nearly barren. The most diverse Spray Cliffs are found in the Blue Ridge Escarpment gorges of Transylvania, Jackson, and Macon counties.

3.8.6. *Discussion*: This community occurs in unusually stable and equitable environments. The humidity is high and moisture supply is essentially constant. Temperatures are moderated by water, rock, and sheltering from sun and wind, resulting in only rare freezes or high temperatures (Billings & Anderson 1966, Bruce et al. n.d.). Potential disturbances include extreme droughts or freezes that may result in some die-off of sensitive species. Floods or rock falls may damage some parts, but in general Spray Cliffs are well sheltered from physical disturbance. This community type is considered distinct from other cliff communities (even those wetted by seepage), because of the very distinctive flora, featuring many endemic or tropically disjunct pteridophytes and bryophytes. Spray Cliffs differ from cliffs with seepage in having a more constant water supply, higher humidity in the air, and a more strongly moderated climate.

3.8.7. *Examples*: Upper Whitewater Falls, Whitewater River, Jackson and Transylvania counties, North Carolina; Rainbow Falls and Windy Falls, Horsepasture River, Transylvania County, North Carolina; Bearwallow Falls, Toxaway Falls, and Rock Creek Falls (Toxaway River tributaries), Transylvania County, North Carolina; Dry Falls, Crow Creek Falls, and Cullasaja Falls (Cullasaja River and its tributaries), Macon County, North Carolina; Scotsman Creek Falls, and other falls (Chattooga River tributaries), Macon and Jackson counties, North Carolina, Oconee County, South Carolina, Rabun County, Georgia; Schoolhouse Falls, Panthertown Valley, Jackson County, North Carolina; Linville Falls, McDowell County, North Carolina; Rocky Bottom Creek, Gorge of Eastatoe Creek (Eastatoe Creek tributaries), Pickens County, South Carolina.

3.9. UPLAND POOL

3.9.1. *Physical Characteristics*: This community type occurs in small upland depressions where water is ponded by an impermeable substrate, such as shallow bedrock. These areas are too small to be distinguished in standard soil mapping and most occur in areas that have not been mapped. The soils generally have a mucky surface layer and have a shallow clay hardpan or rock layer that prevents drainage. They are seasonally to semipermanently flooded, with rainfall apparently the main source of water, although some have small watersheds.

3.9.2. *Vegetation*: This community type is dominated by various wetland shrubs and herbs. Trees such as *Nyssa sylvatica*, *Quercus phellos*, *Acer rubrum*, and *Liquidambar styraciflua* may be present on the edge or scattered in the center. Shrub species include *Cephalanthus occidentalis*, *Vaccinium* spp., and *Leucothoe racemosa*. Herbs include *Osmunda regalis* var. *spectabilis*, various *Carex* species, *Juncus effusus*, and a variety of *Sphagnum* species, including *S. cuspidatum*, *S. palustre*, and *S. recurvum*.

3.9.3. *Dynamics*: Upland Pools are apparently stable over long periods, but presumably slowly fill with sediment or organic matter. They may tend to succeed to Upland Depression Swamp Forest (Schafale & Weakley 1990) over time. An ephemeral drawdown community may occur when water levels drop. Extended droughts may be necessary for establishment of some species.

3.9.4. *Range*: In the Blue Ridge, this community type is extremely rare, known only from very few scattered sites. This community has hydrologic affinities to depressional wetlands over sandstone on ridges in the Cumberland Plateau of Kentucky, Tennessee, and Alabama. The floristic affinities are unstudied.

3.9.5. *Distinguishing Features*: Upland Pools are easily distinguished from all other wetlands in the southern Blue Ridge. They have standing water for significant parts of the year and are kept wet by poor drainage of rainwater and local runoff rather than by seepage. They usually have a pronounced seasonal fluctuation in water level, filling in the winter and often drying completely in the summer. Although *Sphagnum* may be present, Upland Pools lack the peaty mats and associated bog species found in the bog types.

3.9.6. *Variation*: As presently defined this is a heterogeneous and somewhat discordant category which includes a variety of shrub- and herb-dominated "upland wetlands" with very different substrates. Factors affecting variation include depth of water, clay or rock substrate, and geographic location. Sites may have disjunct Coastal Plain species.

3.9.7. *Discussion*: This community type is bog-like only in the sense of being shrubby or open, non-alluvial wetlands. It does not have well-developed organic mats and lacks most bog species. This is an extremely rare type, with only a few known examples. Upland pools are often important breeding habitats for amphibians.

3.9.8. *Examples*: Linville Mountain Pond, Burke County, North Carolina; Shortoff Mountain Pond, Burke County, North Carolina; North Fork Watershed Pond, Buncombe County, North Carolina.

4. Distribution and Abundance

In North Carolina, non-alluvial mountain wetlands are found in all mountain counties. Their distribution is strongly skewed to particular regions, however, where topographic settings, elevation, and climate are more suitable. The more gentle topography and colder climate of Alleghany and Ashe counties have promoted the formation of bogs there, most of which have now been degraded by ditching and pasturing. Flat second terraces of the French Broad River and its tributaries in Henderson County, southern Buncombe County, and eastern Transylvania County once supported the largest concentration and acreage of non-alluvial wetlands in western North Carolina; flat land is at a premium in mountain counties, and nearly all of these wetlands have been ditched, drained, and converted to truck-farming fields, golf courses, industrial parks, and residential areas.

Secondary concentrations of non-alluvial wetlands are found in Avery and Watauga counties in northwestern North Carolina, and in Macon, Jackson, and Transylvania counties in southwestern North Carolina. Fewer non-alluvial wetlands occur in the Blue Ridge Province in the adjoining states of South Carolina, Georgia, and Tennessee, but the concentration (at least formerly) of bogs in Ashe and Alleghany counties, North Carolina extends northwards into Grayson County, Virginia.

Both the original (pre-settlement) and remaining extent of non-alluvial wetlands are difficult to determine. Because non-alluvial wetlands occur typically as small acreages surrounded by uplands they are often overlooked. Draft National Wetlands Inventory maps (based on interpretation of aerial photographs with limited ground-truthing) show less than 50 % of known sites, though field-oriented inventories such as those conducted in North Carolina have provided information to update and improve the accuracy of the mapping (see Hefner, this volume, for further discussion). Soil Conservation Service soil surveys, especially the older ones, also often fail to map these wetlands, treating them (because of their small acreage) as inclusions in other soil types. Older surveys also grossly generalized the classification of wetland soils in the Blue Ridge, treating all mappable wetlands (no matter how different) in one or two series (such as Toxaway), probably because once a soil was determined to be wet and "undesirable," there was little need to further consider its properties (see Browning, this volume, for further discussion).

Despite the difficulties, we have estimated the original and remaining extent of non-alluvial wetlands in the North Carolina Blue Ridge through use of a combination of soils maps, National Wetlands Inventory maps, information on known sites with relatively intact vegetation, information on drained or otherwise degraded sites, general observations of the landscape, and historical records of the presence of species indicative of a particular type of vegetation. For instance, *Sarracenia jonesii* is endemic to a small area along the North Carolina-South Carolina border. Herbarium records and interviews with botanists active in the 1930's document about twenty-five separate populations for this species in the general vicinity of Hendersonville, North Carolina; *S. jonesii* has been reduced in the last half-century to four populations. The only known habitat for it in the Hendersonville area (and the habitat in which it has always been described as occurring) is the French Broad Valley Bog type (as described below; partly equivalent to the Southern Appalachian Bog, Southern Subtype of Schafale & Weakley 1990). By examination of the mapped occurrences, accounts of earlier botanists, and examination of soils and wetland maps, one can deduce with reasonable accuracy the original extent of this wetland type in Henderson County and vicinity.

Another example is the frequent occurrence in Alleghany and Ashe counties of patches of *Juncus* and other wetland plants in what are now pastures. Such sites have been termed Meadow Bogs by Smith (1993) and Marsh-Bog Complexes by Schafale & Weakley (1985). Such areas almost certainly represent highly degraded remnants of either Southern Appalachian Bogs or Swamp Forest-Bog Complexes (Typic Subtype), and indeed some of them support populations of rare plant or animal species characteristic of one or both of those communities. Despite their open, sunny condition, the only species present at these sites which are characteristic of the more open community type (Southern Appalachian Bog) are those with good dispersal capabilities (such as the wind-dispersed plant *Epilobium leptophyllum* and the surprisingly mobile turtle *Clemmys muhlenbergi*). Based on this fact, the topographic situation and apparent hydrology of the sites, and the apparently greater rarity of Southern Appalachian Bogs in comparison to Swamp Forest-Bog Complexes, we believe the majority of "Meadow Bogs" were originally Swamp Forest-Bog Complexes, some of which have later been colonized by a few "open bog" species. Some "Meadow Bogs," however, were undoubtedly Southern Appalachian Bogs.

In the Blue Ridge of North Carolina, the acreage of non-alluvial wetlands with moderately intact vegetation is estimated to have been reduced from about 2000 ha to a bit more than 300 ha, an approximately six-fold loss (Table 2). Some of the types (described below) have experienced very little loss, either because they are very rare types with only one or a few occurrences which happen not to have been strongly altered (Southern Appalachian Fen, Spruce Subtype of Swamp Forest-Bog Complex, Upland Pool), or because they occur at elevations or in topographic settings that are less likely to have been extensively altered (High Elevation Seep, Spray Cliff). The main bog types (Northern and Southern Subtype of Southern Appalachian Bog, Typic Subtype of Swamp Forest-Bog Complex), however, tend to occur in relatively flat topographic situations, often along the toe of the slope in stream or small river valleys, and often at low to moderate elevations. In the mountains of North Carolina, such sites are among the most altered, by agriculture, pasturage, road construction, urbanization, and tourist development.

The particularly dramatic loss of the French Broad Valley Bog (from ca. 500 to ca. 5 hectares) is a result of the loss of its formerly extensive acreage concentrated along the French Broad River and its tributaries (Mud Creek, King Creek) in the vicinity of Hendersonville, East Flat Rock, Brickton, and Etowah, North Carolina. From the 1930's to the 1960's, this area was ditched and drained by the Soil Conservation Service, including channelization of many of the streams. These areas were then used for crop-farming and pasturage. More recently, additional areas have been lost to urbanization, suburbanization, and golf course development.

5. Factors Determining Variation

In our earlier classification (Schafale & Weakley 1990), we emphasized elevation, location within the state, source of wetland hydrology, and underlying rock type as the primary factors controlling the diversity of non-alluvial communities of the Southern Blue Ridge. Recent analyses (in progress and to be presented in a future paper) validate these factors as the most important determiners of variation. Elevation appears to be the most important factor, location within the state next most important, and underlying rock type third most important. Wiser (1993) found these same factors to be among the most important in explaining variation in high-elevation rock outcrops, another group of relictual Southern Appalachian communities occurring as herb- or shrub-dominated

Table 2. Loss of Natural Vegetation in Non-alluvial Wetlands in the North Carolina Blue Ridge.

NATURAL COMMUNITY TYPE	ESTIMATED ORIGINAL AREA IN NORTH CAROLINA (ha)	ESTIMATED CURRENT AREA IN NORTH CAROLINA (ha)	% OF ORIGINAL REMAINING
Southern Appalachian Fen	1	1	100 %
Southern Appalachian Bog	300	70	23 %
French Broad Valley Bog	450	5	1 %
Low Mountain Seepage Bog	20	2	10 %
Swamp Forest-Bog Complex, Typic Sub-type	1000	100	10 %
Swamp Forest-Bog Complex, Spruce Subtype	50	45	90 %
High Elevation Seep	100	90	90 %
Spray Cliff	5	5	100 %
Upland Pool	5	5	100 %
Total	1931	323	17 %

"islands" in the matrix of a largely forested landscape.

Non-alluvial wetlands occur in the southern Blue Ridge at elevations ranging from roughly 500-2000 m. A few non-alluvial wetlands have been found in the neighboring Piedmont, and these show some relationship to the lowest elevation wetlands of the Blue Ridge. Climate is, of course, strongly correlated with elevation, and some of the variation in non-alluvial wetland communities is closely correlated to elevation. For instance, Coastal Plain species are much more prevalent at lower elevations. While some of this variation is probably related to physiological capabilities of the species, the phytogeographic history of the region may be more important. For instance, *Sarracenia* *purpurea* is a widespread species in bogs in northeastern United States and Canada, north to Labrador and Mackenzie, where it experiences colder conditions than occur even at the highest elevations in the south; its absence from bogs in the northern portion of the Southern Appalachians (north of the Asheville Basin) is more likely related to unknown phytogeographic factors. Geographic location within the southern Blue Ridge, though partially correlated with elevation and rock type, appears also to be an independent factor in determining the vegetation of wetland sites.

Landscape position and hydrology are clearly important factors. Upland Pools have seasonally ponded water on flat ridge tops. Spray Cliffs are steep, vertical, or overhanging, their water source being a constant bathing with a fine aerosol of water droplets from waterfalls, sometimes supplemented by seepage. High Elevation Seeps are always on relatively steep slopes and receive water from strong sources of seepage. Swamp Forest-Bog Complex types are on flat or very slightly sloping sites, usually in the infrequently flooded portions of floodplains of small to large streams or small rivers in mountain valleys. The only example of Southern Appalachian Fen occurs on a slightly sloping shelf on the upper portion of a mountain, fed by multiple seepages. Southern Appalachian Bogs occur in a wide variety of landscape positions, and with various sources of wetland hydrology. This variation (more or less correlated with variation in vegetation structure and composition) may be the basis for the future recognition of additional types or subtypes (see discussion of variation in Southern Appalachian Bogs, above).

Soils and geology are also responsible for variation within non-alluvial wetlands of the southern Blue Ridge, but this source of variation is completely unstudied. Among bog types, a few important factors of soil and geology can be deduced. The difference between bogs developed over mafic and felsic rocks is apparent, with the Southern Appalachian Fen type restricted to mafic rocks (amphibolite in this case), the Long Hope Valley Variant of Southern Appalachian Bog also occurring over amphibolite, and nearly all other bogs developed over felsic rocks. Seepage from mafic rocks is presumably higher in Ph, conductivity, and cations (such as calcium and magnesium) than seepage from felsic rocks, and this has effects on soil chemistry, nutrient availability, and species composition.

Soil depth and origin differ tremendously. Some non-alluvial wetlands have developed on alluvial deposits, but are now removed from the reach of flooding by stream down-cutting or levee deposition. These wetlands often have deep soils. For example, the Pineola Bog (Avery County, North Carolina), which is in the floodplain of the Linville River, may be on an old cutoff oxbow and has peaty soils apparently over two meters in depth. Other wetlands, fed by seepage and especially those occurring on substantial slopes, have very shallow soils with bedrock near the surface. Depth to bedrock in southern Blue Ridge bogs varies from less than 30 cm to well over 200 cm. Bogs with thin soils over bedrock generally lack trees and shrubs, presumably because of freeze-thaw cycles or alternating drought and flooding, and typically show a regular zonation of various herbs outwards from a rivulet to a narrow shrub-dominated zone. Bogs with deeper soils tend to have a complex mosaic of herb-, shrub-, and tree-dominated patches, rather than regular zonation.

6. Biogeographic Affinities

In order to understand non-alluvial wetlands of the Southern Blue Ridge it is prerequisite to consider their history. Present species composition often provides some information about the history and biogeographic affinities of sites. About 600 vascular plant taxa occur in non-alluvial wetlands in the Southern Blue Ridge of North Carolina. Each can be classified by its overall distribution into a number of biogeographically coherent classes. Five broad classes can be defined: northern species, widespread species, Southern-Central Appalachian species, Coastal Plain species, and tropical/extra-continental species. There are, in addition, interesting patterns within several of the classes.

The largest class is the widespread species, consisting of about 36 % of the total. These are primarily species with a wide distribution in eastern North America, occurring in wetlands (and sometimes uplands) in a wide variety of situations, generally not showing strong habitat or regional fidelity. The presence or absence of these species is usually not especially revealing about the history, edaphic features, or character of the wetland in which they occur. Examples are *Acer rubrum* var. *rubrum*, *Eupatorium perfoliatum*, *Rosa palustris*, *Juncus effusus*, *Sambucus canadensis*, and *Alnus serrulata*.

Northern species include about 31 % of the total. These are species distributed primarily in the northeastern United States and adjacent Canada (sometimes also in northern Eurasia). These are species at or near the southern limit of their distribution in their occurrences in wetlands of the Southern Blue Ridge. Some of these species are more or less limited to these wetlands (such as *Campanula aparinoides*, *Filipendula rubra*, *Juncus brevicaudatus*, *Caltha palustris*, *Eriophorum virginicum*, *Vaccinium macrocarpon*), while others are ecologically more widely distributed species which also occur in bogs as rare or typical components (such as *Lycopodium clavatum*, *Maianthemum canadense*, *Tsuga canadensis*, *Picea rubens*, *Viburnum cassinoides*, *Pinus strobus*, *Betula alleghaniensis*). While species in this class form a portion of the flora at all non-alluvial wetlands in the Southern Blue Ridge, they are particularly prevalent (often making up 40-60 % of the flora) in Southern Appalachian Fens and Southern Appalachian Bogs. Most of these species range south through the Appalachians in a more or less continuous distribution, and can thus be considered peripherals near their southern limit. Others, however, are disjunct to their sites in southern bogs (*Arethusa bulbosa*, *Carex oligosperma*, *Utricularia minor*, *Menyanthes trifoliata*). The intervening distributional gap is often on the order of 500 km. These disjunct species emphasize the relictual nature of many of these wetlands.

The third largest class contains the 20 % of the flora with Coastal Plain affinities. These are species which have the bulk of their range in the Coastal Plain, most of them occurring in the mountains only as rare disjuncts in bog habitats, and are often not present (or very rare) in the Piedmont. Examples are *Fuirena squarrosa*, *Rhynchospora rariflora*, *Smilax laurifolia*, *Eleocharis tortilis*, *Woodwardia areolata*. This class is absent or nearly so in most Southern Appalachian Fens and Southern Appalachian Bogs, but forms 25-35 % of the flora in the French Broad Valley Bogs and Low Mountain Seepage Bogs. A very interesting set of species within this group are plants which are disjunct from a more northern Coastal Plain distribution to a montane distribution in the Southern Appalachians: *Thelypteris simulata*, *Triadenum virginicum*, *Gaylussacia dumosa* var. *bigeloviana*, *Helonias bullata*, *Juncus caesariensis*, *Carex collinsii*, *Narthecium americanum*. Two other species (*Myrica gale*, *Chamaedaphne calyculata*) could be classed in either the northern or Coastal Plain group; both are circumboreal bog shrubs, extending furthest south in eastern North America in the Coastal Plain (*M. gale* to Maryland, *C. calyculata* to eastern North Carolina) and disjunct in the southwestern Blue Ridge of North Carolina. All of these species except *Thelypteris simulata* are restricted to French Broad Valley Bogs (with *Juncus caesariensis* also found in Low Mountain Seepage Bogs).

The fourth largest class includes species primarily of the Southern and Central Appalachians, consisting of 13 % of the total. Examples are *Ilex collina*, *Diervilla sessilifolia*, *Rhododendron catawbiense*, *Lilium grayi*, *Houstonia serpyllifolia*, *Isoetes caroliniana*, *Sagittaria fasciculata*, and *Sarracenia jonesii*. Some of these, such as *Sarracenia jonesii* and *Sagittaria fasciculata*, are Southern Appalachian bog endemics, clearly evolutionary derivatives of more widespread, Coastal Plain species, and thus offer a relationship to the third category. Two other species, *Kalmia carolina* and *Chelone cuthbertii* show a similar relationship, as bimodal endemics of the Southern Blue Ridge and the Coastal Plain of the Carolinas and Virginia. Some of these are Southern Appalachian generalists, present in other habitats than non-alluvial wetlands, while others are bog specialists. Most of the endemics are found only in French Broad Valley Bogs (*Sarracenia jonesii*, *Sagittaria fasciculata*), or only in Southern Appalachian Bogs (*Ilex collina*, *Chelone lyonii*, *Lilium grayi*), while some occur in both (*Isoetes caroliniana*, *Houstonia serpyllifolia*, *Carex bromoides* ssp. *montana*).

The fifth category, tropical and extra-continental disjuncts, is a small one (1 %) among vascular plants, but considerably larger among nonvascular plants. These are species dependent on very humid habitats and are either disjunct from the tropics or from eastern Asia. The best examples among vascular plants are all pteridophytes: *Asplenium monanthes*, *Hymenophyllum tunbrigense*, *Hymenophyllum tayloriae*, *Trichomanes intricatum*, and *Grammitis nimbata* (Farrar 1967, Pittillo et al. 1975, Wagner & Sharp 1963). Dozens of bryophytes also fit this pattern (Anderson & Zander 1973). All of these species are limited to the Spray Cliff natural community, and are not found in more "conventional" non-alluvial wetlands. While some species may be recent colonists, most are certainly of ancient occurrence in these areas, emphasizing the strongly relictual nature of these peculiar, vertical wetlands.

At the height of Pleistocene glaciation, periglacial and tundra conditions prevailed at the highest elevations of the Southern Blue Ridge (Delcourt et al. 1993). Colder climates would have resulted in lower evapotranspiration rates than prevail today, and it is likely that non-alluvial wetlands occupied considerably greater areas in the southern mountains than they do today, at low to high elevations. Long Hope Valley, a north-facing, nearly flat-bottomed valley at 1340 m elevation, surrounded by peaks rising to 1700 m, would likely have supported tundra and krummholz vegetation.

7. Dynamics and Natural Disturbances

The factors responsible for creating and maintaining non-alluvial wetland communities of the Southern Blue Ridge are poorly known. Spray Cliffs are apparently very ancient relictual communities, often with dozens of bryophyte and pteridophyte species disjunct from other continents, many of them incapable of sexual reproduction (Anderson & Zander 1973, Billings & Anderson 1966). They are maintained by constant high humidity, steepness, general absence of soil, occasional soil slumping and tree fall, and periodic flood and freezing events which prevent succession to woody communities.

Upland Pools are very rare communities, with only three mountain examples known. The geologic factors which are responsible for their creation are unclear. The few known mountain examples occur in shallow natural depressions on upland ridges, where water is apparently perched over impermeable bedrock. Succession to forest is prevented by seasonal flooding of long duration.

The remainder of the communities, the more bog-like ones, show considerable variation in physiognomy, much of the it difficult to interpret. Anecdotal accounts indicate that most examples are experiencing (or have experienced in recent decades) invasion or increase of shrubs or trees at the expense of herbaceous zones. This vegetative succession threatens to completely close some bogs and eliminate many of the herbaceous species. While bogs may be undergoing primary succession that will eventually lead to a forest community, it seems unlikely that this process is proceeding so rapidly in recent decades after much longer periods of continued existence. This suggests either that the age of bogs is less than thought, or that some subtle change in conditions is promoting vegetative succession to woody species.

At least some bogs are known to be very old. Several bogs have been cored and dated, with dates of peat, sediment, or pollen accumulations at some sites dating to 10,000-12,000 years before present (Shafer 1984, Shafer 1986, M. Kneller, pers. comm.). Additional sites are unquestionably of similar ages, based on floristics, climate, elevation, and geographic position, such as the 23 bogs in Long Hope Valley (Ashe and Watauga counties) and the Bluff Mountain Fen (Ashe County). These sites have likely supported open, graminoid-dominated vegetation for the past 12,000 years (Pittillo, this volume). Many of these sites show little or no tendency towards woody encroachment.

Pineola Bog (Avery County), one of the largest of Southern Appalachian non-alluvial wetlands at 20 ha, is also very old, dating to 10,000 or more years before present, and has some of the deepest peat known in the Southern Appalachians, perhaps as deep as 2 m (M. Kneller, pers. comm.). This site, however, is showing considerable woody succession, and species requiring open, sunny conditions, such as *Vaccinium macrocarpon*, are much less common than in the 1930's and 1940's (L.E. Anderson, pers. comm; A.E. Radford, pers. comm.). Pineola Bog has been grazed fairly extensively in the past, has a U.S. highway bisecting it, has agricultural land nearly surrounding it, and has been encroached into and partially filled by construction activities. Any one of these disturbances (or a combination of them) may be responsible for changes in vegetation structure.

Other bogs may indeed be of recent origin, however. The Panthertown Valley bogs (Jackson County) may have formed as a result of logging and catastrophic fire, followed by beaver activity in the flat valley bottom of Panthertown and Frolictown creeks. The prevalence of widespread wetland species and the near absence of disjunct, relictual species in its flora suggests that it may be of relatively recent origin, its species having been recruited from the surrounding area (see Table 1).

Southern Appalachian bogs in some areas may have been maintained historically by beavers. Mitchell & Niering (1993) studied a wetland complex in Connecticut and concluded that "it is highly possible that prehistoric beaver flooding, as well as periodic droughts, in addition to more recent anthropogenic influences, have modified past vegetation. Disturbances associated with such periodic flooding and beaver activities may have also aided in the perpetuation of the bog flora. Thus, one might conclude that, historically, the system has been in a constant state of flux, including prolonged quiescent periods in which little change occurred, followed by more drastic oscillations... For most peatlands, this view of vegetation change appears to be a much more realistic model than any orderly successional dogma." Bogs of the Central Appalachians of West Virginia also show complex histories of beaver-caused modifications resulting in the maintenance (or expansion) of *Sphagnum*- or graminoid-dominated wetlands (Walbridge, pers. comm.). Although beaver-related successional changes have not been studied in the Southern Appalachians, we believe that conclusions similar to those of Mitchell & Niering (1993) likely apply to valley-bottom bogs of the southern Blue Ridge. The extirpation of beavers in the Southern Appalachians would have created a hiatus in this important wetland creating and altering force.

Along large stream valleys or small river valleys, beavers may have been responsible for a shifting mosaic of boggy habitats. Starting from open water, with *Sphagnum* mats around their margins, abandoned beaver ponds would have succeeded over a course of decades through herb-dominated communities to shrubby bogs, eventually ending in complexes of forested and shrub- or herb-dominated vegetation. This mosaic may have shifted slowly enough to allow rare and relictual species to disperse from successional bogs into newly created ones. Lending credibility to this theory is the recent recolonization by beavers of several areas with bogs, such as Panthertown Valley, Julian Price Park (Watauga County), and the Nantahala River bogs (S. Simon, pers. comm.; B. Teague, pers. comm.). Beaver activity appears to have increased the area of "boggy" habitats at these sites, but the short period of beaver activity (less than ten years) does not allow a confident prediction of the long-term effects.

Grazing has been nearly universal in bogs, and few examples exist in pristine condition (a few of the Long Hope Valley bogs may be the only examples in the Southern Blue Ridge which have never experienced pasturing). Grazing is presumed to have a number of effects on bogs. Browsing by cattle helps control woody species, but trampling and nutrient inputs modify bogs in numerous ways, and tend to destroy herbs and bryophytes, especially *Sphagnum*. *Sphagnum* appears to be the keystone of these systems, and nutrient inputs from cow dung are highly detrimental to *Sphagnum* cover, vigor, and diversity (L.E. Anderson, pers. comm.). Once *Sphagnum* cover is substantially reduced, hydrologic alteration of the bog is highly likely. While potentially reversible, the loss of *Sphagnum* and other bog species may result in a permanently altered successional trajectory. Thus, paradoxically, grazing by cattle may have been responsible for the more open condition described for Southern Appalachian bogs in the 1930's and 1940's, but may have set in motion modifications of hydrology and supply of nutrients promoting rapid succession by woody species.

Aerial deposition (changes in the chemistry of rain) is another potential nutrient input that may be altering woody succession. Additionally, most bogs were formerly surrounded by forested vegetation, but the great majority now have agricultural lands upslope. Many sites are closely surrounded by agricultural fields or pastures. Fertilizers certainly have impacts in some bogs. Alteration of the watershed has other effects. The formerly forested watersheds released water more slowly and constantly to the bog; a largely unforested watershed releases water rapidly, particularly in storm events (frequent in the Southern Appalachians). Flooding events tend to result in more rapid down-cutting of rivulets in the bog and of the characteristic bog-peripheral stream, leading to increased hydrologic head and drying of the bog. If associated with loss of water-retentive *Sphagnum* associated with grazing, down-cutting could have particularly devastating effects on a delicately balanced water budget.

The presence in Southern Appalachian bogs of species commonly associated with fire-maintained ecosystems of the Coastal Plain has suggested that fire may have been a factor in the maintenance of open, graminoid-dominated systems. This suggestion seems somewhat plausible for a few sites, such as the Eller Seepage Bog (Clay County), which has a very large component of "Coastal Plain fire species," but it seems unlikely that most mountain bogs burned with any regularity. Most are in topographic situations among the least likely for fires to reach, often surrounded by mesic (or wetter), forested communities which would burn only under very rare circumstances. Most "Coastal Plain fire species" are not fire-dependent per se. Rather, they are species of open, sunny, moist to wet, acidic, peaty or sandy situations, largely maintained in the Coastal Plain by fire. Non-alluvial wetlands in the Southern Blue Ridge, generally occurring over felsic rocks which yield acidic, nutrient-poor soils, and with hydrology maintaining saturated and often peaty situations, may offer closely analogous habitats, even in the absence of fire. Northern bogs also often have species of Coastal Plain affinities, but are not fire-maintained habitats.

8. Conservation

The Blue Ridge region of western North Carolina, southwestern Virginia, eastern Tennessee, northwestern South Carolina, and northeastern Georgia has a large percentage of land in public ownership (Pisgah, Nantahala, Cherokee, Jefferson, Sumter, and Chattahoochee National Forests, Great Smoky Mountains National Park, various state parks, and other publicly-owned management areas). Non-alluvial wetlands of the southern Blue Ridge, however, are predominantly distributed at low elevations in floodplains of streams and rivers throughout the region, and on slopes in northwestern North Carolina, in areas generally in private ownership. Although the total current area of non-alluvial wetlands in the southern Blue Ridge is estimated to be less than 400 hectares, these communities have a disproportionate importance, by providing habitat for many rare and common species of plants and animals. They provide diversity in an otherwise overwhelmingly upland, terrestrial landscape (Pearson, this volume). Various conservation tools, including inventory, scientific study, education, landowner contact and voluntary conservation, regulation, acquisition, and management, can be applied to the problem of conserving mountain wetlands. A combination of all these tools will probably be needed if a significant portion of even the remnant of wetlands are to be preserved.

Inventory or survey of remaining wetlands is needed. All other conservation tools depend on the basic knowledge of the location and relative importance of remaining wetland sites. The U.S. Fish and Wildlife Service has conducted or is in the process of conducting National Wetlands Inventories throughout the southern Blue Ridge (Hefner, this volume). Unfortunately, the wetland types of the southern Blue Ridge are difficult to interpret from aerial photography. Moreover, many of the wetlands are too small to be recognized or mapped at the scale of 1: 24,000. While the National Wetlands Inventory provides valuable information on the status of wetlands, its utility in the southern Blue Ridge is limited by the nature of the wetlands present.

Inventories conducted by Natural Heritage Programs seek to identify the most ecologically significant sites in a given area. Natural Heritage Programs in all five states of the southern Blue Ridge have sought non-alluvial wetland areas and documented high quality sites. Even well-funded and detailed inventories are limited by the small size and relatively unpredictable distribution of wetlands in this region. Moreover, most bog wetlands in the southern Blue Ridge are surrounded by nearly impassable *Rhododendron maximum* thickets that render field survey time-consuming and difficult. Still, Natural Heritage Program inventories have located over a hundred bog sites in North Carolina alone (Gaddy 1981a, Smith 1993). Natural Heritage Program inventories generally result in basic site information, such as location, dominant plant species, species lists, rare species present, and ownership.

More detailed scientific study of wetlands in the region has been extremely limited. Detailed studies of soils, hydrology, nutrient cycling, dynamics, fauna (with the exception of bog turtles), and flora are almost non-existent. Detailed information of this sort is needed in order to provide better understanding of these systems, not only for pure scientific value but also to apply to their protection and management.

The southern Blue Ridge has historically been a rural region, dependent on subsistence agriculture and logging. While tourism and industry have become important parts of the region's economy, wetlands are still regarded by many landowners as impediments to cultivation and economic return and hence targets of drainage. Education about the significance and values of mountain wetlands is needed to prevent the ongoing destruction and degradation of wetland sites. Following inventory or identification of the location of wetland sites, one form of "targeted education" is landowner contact, which involves providing information to the owners of important natural areas about the resources on their property and options available for protecting them. Those options include voluntary conservation agreements, management agreements, leases, conservation easements, and bargain or market-value sale. Some of these options involve direct or indirect financial returns to the landowner, turning a perceived liability into an asset.

Placement of fill in wetlands is federally regulated under provisions of Section 404 of the Clean Water Act, but until recently, implementation of these regulations in the southern Blue Ridge was poorly enforced. The U.S. Army Corps of Engineers now has an active program regulating wetland fill in the southern Blue Ridge, but once again, the small size and isolated nature of many mountain wetlands make them difficult to effectively protect. In cases where fill is placed in wetlands without a permit, simple removal of the fill may not serve to restore the character and functions of the wetland. The restoration of severely damaged wetland sites, especially those with substantial *Sphagnum*, is difficult, if not impossible. Because of the sensitivity of *Sphagnum* to sediment and additional nutrients, the creation of boggy wetlands is also unlikely to be successful.

Acquisition of significant wetland sites by federal, state, or local conservation agencies or by private conservation organizations (such as The Nature Conservancy) offers the greatest potential for the protection of some sites. However, the resources available are limited, and only the most significant sites are likely to receive protection in this manner. Moreover, while wetland acreage is very limited, the effective and long-term protection and management of wetland sites requires some control over land management of much larger areas. A one-hectare wetland may be affected by pasturing, fertilizing, logging, or ground-disturbing activities anywhere in a watershed of tens or hundreds of hectares.

Nearly all remaining wetlands in the southern Blue Ridge have had some level of alteration in their watersheds. Restoration of the natural hydrologic regime (in terms of the amount, seasonality, and chemistry of water) is critical in maintaining relictual wetland systems. As discussed above, management issues are clouded by our poor understanding of the natural functioning and dynamics of these systems. There is a critical need for additional study to answer questions pertinent to the management and restoration of protected sites. An appreciation of the interest, functions, and values of the unique and endangered wetlands of the southern Blue Ridge has developed in time to allow the conservation of some remnants, but their protection will be achieved only with expense, difficulty, and perseverance.

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