

North Carolina Ecosystem Response to Climate Change: DENR Assessment of Effects and Adaptation Measures

DRAFT

Mountain Bogs and Fens

Ecosystem Group Description:

Montane bogs are among the rarest natural communities in the Southern Appalachians and in North Carolina. Unlike northern bogs of glacial origin, Southern Appalachian bogs form in poorly drained depressions or on gentle slopes, generally in relatively flat valley bottoms which are not subject to flooding. They may vary from being permanently wet to intermittently dry and are generally fed by seepage. They are underlain by wet organic or mucky mineral soils, which are very acidic. The factors responsible for creating and maintaining bog communities are not well known. Grazing has been nearly universal in bogs, and few examples exist in pristine condition. Most are experiencing invasion of shrubs or trees at the expense of the herbaceous zones. This tendency toward rapid succession suggests that some form of periodic or chronic natural disturbance, now disrupted, may have kept the bogs open. Potential past disturbances include flooding by beavers, grazing by herds of large mammals, fire, and clearing by Native Americans.

The Southern Appalachian Bog and Southern Appalachian Fen types have a mosaic or zoned pattern of shrub thickets and herb dominated areas, mostly underlain by sphagnum mats. Trees may be scattered throughout or may dominate on the edges. The shrub and herb layers of the bog, while not highly diverse, are uniquely adapted to the acidic, nutrient-poor environment of the bog and may include numerous rare species. Swamp Forest- Bog Complex types occur along streams and are more dominated by trees, but have boggy herbs and sphagnum in openings.

Ecosystem Level Effects:

Predicted Impacts of Climate Change:

Climate Change Factor: Likelihood: Effect: Magnitude: Comments:

| | | | | |
|--------------|------|-----|------|--|
| Mild Winters | High | | Low | |
| Hot Spells | High | Neg | Low | |
| Flooding | High | Neg | Med | |
| Drought | High | Neg | High | |

We expect the future climate to include warmer temperatures, longer growing seasons, likely more hot spells and drought, and more severe storms. The cncm-cm3 model predicts 4.5 degrees warmer annual average temperature by 2050. The mid value of the 16 models in Climate Wizard is about 4 degrees (Maurer et al., 2007). Average annual rainfall is expected to increase, but only slightly. However, the uncertainty is high. Rainfall predictions among the models range from a loss of 12 inches to an increase of 15 inches. Orographic cloud cover, storms, and fog are less crucial in these communities than in those of

the higher elevations, but are probably still significant. Since the readily available climate models don't account for these effects, the future climate experienced by these communities remains very uncertain.

The effect of an expected increase in both droughts and intense rainfall events may be particularly important for these systems. Many bogs are located in bottomland locations that do not regularly flood but which would flood in extreme events. Besides stream flooding, overland runoff from adjacent uplands during severe storms would be a problem in many bogs. The nutrient input and potential scouring of severe floods would be detrimental to bog communities. While plants in bogs are probably never truly limited by moisture, droughts would have significant effects on competitive relationships among species and on the community as a whole. Droughts in the present climate appear to have exacerbated the ongoing invasion of upland and generalist wetland plants in some bogs.

Predicted Ecosystem Responses:

| Ecosystem Response: | Likelihood: | Effect: | Magnitude: | Comments: |
|-------------------------|-------------|---------|------------|---|
| Acreeage Change | Med | Neg | High | Many bogs may reduce in size if margins dry out due to drought. |
| Exotic species invasion | Med | Neg | Med | Invasive species are already a problem in some areas and may increase with drought and warmer temperatures. |
| Compositional Change | Med | Mix | Med | Drought and warm temperatures may allow generalists and upland species to invade. |

Bogs and fens occur as small, widely separated patches. They will not be able to migrate in response to climate change. They occur in specialized hydrological environments that are not driven primarily by climate. Much of their biota ranges far to the north and little, if at all, to the south. However, it is unclear how much is at its limit of climatic tolerance or is limited by present climate.

The ecology of these communities is among the least well understood of any in North Carolina, and this uncertainty has implications for how they will weather climate change. Some biologists regard them as successional communities following beaver ponds, which would naturally form a shifting pattern. Although they do not currently appear to migrate or to develop from present beaver ponds, this would imply an ability of the biota to migrate and the potential for communities to shift. An alternative view regards them as relictual communities, tied to geologically determined sites. In this case, no migration at all is likely. But it implies that they represent biotas that have survived the drastic climate changes of the Pleistocene and the Hypsithermal, and may be fairly resilient to climate change. An important issue is whether the biota can move in this landscape.

Many of these communities contain pines, hemlocks, or spruces, which are susceptible to insect pests. A warmer climate with more drought may make them more susceptible.

In either case, at least some compositional change is likely. Warmer temperatures may be a threat to some species, while wetland species from the south may find their way into some sites. Many bogs are already subject to invasion by upland and generalist wetland plants, which threaten their more distinctive species. This invasion is likely to become worse during droughts. Some bogs are subject to invasion by exotic plants such as Japanese stiltgrass (*Microstegium vimineum*), multiflora rose (*Rosa multiflora*), and Asian dayflower (*Murdannia keisak*). These invasions are likely to increase, and a warmer climate with more variable rainfall will likely make them worse.

Habitat Level Effects:

Natural Communities:

Third Approximation Name:

Comments:

Southern Appalachian Fen

Southern Appalachian Bog (Southern Subtype)

Southern Appalachian Bog (Northern Subtype)

Southern Appalachian Bog

Swamp Forest-Bog Complex (Spruce Subtype)

The Spruce Subtype contains *Picea rubens* occurring below its normal elevational range. While this demonstrates that this species can tolerate warmer conditions than is generally assumed, this species may be at its limit of tolerance in these communities, where it could disappear with warmer weather. This subtype may lose its distinctive character and blend with the Typic Subtype if this happens.

Swamp Forest-Bog Complex (Typic Subtype)

Swamp Forest-Bog Complex

Because the wet openings in these communities are small, drought may allow shrubs and trees to spread into them. However, extreme wet periods may reverse this trend. Because they have a substantial canopy, an increase in severe wind storms will affect these communities by creating more canopy gaps, which may favor the light-loving wetland plants of the openings.

LHI Guilds:

Guilds with Significant Concentration in Ecosystem Group: Comments:

Montane Open Mires

The Montane Open Mires guild includes both mountain bogs and wet pastures as primary habitats. Too few faunal surveys have yet been conducted in these habitats to determine if finer guilds can be distinguished.

Species Level Effects:

Plants

| Species: | Element Rank: | Endemic | Major Disjunct | Extinction/Extirpation Prone | Status: US/NC | Comments: |
|-----------------------------|---------------|---------|----------------|------------------------------|---------------|---|
| <i>Cladonia psoromica</i> | G1/S1 | Yes | | Yes | FSC/SR-L | Intrinsically vulnerable; known only from one site globally. |
| <i>Gaylussacia orocola</i> | G1/S1 | Yes | | Yes | /SR-L | Intrinsically vulnerable; known only from a few sites in NC. |
| <i>Carex</i> sp. 2 | G1/S1 | | | | FSC/SR-T | |
| <i>Sarracenia oreophila</i> | G2/S1 | | | Yes | E/E-SC | NC is at the northern limit of this species' range, but it is unlikely to move north with warmer temperatures associated with climate change (due to patchy, fragmented habitat). |

| | | | | | |
|---|-----------|-----|-----|----------|---|
| <i>Juncus caesariensis</i> | G2/S1 | Yes | | FSC/E | NC is at the southern limit of this species, and it could be extirpated here due to changing climate. |
| <i>Sagittaria fasciculata</i> | G2/S2 | Yes | Yes | E/E | All remaining sites are disturbed and highly vulnerable to changes in hydrology. |
| <i>Marshallia grandiflora</i> | G2/SH | | | FSC/SR-T | This species historically reached its southern range limit in NC, but has already been extirpated by human-mediated and unknown causes. |
| <i>Packera crawfordii</i> | G2G3/S1 | | | /SR-T | |
| <i>Platanthera integrilabia</i> | G2G3/SH | | | C/E | |
| <i>Sarracenia jonesii</i> | G2Q/S1 | | | E/E-SC | |
| <i>Ilex collina</i> | G3/S1 | | | /T | |
| <i>Helonias bullata</i> | G3/S2 | | | T/T-SC | |
| <i>Parnassia grandifolia</i> | G3/S2 | | | FSC/T | |
| <i>Chelone cuthbertii</i> | G3/S3? | | | FSC/SR-L | |
| <i>Lilium grayi</i> | G3/S3 | | | FSC/T-SC | |
| <i>Parnassia grandifolia</i> | G3/S2 | | | FSC/T | |
| <i>Poa paludigena</i> | G3/S1 | | | FSC/E | |
| <i>Thalictrum macrostylum</i> | G3G4/S2 | | | FSC/SR-L | |
| <i>Danthonia epilis</i> | G3G4/S3 | | | FSC/SR-T | |
| <i>Stenanthium gramineum</i> var. <i>robustum</i> | G3G5Q/S1 | | | /SR-P | |
| <i>Carex trichocarpa</i> | G4/S1 | | | /SR-P | |
| <i>Helenium brevifolium</i> | G4/S2 | | | /E | |
| <i>Vaccinium macrocarpon</i> | G4/S2 | | | /SR-P | |
| <i>Arethusa bulbosa</i> | G4/S1 | | | /E | |
| <i>Chelone obliqua</i> | G4/S2 | | | /SR-T | |
| <i>Carex baileyi</i> | G4/S2 | | | /SR-P | |
| <i>Splachnum pennsylvanicum</i> | G4?/SH | | | /SR-O | |
| <i>Carex tetanica</i> | G4G5/S1 | | | /SR-P | |
| <i>Filipendula rubra</i> | G4G5/S1 | | | /E | |
| <i>Solidago uliginosa</i> | G4G5/S1S2 | | | /SR-P | |
| <i>Iris prismatica</i> | G4G5/S1S2 | | | /SR-T | |
| <i>Thelypteris simulata</i> | G4G5/S1 | | | /T | |
| <i>Triantha glutinosa</i> | G4G5/S1 | | | /SR-P | |
| <i>Sceptridium oneidense</i> | G4Q/S2 | | | /SR-P | |
| <i>Platanthera flava</i> var. <i>herbiola</i> | G4T4Q/S1? | | | /SR-P | |
| <i>Carex projecta</i> | G5/S1 | | | /SR-P | |
| <i>Sphagnum fuscum</i> | G5/S1 | | | /E | |
| <i>Sphagnum russowii</i> | G5/S1 | | | /SR-D | |
| <i>Cephaloziella hampeana</i> | G5/S1 | | | /SR-D | |
| <i>Carex vesicaria</i> | G5/S1 | | | /SR-P | |
| <i>Taxus canadensis</i> | G5/S1 | | | /SR-P | |

| | | |
|---------------------------------|---------|-------|
| <i>Carex trisperma</i> | G5/S1 | /SR-P |
| <i>Utricularia cornuta</i> | G5/S1S2 | /SR-P |
| <i>Sphagnum warnstorffii</i> | G5/S1 | /SR-D |
| <i>Stachys eplingii</i> | G5/SH | /SR-T |
| <i>Carex cristatella</i> | G5/SH | /SR-P |
| <i>Utricularia minor</i> | G5/SH | /SR-D |
| <i>Veronica americana</i> | G5/S2 | /SR-P |
| <i>Carex conoidea</i> | G5/S1 | /T |
| <i>Carex buxbaumii</i> | G5/S2 | /SR-P |
| <i>Epilobium ciliatum</i> | G5/S2 | /SR-P |
| <i>Caltha palustris</i> | G5/S1 | /SR-P |
| <i>Campanula aparinoides</i> | G5/S2 | /SR-P |
| <i>Campylium stellatum</i> | G5/S1 | /SR-D |
| <i>Sphagnum subsecundum</i> | G5/S1 | /SR-P |
| <i>Sphagnum capillifolium</i> | G5/S1 | /SR-P |
| <i>Phegopteris connectilis</i> | G5/S2 | /SR-P |
| <i>Platanthera peramoena</i> | G5/S2 | /SR-P |
| <i>Oenothera perennis</i> | G5/S2 | /SR-P |
| <i>Pycnanthemum virginianum</i> | G5/S1? | /SR-P |
| <i>Myrica gale</i> | G5/S1 | /E |
| <i>Muhlenbergia glomerata</i> | G5/S1 | /SR-P |
| <i>Micranthes pennsylvanica</i> | G5/S1 | /SR-P |
| <i>Menyanthes trifoliata</i> | G5/S1 | /T |
| <i>Lycopodiella inundata</i> | G5/S1 | /SR-P |
| <i>Dichanthelium spretum</i> | G5/S1S2 | /SR-D |
| <i>Rhynchospora alba</i> | G5/S2 | /SR-P |
| <i>Cladium mariscoides</i> | G5/S3 | /SR-O |
| <i>Liparis loeselii</i> | G5/S1 | /SR-P |
| <i>Platanthera grandiflora</i> | G5/S2 | /SR-P |
| <i>Geum aleppicum</i> | G5/S1 | /SR-P |
| <i>Sphagnum fallax</i> | G5/S2 | /SR-P |
| <i>Crocanthemum bicknellii</i> | G5/S1 | /SR-P |
| <i>Dalibarda repens</i> | G5/S2 | /E |
| <i>Taxus canadensis</i> | G5/S1 | /SR-P |
| <i>Dicranum undulatum</i> | G5/S1 | /SR-D |
| <i>Gentianopsis crinita</i> | G5/S1 | /E-SC |
| <i>Sphagnum angustifolium</i> | G5/S1 | /SR-D |
| <i>Sphagnum contortum</i> | G5/S1 | /SR-D |
| <i>Hierochloa odorata</i> | G5/S1 | /E |
| <i>Hypnum pratense</i> | G5/S1? | /SR-P |
| <i>Lonicera canadensis</i> | G5/S2 | /SR-P |

| | | |
|--|-----------|-------|
| <i>Sphagnum flexuosum</i> | G5/S1 | /SR-P |
| <i>Carex oligosperma</i> | G5?/S1 | /E |
| <i>Carex arctata</i> | G5?/S1 | /SR-P |
| <i>Geum laciniatum</i> var. <i>trichocarpum</i> | G5T3T5/S1 | /SR-P |
| <i>Arisaema triphyllum</i> ssp. <i>stewardsonii</i> | G5T4/S2 | /SR-P |
| <i>Lilium canadense</i> ssp. <i>editorum</i> | G5T4/S1 | /SR-P |
| <i>Lilium canadense</i> ssp. <i>canadense</i> | G5T4?/S1 | /SR-P |
| <i>Carex lasiocarpa</i> var. <i>americana</i> | G5T5/S1 | /SR-P |
| <i>Coptis trifolia</i> var. <i>groenlandica</i> | G5T5/S1 | /SR-P |
| <i>Calamagrostis canadensis</i> var. <i>canadensis</i> | G5T5/S1 | /SR-P |
| <i>Packera paupercula</i> var. <i>paupercula</i> | G5TNR/S1? | /SR-P |
| <i>Narthecium montanum</i> | GX/SX | /SR-L |

Mountain Bogs and Fens are home to a huge number of rare plant species in NC, including some that are endemic to southern appalachian bogs, and many that reach their southern range limits in NC. Because the composition and suite of rare species associated with each site varies dramatically, it is important to protect many examples, and to manage appropriately.

Many of the rare species associated with Mountain Bogs and Fens are herbs and are vulnerable to competition from woody species and more aggressive habitat generalists. If changes in hydrology make these sites more dry, this problem is likely to be exacerbated.

Terrestrial Animals

| Species: | Element Rank: | Endemic | Major Disjunct | Extinction/ Extirpation Prone | Status: US/NC/WAP | Comments: |
|---------------------------------|---------------|---------|----------------|-------------------------------|-------------------|-----------|
| <i>Glyptemys muhlenbergii</i> | G3/S2 | | Yes | | LT(S/A)/T/P | |
| <i>Meropleon diversicolor</i> | G4/SU | | | | /W3/ | |
| <i>Macrochilo louisiana</i> | G4/S2S3 | | | | /SR/ | |
| <i>Euphyes bimaculata</i> | G4/S2 | | | | /SR/ | |
| <i>Euphydryas phaeton</i> | G4/S2 | | | | /SR/ | |
| <i>Gabara distema humeralis</i> | G4T4/S3? | | | | /W3/ | |
| <i>Thamnophis sauritus</i> | G5/S4 | | | | //P | |
| <i>Apamea mixta</i> | GU/S1S2 | | | | /SR/ | |

None of the guild members associated with this Ecosystem Group are confined to the mountains or to purely natural seepage communities.

Combined Threats and Synergistic Impacts:

Importance of Climate Change Factors Compared to Other Ecosystem Threats:

| Threat: | Rank Order: | Comments: |
|-----------------------------------|-------------|---|
| Development | 1 | |
| Conversion to agriculture/sylvicu | 1 | |
| Groundwater Depletion | 2 | |
| Flood Regime Alteration | 3 | |
| Impoundments | 4 | |
| Climate Change | 5 | The level of threat posed by climate change is unclear, while the other threats are ongoing and result in more drastic effects. |

Mountain bogs and fens face a number of immediate threats that can cause more drastic destruction than climate change is likely to. Many examples are not protected, and ongoing residential and commercial development and conversion to pasture or agriculture continues to destroy or degrade examples, through direct and indirect effects. While less frequent, some have been destroyed by artificial ponds.

Protected examples are subject to ecological problems such as invasion by woody plants or by exotic species. The cause of these problems is not well known. Some are related to hydrological alteration by drainage ditches, loss of ground water input, or entrenchment/channelization of streams that lowers water tables. Others may be related to nutrient input and to disturbance by past land use. These are severe ongoing problems, but drought is likely to exacerbate them, and warmer temperatures may as well.

Beavers represent an additional unknown factor in mountain bogs and fens. Many sites, including a number of protected sites, have been affected by beaver ponds in recent years. Beaver impoundments may kill bog plants, including rare species. However, some characteristic species, such as bog turtles, may benefitted from them in the long run.

Recommendations for Action:

Interventive Measures:

| Intervention: | Importance: | Feasibility: | Comments: |
|--|-------------|--------------|-----------|
| Reintroduce Species | Mediu | High | |
| Preservation of Riparian Buffers/Floodplains | Mediu | Medium | |
| Control Invasive Species | High | Medium | |
| Protect/Expand Remaining Examples | High | High | |
| Restore/Maintain Hydrology | High | Medium | |

Protecting the remaining unprotected examples and conducting appropriate management in the protected examples are the most important actions for these communities. This includes determining the best vegetation management practices and understanding and correcting artificial alterations to hydrology.

Drainage, water diversion, and ground water depletion make these wetlands more vulnerable to drought and increased temperatures than they would otherwise be.

Because of past alterations, many sites have lost species that once were known in them. Restoring the biota to as full a species complement as possible would likely make these systems more resilient for adapting to a change climate, and would improve the prospects for survival of these species.

Because damaging floods, scouring, and nutrient/sediment input are threats to mountain bogs and fens, steps that reduce their severity will help protect them. Conservation of riparian buffers will benefit these communities as well as the aquatic communities of the streams themselves. Protection of upland buffers around bogs, to reduce the impact of runoff, is also important. It is likely to be more important in a future with more intense rainfall.

Beaver control measures should be considered at sites where potential loss of rare species may occur due to the creation of impoundments or use of certain rare plants as food by the beavers. These measures include use of pond levelers, protective screening of rare plants, or as a last resort, removal of the beavers. Where extirpation of rare species is not expected, however, development of beaver pond complexes should be allowed, particularly where it may lead to restoration of higher water tables or clearings that favor the regeneration of wetland herbs and shrubs.

Ecosystem Group Summary:

Mountain Bogs and Fens are an extremely rare community type in the Southern Appalachians and are home to a very large number of rare plants. Climate change effects such as droughts and severe flooding may be particularly problematic in these communities. Climate change, however, is not likely to be as detrimental compared to impacts caused by development, conversion to agriculture, and other threats related to incompatible land use. Protecting remaining unprotected sites and conducting appropriate management is the most important conservation actions for these community types. Additionally, restoring hydrology and preserving the surrounding riparian buffers will help increase resiliency of Mountain Bogs and Fens when faced with more drought and severe storms and floods.

References:

Maurer, E.P, L.Brekke, T.Pruitt, and P.B. Duffy. 2007. Fine-resolution climate projections enhance regional climate change impact studies. *Eos Trans. AGU*, 88(47), 504.
