

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

DRAFT

## Brownwater Coastal Plain Floodplains

### Ecosystem Group Description:

This Ecosystem Group includes the vegetated communities that occur on the floodplains of brownwater rivers. Brownwater rivers originate in the Piedmont or Mountains and flow into the Coastal Plain. In contrast to blackwater rivers, they carry heavy loads of mineral sediment, particularly clay and silt. The water is generally near neutral in pH and high in nutrients. The deposition of sediment in the floodplain provides a periodic nutrient input that keeps the soils rich. Depositional topographic features such as natural levees, point bars, ridge-and-swale systems, and sloughs are well developed, with their size depending on the size of the river.

Communities that occur in Brownwater Coastal Plain Floodplains include Coastal Plain Levee Forest and Bottomland Hardwoods in the larger floodplains, usually dominated by high-diversity canopies and understory shrubs and vines. Coastal Plain Small Stream Swamps occur in small floodplains and occur only in the upper Coastal Plain and usually extend only a short distance. Cypress-Gum Swamps occur in the wettest forested parts of the floodplain, in sloughs and backswamps. They are dominated by the few tree species able to tolerate such long term flooding. These swamps usually harbor bald cypress, rather than pond cypress typically found in Blackwater river floodplains. Coastal Plain Semipermanent Impoundments are primarily beaver ponds, sediment-blocked tributaries or, occasionally, old millponds. Cypress and gum trees may survive permanent flooding and provide a partial canopy. The wetland edges host a diversity of shrubs and herbs and a diverse community of aquatic plants develops in the water. Oxbow Lakes are generally less diverse and occur along the large rivers in abandoned channel segments that are cut off and blocked so that they retain open water. Sand and Mud Bars occur along the river on deposits that are too young or too frequently disturbed to support forest, but are vegetated by herbs or by alder, willow, river birch, or other early successional woody species.

### Ecosystem Level Effects:

#### Predicted Impacts of Climate Change:

| Climate Change Factor:           | Likelihood: | Effect: | Magnitude: | Comments:   |
|----------------------------------|-------------|---------|------------|---|
| Sea Level Rise -- Inundation     | High        | Neg     | Med        |   |
| Wind Damage                      | Med         | Neg     | Med        | Decreased tree age and increased frequency of canopy gaps.                                      |
| Mild Winters                     | High        | Neg     | High       |   |
| Flooding                         | High        |         | Med        | Possible increased frequency and/or severity. Possible mix of positive and negative influences. |
| Drought                          | High        | Neg     | Low        |   |
| Sea Level Rise -- Salt Intrusion | High        | Neg     | Med        |   |

An average of climate model predictions for the Roanoke River area predicts annual average temperatures to rise 4 degrees by 2050, with a range of 2.4-5.5 degrees (Maurer et al., 2007). At Wilmington, the expected increase in annual average temperature is 3.4 degrees, with a range of 2.4 - 5.2. Rainfall change averages out to very little, but predictions range from a reduction of 15 inches to an increase of 16 inches. Summer rainfall predictions range even more widely, from a reduction of 8.6 inches to an increase of 26.5 inches. More important than average rainfall or temperature will be changes in frequency and magnitude of extreme rainfall events, which will affect flood regimes. This increase is generally expected, but less detailed information on predictions is available. An increase in droughts is also expected.

Changes in flood regimes and rising sea level are the most important climate effects. The effects of rising sea level will be felt only in the lower reaches of the rivers. Large expanses in these areas will shift to tidal swamps. Because there is not substantial potential for coastal plain floodplain systems to expand inland, there will be a net loss in area. However, these systems will remain common.

Increased magnitude of floods could affect higher terraces that now see little flooding. If flood frequency also increases, it might possibly cause the boundaries between Bottomland Hardwoods and Cypress-Gum Swamp to shift, but such changes are likely to be small. On rivers where the natural flood regime is altered by dams, large floods that are now missing may again occur. However, the change rainfall regime may also induce water management that produces more floods of unnatural, destructive long duration.

If floods become more extreme, channels may begin to migrate more. It is unclear how likely or serious it may be. Channel migration is currently slow and significant shifts are rare because vegetated banks stabilize the channels. Even the record floods associated with Hurricane Floyd produced few channel shifts. However, in the Pleistocene, which was cooler but had more extreme floods, the large brownwater and blackwater rivers had braided channels, with much newly deposited bar habitat and with enough bare sand that sand dunes were able to form (e.g. relict sand dunes are visible on the Neuse and Cape Fear, and even more on rivers in South Carolina and Georgia). Leigh (2008) and Leigh et al., (2004) suggest that Coastal Plain rivers may be near that threshold for switching to a braided morphology.

Even without this shift, more large floods might mean increased area but reduced stability of bars. This would come at the expense of forests along the river banks, often the most mature in the floodplains. Increased scouring would increase the sediment load in the river and potentially have severe effects on the aquatic community. The potential for changed bank erosion and channel migration may be highly non-linear and hard to predict. Much erosion happens on high banks when water levels are intermediate, so that the main force of the water is below the roots of bank vegetation. These intermediate levels may become less frequent, so that erosion may not increase.

Given the water availability in floodplains, drought is unlikely to stress floodplain ecosystems. The effect will be mostly in the form of allowing upland species to invade. If flooding still occurs or increases, any invasion of upland species is likely to be short-lived.

**Predicted Ecosystem Responses:**

| Ecosystem Response:     | Likelihood: | Effect: | Magnitude: | Comments:  |
|-------------------------|-------------|---------|------------|--|
| Exotic Species Invasion | High        | Neg     | Med        | Climate change likely will bring additional invasive species |
| Compositional Change    | High        | Mix     | Low        |  |
| Structural Change       | Med         | Neg     | Med        |  |
| Acreege Change          | High        | Neg     | Med        | Mostly caused by rising sea level.                           |

Downstream portions will turn into tidal systems. No significant inland migration is possible, so there will be a net loss of acreage. However, these communities will remain common. Some coastal plain species may be able to expand into the piedmont as the climate warms, but many of the differences between brownwater and piedmont floodplains are the result of geology rather than climate.

Increased wind damage would decrease average canopy age and increase the proportion of gaps. Increased tree growth rates may offset the structural effect to some degree. Increased wind disturbance may cause some shifts in species composition, such as favoring sweetgum and loblolly pine over oaks in bottomland hardwoods. These will be relatively small compared to the past and ongoing similar effects of logging, but will exacerbate them. Increased scouring by more severe floods would create more early successional bar communities at the expense of mature communities on the banks.

Except where wholesale change to tidal systems occurs in the downstream portions, change in native species composition is likely to be relatively minor. Increased temperatures/decreased winter kills may allow southern species to move farther north. However, brownwater floodplains are far apart, are not connected, and few have north-south courses. Species that use blackwater tributaries as well as the brownwater floodplains will be able to migrate northward and will find short distances to jump from one drainage basin to another. But species confined to brownwater floodplains will have difficulty migrating northward.

The arrival of native species characteristic of more southern floodplains, such as *Planera aquatica* or *Nyssa ogeechee* should not be regarded as a concern. However, it also brings increased potential for invasion by exotic species that are already problematic farther south, such as *Triadica sebifera* (Chinese tallow tree). Invasive exotic species already spreading in these systems, such as *Ailanthus altissima* (tree-of-heaven), Asian dayflower (*Murdannia keisak*), and stilt grass (*Microstegium vimeum*) will continue to spread regardless of the climate, but any increased disturbance by flooding or wind storms may accelerate it.

## Habitat Level Effects:

### Natural Communities:

| Third Approximation Name:                               | Comments:   |
|---|---|
| Oxbow Lake  | Increased frequency of major floods may possibly create more new oxbow lakes. However, increased sediment movement may accelerate the natural process of their filling in.  |
| Coastal Plain Semipermanent Impoundment                 | Beaver populations are increasing and spreading, and are likely to continue to regardless of future climate. These communities are likely to increase in abundance and extent.  |
| Sand and Mud Bar  | Abundance of bars is likely to increase if flooding frequency or intensity increase. Bars will probably be less stable than at present. Given how unstable they are at present, this is unlikely to produce much change.              |
| Coastal Plain Small Stream Swamp (Brownwater Subtype)   |   |
| Coastal Plain Bottomland Hardwoods (Brownwater Subtype) | Bottomland Hardwoods likely will be most affected by structural and compositional changes from increased wind storms.   |
| Cypress--Gum Swamp (Brownwater Subtype)                 | These communities tolerate a wide range of flooding and are unlikely to be significantly damaged by increased flooding.   |
| Coastal Plain Levee Forest (Brownwater Subtype)         | Levee forests will be the most affected by any increase in flood scour. However, unless there is a drastic change, such as a shift to braided channels, the loss of area is unlikely to represent a large loss for these communities. |

**LHI Guilds:**

Guilds with Significant Concentration in Ecosystem Group:    Comments:

Wet-Mesic Hardwood Forests

Wet Hardwood Forests

Forested Floodplains

Forest Canebrakes

Cypress-Gum Swamp Forests

Brownwater Levee Hardwood Forests

Guild is entirely contained within this habitat type. Most of the species in this guild, however, also occur in similar habitats in the Piedmont.

**Species Level Effects:**

**Plants**

| Species:                | Element Rank: | Endemic | Major Disjunct | Extinction/Extirpation Prone | Status: US/NC | Comments:  |
|-------------------------|---------------|---------|----------------|------------------------------|---------------|--|
| Heteranthera multiflora | G4/S1         |         |                |                              | /SR-P         |  |
| Urtica chamaedryoides   | G4G5/S1       |         | Yes            |                              | /SR-P         | Disjunct to Roanoke R., but a southern species   |
| Trillium sessile        | G4G5/S1       |         |                |                              | /SR-P         |  |
| Camassia scilloides     | G4G5/S1       |         |                |                              | /T            |  |
| Paspalum fluitans       | G5/S1         |         |                | Yes                          | /SR-D         | Widespread in southeastern US, but in NC this species is known from a few historical locations and only one extant site.                             |
| Enemion biternatum      | G5/S2         |         |                |                              | /SR-P         |  |
| Carya laciniosa         | G5/S1         |         | Yes            |                              | /SR-P         | This species occurs in NC only small, isolated populations. While it ranges farther south in the Midwest, it is vulnerable if disturbances increase. |
| Carex projecta          | G5/S1         |         |                |                              | /SR-P         |  |

Species that occur in small, isolated populations, such as *Carya laciniosa*, *Camassia scilloides*, and *Paspalum fluitans* may be particularly vulnerable to an increase in disturbance. *Paspalum fluitans* is known to be extant in NC in only one site, the upstream end of a small island in a brownwater river; changes in hydrology of this site could be devastating for the species within NC.

A number of rare plants of this Ecosystem Group are restricted in NC to the Roanoke River floodplain. For those that are at the southern/southeastern edge of their range, a northward shift in range could eliminate them from the state. However, the large size and rich soils of the Roanoke River floodplain may be more important than temperature for their occurrence there, making them less likely to move. Northward movement of plants and animals confined to brownwater floodplains may be difficult because these rivers are far apart and their tributaries are blackwater or Piedmont floodplains that may be unsuitable to these species. Movement of plants will be more difficult and less likely than on blackwater floodplains.

## Terrestrial Animals

| Species:                             | Element Rank: | Endemic | Major Disjunct | Extinction/ Extirpation Prone | Status: US/NC/ WAP | Comments:  |
|--------------------------------------|---------------|---------|----------------|-------------------------------|--------------------|--|
| Anacamptodes cypressaria             | G2G4/SU       |         |                |                               | /SR/               |  |
| Hypomecis longipectinaria            | G2G4/S3S4     |         |                |                               | /W3/               |  |
| Catocala lincolnana                  | G3/S2S3       |         |                |                               | /SR/               | North Carolina specimens all from brownwater floodplains and Rocky Point Marl Forest   |
| Cerma cora                           | G3G4/S2S3     |         |                |                               | /SR/               |  |
| Acronicta perblanda                  | G3G4/S1S2     |         |                |                               | /SR/               |  |
| Argillophora furcilla                | G3G4/S2S3     |         |                |                               | /W3/               |  |
| Catocala marmorata                   | G3G4/S1S3     |         |                |                               | /SR/               | Associated with swamp cottonwood but also occurs, at least as a stray, well outside the Coastal Plain.   |
| Franclemontia interrogans            | G3G4/S3?      |         |                |                               | /SR/               |  |
| Myotis austroriparius                | G3G4/S3       |         |                |                               | FSC/SC/P           |  |
| Corynorhinus rafinesquii macrotis    | G3G4TNR/S3    |         |                |                               | FSC/T/             |  |
| Limnothlypis swainsonii              | G4/S3B        |         |                |                               | /W2,W5/P           |  |
| Dasychira atrivenosa                 | G4/S3?        |         |                |                               | /W3/               |  |
| Cisthene kentuckiensis               | G4/SU         |         |                |                               | /W3/               |  |
| Papaipema sp. 3                      | G4/S3S4       |         |                |                               | /W3/               |  |
| Acrapex relictus                     | G4/S3         |         |                |                               | /W3/               |  |
| Dendroica cerulea                    | G4/S2B        |         | Yes            |                               | FSC/SR/P           | Disjunct population in Lower Roanoke Floodplain  |
| Catocala orba                        | G4/S2S3       |         | Yes            |                               | /SR/               | Only North Carolina s specimen is from Devil's Gut   |
| Oporornis formosus                   | G5/S4B        |         |                |                               | //P                |  |
| Anhinga anhinga                      | G5/S3B        |         |                |                               | /W2/P              |  |
| Hemidactylum scutatatum              | G5/S3         |         |                |                               | /SC/P              |  |
| Catocala blandula, Southeastern form | G5T3/S1S3     |         | Yes            |                               | /W3/               | Known in the Coastal Plain only from Devil's Gut; also in the mountains  |
| Apameine, New Genus 2, Species 1     | GNR/S2S3      |         | Yes            |                               | /W3/               | Single specimen from the Coastal Plain from Greenbank Bluff  |
| Apameine, New Genus 2, Species 3     | GNR/S2S3      | Yes     |                |                               | /SR/               | Only known from the North Carolina Coastal Plain and the Dismal Swamp in Virginia.   |
| Apameine, New Genus 4, Species 1     | GNR/S2S3      | Yes     |                |                               | /SR/               | Recently described as Lascopia roblei. Only known from the North Carolina Coastal Plain and an adjoining area of the Great Dismal Swamp in Virginia. |

Two of the cane-feeding moths are endemic to the region but also occur in Blackwater Floodplains and Non-Riverine Swamp Forests. Another cane-feeding moth appears to be significantly disjunct within the lower Cape Fear floodplain. Two hawthorn-feeding moths also appear to have disjunct populations in the lower Roanoke floodplain, as does the Cerulean warbler. None of these species appear likely to be affected by climate change-related impacts.

## Combined Threats and Synergistic Impacts:

### Importance of Climate Change Factors Compared to Other Ecosystem Threats:

| Threat:                           | Rank Order: | Comments:  |
|-----------------------------------|-------------|--|
| Logging/Exploitation              | 1           | This is the most destructive recent force and may get worse if drought allows more access to wetter areas. |
| Climate Change                    | 2           |  |
| Invasive Species                  | 2           |  |
| Flood Regime Alteration           | 2           | Upstream dams are significant on some rivers but not others  |
| Conversion to agriculture/sylvicu | 3           | Very significant in the past but most feasible conversion is already done.                                 |

Other than rising sea level, the effects of climate change are particularly uncertain in these systems. Increased flood severity and increased drought are generally expected but the readily available output of multiple models, such as those on Climate Wizard, does not include these parameters. We also know little about magnitude or thresholds for significant change given a particular change in these parameters. An extreme response, such as a shift from meandering to braided channels would bring substantial changes. Otherwise, climate change effects upstream of the tidal zone are likely to be limited, and the other threats lists here are likely to be more significant.

Ligustrum, Microstegium, Lonicera japonica, Stellaria media are causing severe damage to Levee Forests already and are increasing. If not controlled, incipient Triadica invasion and ongoing Murdannia invasion will greatly expand the acreage severely affected, regardless of climate.

The significance of flood regime alteration by dams and water control is highly variable. On the Roanoke River, where much land is protected from exploitation and where upstream dams are managed for power generation and flood control, it is the worst threat. It is less severe on the Neuse and Cape Fear, where dams managed for water supply and limited flood control are present. Smaller brownwater rivers are not substantially altered by dams. However, increased drought may lead to demand for more reservoirs upstream and to more water withdrawal and interbasin transfer in all large river systems.

## Recommendations for Action:

### Interventive Measures:

| Intervention:                     | Importance: | Feasibility: | Comments:  |
|-----------------------------------|-------------|--------------|--|
| Restore/Maintain Hydrology        | High        | Medium       | Variable need. Primarily where dams have altered hydrology, such as on the Roanoke. Need to avoid excessive water withdrawal and harmful new reservoirs. Need to get more natural water release regimes from dams. |
| Protect/Expand Remaining Examples | High        | High         |  |
| Control Invasive Species          | High        | Medium       |  |

Protecting more examples from exploitation, controlling invasive species, and restoring altered flood regimes will all increase the resilience to expected climate changes as well as providing ecological benefits under the

current climate. Mature examples in natural condition, with their full complement of native species and free of invasive species, will weather climate change and associated disruptions best. Because some rivers have altered flood regimes that now lack the larger natural floods, the ecosystems have begun to adapt to an environment with less flooding. Early restoration of the larger floods that now are eliminated by existing dams would allow systems to begin readjusting to larger floods in a controlled way, before the uncontrollable floods of the future may arrive.

Logging and climate change can be expected to exacerbate each other's effects on community structure and composition, increasing exotic species invasions, and possibly destabilizing channels. Protecting more area from logging will mitigate these effects by providing more mature forest.

## **Ecosystem Group Summary:**

This ecosystem contains a moderate number of disjuncts and near endemics. While impacts are likely to occur near the mouths of the brownwater rivers, converting tidal swamp forests to marshes, the system as a whole will probably persist, along with the rare species it supports.

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