

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

DRAFT

Peatland Pocosins

Ecosystem Group Description:

Peatlands occur on nearly flat, poorly drained areas of the outer Coastal Plain and in large shallow depressions such as Carolina bays. Peat deposits develop where the soil is saturated for long enough periods that organic matter cannot completely decompose. Once peat has developed, it holds water, raising water levels in the soil and making the site wetter. Without decomposition, plant nutrients are tied up in organic matter and the soil is extremely infertile and acidic. Without the overland flooding of river systems, nutrients can be limited to only the small amount that comes in rain water.

The five natural community types are determined by variation in wetness, depth of peat, and fire dynamics. Low Pocosins occur on the deepest peats, in the interior of large domed peatlands, and in the largest peat-filled Carolina bays. These, the wettest, most nutrient-poor sites, support only low shrubs and scattered stunted pond pine trees. Often beds of pitcher plants and sphagnum moss cover large areas, and bog species such as cranberries occasionally occur. High Pocosins occur in somewhat less deep peats. The shrubs, up to six or eight feet tall and impenetrably dense, are generally laced together with greenbriars and punctuated with sparse stunted pond pines. Pond Pine Woodlands occur on shallow organic deposits on the edge of peatlands and in shallow swales and bays, where tree roots can grow through the thin organic layer to reach mineral soil below. Pond pines are tall and often fairly dense and the shrub layer is tall and usually very thick. In some Pond Pine Woodlands the dense shrub layer is replaced by canebrake.

Peatland Atlantic White Cedar Forests occur in sites similar to Pond Pine Woodland or High Pocosin but are dominated by Atlantic white cedar instead of pond pine. Bay Forests may occur in similar sites, but they are usually more associated with the heads of creeks draining out of the peatlands. They have a canopy dominated by evergreen hardwood trees .

Fire is a major natural force in peatland communities. While they are too wet to burn most of the time, during droughts intense fires can occur. Fires usually burn the dense shrubs to the ground and may burn holes in the peat soil itself. While appearing destructive, such fires act as a renewing force, releasing nutrients that stimulate seed germination and quick regrowth from root sprouts, regenerating plant communities. Pond pines can resprout not only from roots but from charred trunks as well. Atlantic white cedar is killed by fire but is able to reestablish in dense stands from seed accumulated in the peat. Atlantic White Cedar Forests occur only where a fire has occurred under the proper conditions, and once established, can last for a century or more. In Pond Pine Woodlands, fire may have been more frequent and less intense, favoring dominance of cane over broadleaf shrubs.

Ecosystem Level Effects:

Predicted Impacts of Climate Change:

Climate Change Factor:	Likelihood:	Effect:	Magnitude:	Comments:
Wind Damage	High	Neg	Med	Severe threat for Atlantic White Cedar, moderate for Pond Pine Woodland, no threat for other communities.
Sea Level Rise -- Salt Intrusion	High	Neg	Med	Salt intrusion, exacerbated by ditches, will affect a limited fraction, primarily in the Alligator River.
Sea Level Rise -- Inundation	High	Neg	Low	A relatively small fraction of these systems is low enough to be inundated. More may be affected by hydrological shifts without being inundated.
Mild Winters	High	Mix	Low	
Fire	High	Mix	Med	Severe fires are natural, and increased fire may offset the loss of natural fire in recent years. But damaging peat fires may increase.
Drought	High	Neg	Med	Increased drought will lead to increased risk of peat fires, and may also affect nutrient cycling and peat accumulation.

The Climate Wizard median temperature model (Maurer et al., 2007) predicts a rise in average annual temperature in northeastern North Carolina of around 3.5 degrees by 2050. The average annual rainfall model predicts a decrease of only 2 inches. The rainfall values in the different models range from an increase of 16 inches to a decrease of 16 inches. An increase in severe storms and particularly in droughts may be the most important change.

Peatland Pocosins are partially or fully ombrotrophic wetlands, with their hydrology driven by rainfall, sheet flow, and evaporation. The low hydraulic conductivity of the organic soil is an important characteristic. Effects of more severe storms and of droughts may be buffered to some degree by the water holding capacity and slow water movement in unditched peatlands. However, longer drought duration or severity might have important effects on fire or on organic matter decomposition.

While most peatlands are above the elevations that are likely to be inundated by rising sea level, extensive protected examples in Dare, Tyrrell, and Hyde County are low enough to be threatened. Some are already being lost along the edges of estuaries and tidal rivers as sea level rises. The existence of ditches allows estuarine waters and salt to penetrate far inland and increases the extent of such loss. It is possible that more inland examples may be indirectly affected by rising sea level reducing the already-low gradient that drives water flow. This could make the pocosins wetter, possibly shifting communities to wetter, lower pocosin types or possibly increasing peat accumulation.

Intense fire is a natural part of pocosin systems. Fire suppression has reduced fire frequency and altered communities and ecosystem processes. However, fires that occur during drought are sometimes uncontrollable. Some wild fires are beneficial, but extensive peat consumption, especially in ditched peatlands, is a severe disturbance. An increase in drought-driven fires would thus produce ecological benefits in some areas but harm in others. In domed peatlands, the depth of peat accumulation represents an equilibrium driven by an increase in peat burning as the depth increases. It is unclear how this would interact with increased drought and possibly rising water tables.

Predicted Ecosystem Responses:

Ecosystem Response:	Likelihood:	Effect:	Magnitude:	Comments:
Compositional Change	Low	Unce	Unce	Uncertain effects caused by changes in drought, fire, and peat decomposition, more than temperature.
Structural Change	High	Neg	Med	Potentially severe for Atlantic White Cedar, moderate for Pond Pine Woodland, limited for other pocosins.
Acreage Change	High	Neg	Med	Some extensive protected examples will be lost, but the majority of the acreage will not be lost.

Peatlands are hostile environments for species and communities other than those adapted to them. Rising sea level in the lowest elevation examples is the only aspect of climate change that is likely to convert them to other community types or to destroy them. Because some large examples lie at very low elevations, there will be a significant loss of acreage in these areas. Most other examples lie above the elevation that will be affected by rising sea level.

Effects of changes in drought, fire, drainage, and decomposition, may cause shifts in community types or in community dynamics. These processes have already been somewhat disrupted by suppression of fire and by ditching in many examples. It is uncertain what effect a future climate will have on them. An increase in uncontrollable wild fires might be ecologically beneficial to areas that have been deprived of their natural fire regime, while more extensive peat fires may be disruptive. Similarly, an increase in wet years might help reverse some of the loss of smaller, more water-tolerant plants that has accompanied the reduction in fires. There are few more southerly species that are likely to invade these communities. Peatlands are much less common farther south, and many of the component species range well to the south. Some species reach their southern range limit in pocosins, but temperature is unlikely to be the primary determinant of their range limit.

Peatland Atlantic White Cedar Forests may respond differently from other Peatland Pocosin communities. They are particularly susceptible to wind damage in hurricanes. An increase in hurricane or wind storm frequency would be a significant threat to them. Given their susceptibility to wind damage in even mild hurricanes, an increase in hurricane severity may not make as much difference. Atlantic white cedar regenerates in even-aged stands following stand-killing fires. The loss of natural fire is one of the factors believed responsible for the decline in these communities. An increase in uncontrollable wild fires might possibly benefit them, but drought-driven fires that burn deeply into the organic layer are believed detrimental to white cedar regeneration.

Habitat Level Effects:

Natural Communities:

Third Approximation Name:	Comments:
Bay Forest	Bay Forests are believed to develop in sites with limited fire. However, they appear resilient to single severe wild fires. The effect of drought and changes in fire potential on these communities is unknown.
Peatland Atlantic White Cedar Forest	Atlantic white cedar trees are particularly susceptible to wind throw, and an increase in storm frequency could be significant to them. However, given their susceptibility even in less intense hurricanes, an increase in hurricane intensity could make little difference. Atlantic white cedar depends on fire to reproduce naturally, and an increase in wild fires might conceivably reverse some of the effects of fire suppression. However, fire that consumes too much of the organic layer is detrimental to regeneration.

Pond Pine Woodland

Pond Pine Woodlands may be more affected by severe fire than the other pocosin communities. Because they take a longer time to recover from fire than pocosins, more frequent fire might shift the boundary between them and High Pocosin. Pond Pine Woodland will lose the largest acreage to rising sea level, but will remain the most extensive pocosin community type. Increased wind damage to the canopy may affect the canopy structure and age of trees. However, wind is probably a minor factor compared to fire in their canopy dynamics.

High Pocosin

Effects on High Pocosin are similar to the other communities.

Low Pocosin

Low Pocosins are maintained by extreme wetness and deep peat, as well as by fire. Effects of climate change are unclear. Rising water tables and inhibited sheet flow might benefit them, even allowing them to expand. Increased drought and fire might benefit them. If droughts were long, less water-tolerant species might be able to invade. However, it would take persistent drier conditions to promote long-term change. Subsequent wet years would eliminate species that invaded during droughts.

LHI Guilds:

Guilds with Significant Concentration in Ecosystem Group: Comments:

Wet Acidic Shrublands

Forested Floodplains and Non-Riverine Wet Flats

Atlantic White Cedar Forests

The guilds comprised by this theme all include a broader range of habitat types than peatlands per se. The Wet, Acidic Shrublands Guild, which contains many of the species most typical of peatland habitats, also includes some types of riparian and flatwoods habitats, as well as non-riverine wetland communities associated with mineral soils. The same is also true for the Atlantic White Cedar Forests Guild.

Species Level Effects:

Plants

Species:	Element Rank:	Endemic	Major Disjunct	Extinction/Extirpation Prone	Status: US/NC	Comments:
Macbridea caroliniana	G2G3/S2				FSC/T	North Carolina is the northern limit of the range of this southeastern coastal plain endemic plant.
Lindera melissifolia	G2G3/S1				E/E	
Solidago verna	G3/S3				FSC/T	There are fewer than 100 populations globally of this southeastern coastal plain endemic species.
Lysimachia asperulifolia	G3/S3	Yes			E/E	There are fewer than 100 populations globally of this southeastern coastal plain endemic species.
Dionaea muscipula	G3/S3	Yes			FSC/SR-L, SC	This species is limited to a few counties in NC and SC.
Solidago leavenworthii	G3G4/S1				/SR-P	North Carolina is the northern limit of the range of this southeastern coastal plain endemic plant.
Peltandra sagittifolia	G3G4/S2S3				/SR-P	North Carolina is the northern limit of the range of this southeastern coastal plain endemic plant.
Helianthus floridanus	G3G4/S1				/E	North Carolina is the northern limit of the range of this southeastern coastal plain endemic plant.

Carex sp. 4	G3G4/S2	/SR-L
Vaccinium macrocarpon	G4/S2	/SR-P
Drosera filiformis	G4/S2	/SR-P
Hibiscus aculeatus	G4G5/S1	/SR-P
Rhynchospora alba	G5/S2	/SR-P

Peatland pocosins support many rare and common species that are endemic to the southeastern coastal plain. Rare species associated with peatland pocosins are dependent on the combination of wet conditions and frequent fire. Changes in climate that reduce frequency of fire or degree of moisture could cause extinction of the rarest species. The combined effects of drought (resulting from climate change or otherwise) and land management practices that reduce moisture (including ditching/drainage for silviculture and planting Loblolly pines) could make habitat too dry for many rare species that occur in peatland pocosins and/or increase the frequency of fire. Many rare plant species associated with Peatland Pocosins occur along the ecotones. Changes that reduce the size of pocosins could leave species along the edge particularly vulnerable.

Terrestrial Animals

Species:	Element Rank:	Endemic	Major Disjunct	Extinction/Extirpation Prone	Status: US/NC/WAP	Comments:
<i>Orygia detrita</i>	G3G4/S2S3				/SR/	
<i>Myotis austroriparius</i>	G3G4/S3				FSC/SC/P	
<i>Lithophane lemmeri</i>	G3G4/S1S3				/SR/	
<i>Dysgonia similis</i>	G3G4/S2S3				/SR/	
<i>Callophrys hesseli</i>	G3G4/S3		Yes		/SR/	Restricted to stands of white cedar but occurs in both the Outer Coastal Plain and Sandhills.
<i>Corynorhinus rafinesquii macrotis</i>	G3G4TNR/S3				FSC/T/	
<i>Spilosoma dubia</i>	G4/S3S4				/W3/	
<i>Hypagyrtis brendae</i>	G4/S2S3		Yes		/SR/	Restricted to stands of white cedar but occurs in both the Outer Coastal Plain and Sandhills.
<i>Cleora projecta</i>	G4/S3?				/W3/	
<i>Callosamia securifera</i>	G4/S2S3				/SR/	
<i>Xestia youngii</i>	G5/S3S4				/W3/	
<i>Pseudacris brimleyi</i>	G5/S3S4				/W1/P	
<i>Anhinga anhinga</i>	G5/S3B				/W2/P	

None of the members of these guilds are confined to the peatdome pocosins in the Outer Coastal Plain or the Carolina bays in the Inner Coastal Plain, although many of them have their largest known populations in those areas. While the largest expanses of peatlands may be severely affected by sea-level rise, the guilds are likely to survive farther inland, including in the Sandhills, as well as more elevated, though still poorly drained habitats in the Outer Coastal Plain.

Combined Threats and Synergistic Impacts:

Importance of Climate Change Factors Compared to Other Ecosystem Threats:

Threat:	Rank Order:	Comments:
Logging/Exploitation	1	Unprotected white cedar and pond pine stands continue to be logged and often do not regenerate.
Flood Regime Alteration	2	Ditching for drainage and for road construction alters communities, increases wild fire damage, and likely exacerbates effects of droughts.
Fire	3	Loss of natural fire has altered communities and ecosystem processes. Deep peat fires in artificially drained areas cause lasting damage to communities.
Conversion to agriculture/sylvicu	3	While deeper peats resist conversion, pine plantations continue to replace Pond Pine Woodland and Peatland Atlantic White Cedar Forest.
Climate Change	4	Loss of significant, but minority, acreage is a likely threat. Other threats are very uncertain.

Recommendations for Action:

Interventive Measures:

Intervention:	Importance:	Feasibility:	Comments:
Protect/Expand Remaining Examples	Mediu	High	
Conduct Prescribed Burns	High	Medium	
Restore/Maintain Hydrology	High	High	

Restoring hydrology by reversing the effects of artificial drainage is probably the most important action to protect pocosins. In the lowest elevation areas, ditches will bring tidal water into peatlands and will hasten their destruction. Blocking these ditches with tide gates or plugs is one of the most important and feasible actions to benefit these systems. In more inland peatlands, drainage increases the damage caused by wild fires, and is likely to exacerbate the effects of increased drought. Many pocosins which have retained their natural character despite the presence of ditches may be more affected in the future, as droughts become more frequent. Impounding effects of roads also alter hydrology in some peatlands, and may have increasing impact if rainfall events become more extreme.

Prescribed burning is difficult in pocosins, and safe techniques have not been worked out to burn many examples. Conducting prescribed burns in favorable conditions would reduce the risk of uncontrollable wild fires during droughts, with their accompanying peat fires and widespread smoke problems.

Many examples are protected, but some important sites remain in need of protection. Protecting additional inland examples will help mitigate the loss of those that lie near sea level.

Ecosystem Group Summary:

Overall, climate change is not the most significant threat to Peatland Pocosins. Logging, particularly of Atlantic white cedar and pond pine stands, altered flood regime through ditching, fire suppression, and conversion to agriculture or silviculture are more problematic compared to the effects of climate change. Increased wildfire or increased temperature may actually be ecologically beneficial in some areas, but could be detrimental in others that have been ditched and could cause excessive peat consumption. Areas that occur in the lowest elevations may be lost to sea level rise due to saltwater intrusion and inundation. Conducting prescribed burns and restoring and maintaining hydrology are the most important recommendations to adapt to the expected effects of climate change.

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.
