

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

DRAFT

Natural Lake Communities

Ecosystem Group Description:

Natural lakes occur only in the Coastal Plain part of North Carolina. Some lake basins are clearly Carolina bays, while others are depressions in peatlands that may have been created by deep peat burns or some other cause. Most are oval in shape, but a few are elongate and appear to be simply wide places along creeks. This Ecosystem Group also includes the deeper water systems that lack vegetation as well as the vegetated natural shoreline communities.

Most of the lakes in North Carolina are naturally very acidic. Most have tannin-stained water and are fairly low in productivity. Algae, primarily green algae or diatoms, are the primary plants, although a variety of aquatic vascular plants can be present. Fish numbers and diversity are low to very low. A variety of insects and other invertebrate animals spend some or all of their life cycle in the water. The one clearly different lake community is in Lake Waccamaw, where limestone outcrops on the lake shore give the water a neutral pH and a high calcium content. A much higher diversity of animals is present, including many more fish species and a diverse mollusk fauna. Seven species of mussels, snails, and fish are endemic to this one lake, or to the lake and the upper Waccamaw river system.

The Natural Lake Shoreline community type includes areas of emergent aquatic plants along lake margins and in wetland areas affected by lake hydrology. It is a heterogeneous type with much variation. Most shorelines are marshy, dominated by emergent plants such as maidencane. A few examples are well developed swamp forests, dominated by sweetgum, cypress, or a mixture of trees. The forested shorelines of several lakes are important nesting sites for colonial water birds such as herons.

Ecosystem Level Effects:

Predicted Impacts of Climate Change:

Climate Change Factor:	Likelihood:	Effect:	Magnitude:	Comments:
Sea Level Rise -- Salt Intrusion	Med	Neg	Med	
Sea Level Rise -- Inundation	High	Neg	Med	Severe effects to several lakes, with no effect to most. Could be more severe if sea level rise is greater than expected.
Wind Damage	High	Neg	Low	
Increased Temperature	High	Neg	Low	
Flooding	High	Neg	Med	
Drought	High	Neg	Med	

The most important effect of climate change for lakes is likely to be the occurrence of more extreme rainfall events and more frequent droughts. The Climate Wizard mid value rainfall forecast is for a slight decrease in much of the Coastal Plain, but there is substantial variation among the models: anywhere from a decrease of about 21 inches to an increase of 19 inches per year (Maurer et al., 2007). If long term average rainfall does not change, average lake levels will probably remain around the same, though increased evaporation might lower them to some degree. Lakes undergo natural water level fluctuations and are adapted to them, but these fluctuations may increase. Multi-year droughts in the last several decades have produced long periods of low water. Most lakes are large enough that water level fluctuations are expected to affect the shoreline but not have major effects on the majority of the aquatic community. However, because the slope of most lake beds is very shallow, a large band of lake bed can become exposed at low water. Mussels and any other sessile animals near shore may be affected. Also, low water may combine with the effect of warmer water to produce low oxygen levels that will stress the aquatic community.

Most lakes have some kind of outlet, which may limit how high water may come. However, excessive rainfall could flood higher shoreline zones for longer periods than they are adapted to, or could reach beyond them to flood areas not previously subject to flooding. Flooding of seldom-flooded shorelines could bring a large influx of organic matter into the lake, with later effects on oxygen or nutrient levels.

Severe wind storms will increase wave action on the shorelines and possibly increase erosion and disturbance to vegetation.

Extremes of water levels and shoreline erosion on some lakes may induce reactions from property owners or the state that would be further detrimental to the lake communities, including shoreline armoring or water control engineering. Many lakes already have water control structures at their outlets, and have water levels that are partly artificially manipulated.

Most lakes lie well inland and will not be affected by rising sea level. Several lakes, including Milltail Lake, Whipping Creek Lake, Swan Creek Lake, and Hidden Lake, lie near sea level and are connected to the sounds by creeks. These lakes will lose their identity as sea level rise brings tidal waters into them. The large lakes of the Pamlico Peninsula, such as Lake Mattamuskeet and Lake Phelps, lie at the highest elevations in the area, but may be affected if sea level rise is greater than the mid-level scenario used here.

Predicted Ecosystem Responses:

Ecosystem Response:	Likelihood:	Effect:	Magnitude:	Comments:
Exotic species invasion	Med	Neg	High	Phragmites invasion is already a problem and could increase.
Structural Change	Med	Neg	Low	
Compositional Change	Med	Mix	Low	

The effects of water level fluctuations, including exposure or flooding of shorelines, is generally not expected to be extreme, but will be significant. Changes in storm waves may or may not be significant. Both will act as a stress on aquatic and shoreline communities. This may lead to some changes in composition. Abundance of plants in shoreline communities may shift, and new species may possibly move in from nearby wetlands. The structure of shoreline communities may change to some degree, particularly in forested shorelines where increased wind damage to trees may occur. The forested shoreline at Lake Phelps (Pettigrew State Park) had severe disturbance in Hurricane Isabel in 1993.

Exotic plant invasion in the shoreline community is a significant present concern at several lakes. Exotic

common reed (*Phragmites australis*) is present along several lakes, and has done significant damage at Pungo Lake and New Lake. Numerous exotic plants are present in the rich shoreline swamp at Lake Phelps, with Japanese honeysuckle (*Lonicera japonica*) and Japanese stiltgrass (*Microstegium vimineum*) causing substantial damage. Asian dayflower (*Murdannia keisak*) has newly appeared and could also invade significant area. Increased natural disturbance such as wave erosion, wind throw of trees, or extreme water level fluctuation may increase these problems and spread them to other lakes. Warmer winters and higher average temperatures will make it possible for additional invasive species to survive if they are introduced.

Habitat Level Effects:

Natural Communities:

Third Approximation Name:

Comments:

Natural Lake Shoreline

LHI Guilds:

Natural lakes in the North Carolina Coastal Plain occasionally have some freshwater marsh vegetation around their edges, but contain a much smaller proportion of the habitat for the marsh and sedge mire guilds than do tidal freshwater marshes or beaver ponds.

Species Level Effects:

<u>Plants</u>	Element Rank:	Endemic	Major Disjunct	Extinction/Extirpation Prone	Status: US/NC	Comments:
<i>Myriophyllum laxum</i>	G3/S2				FSC/T	Occurs from VA to FL; only 7 sites in NC are extant.
<i>Eriocaulon parkeri</i>	G3/S1			Yes	/SR-T	Hyde County, NC is the southern range limit of this species; only two occurrences are extant in NC.
<i>Utricularia floridana</i>	G3G5/SH			Yes	/SR-T	White Lake, NC was formerly the northern limit of this species' range; has not been seen in recent years within NC.
<i>Utricularia resupinata</i>	G4/S1				/E	Critically imperiled throughout the southern half of its range; only 2 populations in NC are extant.
<i>Juncus militaris</i>	G4/S1		Yes	Yes	/SR-D	Lake Phelps is the only known occurrence in NC; nearest extant population is in Delaware.

Sagittaria isoetiformis	G4?/S2	/SR-P
Eleocharis robbinsii	G4G5/S2	/SR-P
Bacopa caroliniana	G4G5/S1	/SR-P
Luziola fluitans	G4G5/S2	/SR-P
Sagittaria stagnorum	G4G5/SH	/SR-P
Ricciocarpos natans	G5/S1	/W1
Ludwigia sphaerocarpa	G5/S1	/SR-P
Potamogeton illinoensis	G5/S1	/SR-D
Eriocaulon aquaticum	G5/S2	/SR-P
Schoenoplectus acutus	G5/SH	/SR-P
Bacopa rotundifolia	G5/SH	/SR-D
Myriophyllum tenellum	G5/S1	/SR-P

Aquatic Animals

Species:	NHP Rank:	Endemic	Major Disjunct	Extinction/ Extirpation Prone	Status: US/NC/ WAP	Comments:
Cincinnatia sp. 1	G1/S1				/SC/P	
Amnicola sp. 1	G1/S1				/SC/P	
Menidia extensa	G1/S1				T/T/P	
Fundulus waccamensis	G1/S1				FSC/SC/P	
Lampsilis fullerhati	G1Q/S1				FSC/T/P	
Etheostoma perlongum	G1Q/S1				FSC/T/P	
Elliptio waccamawensis	G2G3Q/S1				FSC/E/P	
Progomphus bellei	G3/S1				FSC/SR/	
Fundulus cf. diaphanus	GUQ/S1				FSC/SR/P	

Combined Threats and Synergistic Impacts:

Importance of Climate Change Factors Compared to Other Ecosystem Threats:

Threat:	Rank Order:	Comments:
Pollution	1	
Development	1	
Invasive Species	2	For some lakes, this is the largest threat
Impoundments	3	Artificial control of lake levels by dams, ditches, or water control structures.
Logging/Exploitation	4	
Climate Change	4	

The greatest threats to unprotected natural lake communities is the direct and indirect effect of development on their shorelines. Development destroys or disturbs shoreline vegetation, often extending well into the lake because of docks and boat activity associated with them. Shoreline construction creates impermeable surfaces that alter runoff into the lake, often involves artificial drainage or fill that further alters water flow, and is a source of pollution by nutrients, pathogens, and toxic chemicals. Most of these problems continue after construction, so past development remains an ongoing stress.

Invasive exotic plants continue to expand in the shoreline communities of several lakes, and have already seriously degraded some portions. For Lake Phelps, Pungo Lake, and New Lake, this is clearly the greatest threat. The very acidic peatland lakes may be less susceptible to invasion, but this is far from certain. Lake Waccamaw, which currently does not have a significant invasive plant presence, is extremely vulnerable.

Artificial alteration of water levels, both raising and lowering, has affected several lakes. The nature and significance of the alteration is not generally well known. Lakes that have water control structures continue to support aquatic communities that appear healthy, and it is generally unclear whether changes in shoreline communities are a result of them. Ongoing management of water control structures can be changed, to the benefit or detriment of the natural lake communities.

Climate change represents a variable threat. The small lakes in Dare and Tyrrell County will almost certainly be lost because of rising sea level. If sea level rise is greater, enough to threaten the large and more unique lakes of the central Pamlico Peninsula, the threat would have to be regarded as higher. Several of these lakes are connected to the sounds by canals, increasing the risk of damage to them.

Climate change will also exacerbate several ongoing problems, though some are uncertain. Increased rainfall intensity will make problems of runoff and pollution from developed areas worse. Low water periods may concentrate pollutants in lakes and warmer temperatures will further increase the potential for stress by low oxygen levels. Increased lake level fluctuations may create demand for less benign management of water control structures, though there is also potential for water control to be used to offset the detrimental effects of fluctuations caused by climate change.

Increased disturbance by wind, waves, and water level fluctuations will increase vulnerability to erosion and invasion. The increase in risk is likely to be low, given how high it is already. However, the presence of

invasive plants will also interfere with the ability of these natural communities to adapt to the changing climate.

Recommendations for Action:

Interventive Measures:

Intervention:	Importance:	Feasibility:	Comments:
Species Reintroduction/Augmentation	Low	High	
Restore/Maintain Hydrology	Mediu	High	
Preservation of Riparian Buffers/Floodplains	High	Medium	Protection of the lake shore "riparian" vegetation offers much benefit even in developed areas.
Limit Impervious Surfaces	Mediu	Low	
Protect/Expand Remaining Examples	Mediu	High	Important for several lakes or parts of shorelines, but most lake shores are already either protected or developed.
Eliminate/Prevent Pollution	High	Medium	
Control Invasive Species	High	Medium	

The most important interventions vary among lakes. For protected lakes, invasive species are the greatest threat; control of them where they are present and monitoring for invasion in new areas is the greatest need. Common reed (*Phragmites australis*), in particular, has the potential to degrade shoreline communities in many lakes. There is a great need for precautions to prevent new introductions of plants that may be able to invade in a warmer climate. Species such as hydrilla and water hyacinth may be significant threats in the future.

For the limited number of lakes or portions of lake shore that are not already developed or protected, protection from future development is the most important need. For those that are already developed, there may be opportunities to mitigate the impact on the lake. Reduction of impervious surface is likely to be difficult, but regulations that prevent an increase in impervious surface would help. Control of waste water to prevent nutrient input is important where failing septic tanks or inadequate sewage treatment are a problem. Even in developed areas, protection or restoration of as much of the shoreline "riparian" vegetation as possible would be beneficial. All of these measures would benefit the health of lakes in the short run, and they would help to mitigate the additional effects of climate change.

For lakes with water control structures, management of these structures to provide a close approximation to natural lake hydrology would be beneficial. This may often mean allowing more fluctuation in water levels that currently occurs. There will likely be a need to modify current water control practices because of the effects of climate change. In many cases, there is a need to understand better what the natural fluctuation in lake levels is at present. Research to determine the natural behavior of lakes, through comparison of controlled lakes with uncontrolled, or through modeling of controlled lakes, is needed. This should be done before the climate has changed further. Advance consideration should be given to how to deal with future changes in lake behavior. As an example, there may be a need to retain higher water levels during wet periods, to prevent more extreme low levels during drought.

Ecosystem Group Summary:

Climate Change is one of the lesser threats to Natural Lake Communities. The greatest threats to unprotected natural lake communities come primarily from development along the shorelines and the resulting pollution. Invasive species have already degraded many Natural Lake Communities, but this may be exacerbated with climate change. Other climate change effects such as drought and flooding would likely be detrimental to the shoreline vegetation in these systems. Priority should be placed on protecting the remaining undeveloped, unprotected lakes and controlling invasive species on those that are protected in order to promote resiliency.

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.
