NATURAL LAKE COMMUNITIES

Contents

NATURAL LAKE COMMUNITIES THEME

Concept: Natural Lake Communities are vegetated wetland communities associated with the natural lakes of the Coastal Plain, influenced by their hydrology, and contrasting with the adjacent upland or wetland communities away from the lake. They range from wet forests to emergent and floating-leaf marshes.

Distinguishing Features: Natural Lake Communities are distinguished by occurring adjacent to large natural bodies of inland permanent fresh water. They are distinguished from the permanently flooded Coastal Plain Depression Communities by being much larger, large enough to have significant wave action. The definition of Cowardin et al. (1979) for the boundary between Palustrine and Lacustrine wetlands, 20 acres, is taken as the distinguishing value, but almost no water bodies are near the threshold. The boundary of the communities in this theme with the aquatic communities of the lakes is placed where emergent and floating-leaf rooted vegetation ends in open water. However, the aquatic community may have substantial interaction with the wetter shoreline communities. The boundary with non-Lacustrine communities is a place where the natural vegetation becomes indistinguishable from that of areas distant from the lake. Lake shorelines with scarped edges and higher surfaces may have no Natural Lake Community, while gently sloping shorelines may have two zones of different Natural Lake Communities before grading into other wetland or upland communities.

Within the Natural Lake Communities theme, communities are divided first into swamps, which have a substantial tree canopy, and marshes, which don't. Both are then subdivided by the dominant vegetation. Lake Waccamaw is an environmentally and biogeographically unique lake, which has its own distinct communities differing substantially in flora and vegetation.

Synonyms:

Sites: North Carolina's natural lakes appear to have several origins, based on their settings. A number occur in large peatlands, and a number of others occur in Carolina bays, which are generally also at least partly filled with peat. A few may have formed by blockage of drainages and are elongate, but most are round. The largest lakes are bordered by mineral soil uplands, at least on substantial parts of their shoreline. All of North Carolina's natural lakes are shallow, and usually their beds slope very gradually, allowing development of a broad shoreline vegetation zone. Vegetated shorelines may appear as smooth concentric zones, but eroding shorelines often appear as irregular, often scalloped, edges with peninsulas and islands of remnant vegetation separated by shallow bays that probably are of recent origin.

Soils: Soils are generally not characterized or distinguished and are little studied. The Natural Lake Shoreline Marsh communities may have mucky substrates or may have clean sand where waves carry organic matter away. Natural Lake Shoreline Swamps may have organic, sandy, or loamy soils, which often are not distinguished from those of the adjacent area.

Hydrology: Natural Lake Communities are associated with a permanent water body, but the hydroperiod of the communities varies as lake levels fluctuate. Some marshes are permanently

flooded, some marshes and swamps draw down seasonally or irregularly, and some have high water tables tied to the lake but are only rarely deeply flooded. Several otherwise unaltered large lakes have had their hydrology controlled by the addition of dams or weirs at their outlets, making it difficult to tell what the hydroperiod of the lake was before they were built. These have the effect of stabilizing water level fluctuations and allow for some artificial management of water levels. However, lake levels drop below the structures during droughts, and water generally overflows them during very wet periods, so they may be more effective at reducing minor fluctuations than major ones.

Water in most lakes comes primarily from rainfall. Lake Waccamaw has a substantial tributary stream with a large watershed, but most other lakes have no stream input and have limited local watersheds. However, many lakes have blackwater, with tannins derived from their local watersheds or shoreline vegetation. All lakes probably interact with groundwater, with their levels normally reflecting the water table. Lake Waccamaw has calcareous water, apparently derived from groundwater discharged through limestone, though an eroding limestone cliff on one shore also contributes.

Vegetation: Vegetation within this theme spans a very wide range of structure. The Natural Lake Shoreline Swamps are dense forests or open woodlands. They usually have a single tree species that is strongly dominant: *Liquidambar styraciflua, Taxodium ascendens,* or *Nyssa biflora*, but the Rich Subtype has a diverse forest canopy that consists of eight or more species somewhat resembling a Brownwater Levee Forest. They often have a dense shrub layer and extensive vines, at least on the edge where light is abundant. Herb layers in them may vary from diverse to depauperate, depending on light availability and amount of wave disturbance. In Natural Lake Shoreline Marsh, herbaceous vegetation dominates. Most are dominated by relatively few species, able to withstand wave movement. *Hymenachne (Panicum) hemitoma* often dominates. On a few lakes, the marsh community in the drawdown zone is diverse and contains rare plant species. Lake Waccamaw is unique in contains an extensive shoreline community dominated by floating-leaf aquatic plants: *Nuphar sagittifolia*.

Dynamics: The most important lake dynamics are water level fluctuations. They are driven by rainfall, groundwater input, evaporation, and in a few cases, by artificial control structures that alter natural patterns to an uncertain degree. Because of the size of lakes, only the more persistent variations in weather tend to affect water levels much. However, there may be substantial variation from the normal hydroperiod, in response to weather cycles. Stahle's (1988) dendrochronology work showed periods of persistent drought or high rainfall on a time scale of around 30 years. Periods of prolonged flooding or prolonged drawdown affect the vegetation of Natural Lake Communities substantially, though most such changes are temporary and should be regarded as natural. However, changes in water control structures may lead to permanent changes in hydroperiods. Where such changes happened long ago, the vegetation likely is stabilized in equilibrium with them. Because long term rainfall exceeds evaporation, all lakes have some kind of outflow. Sometimes it is a distinct outflow stream but sometimes it is a broad zone of overflow.

Another important dynamic on lake shores is wave action. Waves are not intense enough to generally produce natural unvegetated beaches, but clean sand substrate, even in peatland lakes, suggests enough action to carry away accumulating organic matter. These sandy shorelines are

probably in equilibrium, but intensified waves during storms must act as a natural disturbance from which the vegetation then needs to recover. Other shorelines appear to be eroding. They have trees standing in the water on small islands or peninsulas, often with remnants of peat substrate held by their roots and supporting clumps of shrubs at their bases. While this pattern suggests active erosion of a formerly continuous peat shoreline, the number of fallen trees and shrubs at any given time is small, suggesting such erosion happened in the past or at least is very slow. This is in contrast to the shores of the sounds, where large numbers of fallen trees, relict stumps, and broad zones of small tree islands attest to rapid recent erosion.

The water in blackwater lakes is acidic and oligotrophic, limiting the productivity of aquatic and rooted vegetation. Lake Waccamaw is an exception, having calcareous water, but likely still with limited input of other nutrients. Where development has occurred on the lake, addition of nutrients can have substantial effects on water quality and lead to algal growth in the lake. It is unclear how much effect this has on the rooted vegetation of the shoreline communities.

The origin of North Carolina's lakes is not entirely clear. Most original forms have probably all been substantially modified by wave action. Only a couple of smaller lakes appear to have originated by blocking of drainages. The largest, such as Lakes Waccamaw, Mattamuskeet, and Phelps, may be results of irregularities in the original deposition of marine sediments. Their occurrence in very flat outer Coastal Plain landscapes may explain why outflow did not cut a stream channel that would drain them.

The peatland lakes are particularly notable. Common in unpublished literature is a belief that they were created by deep peat burns during droughts, presumably in a formerly continuous peatland. If so, it was during a drought much more severe than any that have happened in historic times. Even when uncontrollable wildfires have occurred during drought and caused severe peat burning, results have been vastly short of forming a lake, and the most severe peat burning occurred in areas with artificial drainage. If a substantial enough lake was able to form, wave action would likely stabilize it, preventing it from refilling with peat, and might expand it by eroding the peat around it.

Lakes in Carolina bays likely have a history similar to that of peatland lakes. They do not fill the entire bay, but instead are bordered by peat on at least some sides. It thus appears likely that these bays, like the more numerous bays around them, were filled with peat and that the lakes originated later.

Comments: North Carolina is the only state in the Mid-Atlantic region to have numerous natural lakes. Southward, lakes appear again only in Florida. Two natural lakes occur in Virginia, only one in the Coastal Plain. Northward, it appears no more occur south of the glaciated region.

References:

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Office of Biological Service. FWS/OBS-79-31.

Stahle, D. W., M. K. Cleaveland, and J. G. Hehr. 1988. North Carolina climate changes reconstructed from tree rings: A.D. 372-1985. Science 240:1517-1519.

KEY TO NATURAL LAKE COMMUNITIES

1. Vegetation dominated by trees, a forest or open woodland.
   2. Forest dominated by *Liquidambar styraciflua*.. **Natural Lake Shoreline Swamp (Sweetgum Subtype)**
   2. Forest not dominated by *Liquidambar*.
      3. Forest dominated by *Taxodium* or *Nyssa*, generally *Taxodium ascendens* or *Nyssa biflora*.
         4. Forest on Lake Waccamaw; herb layer containing *Sclerolepis uniflorus, Cladium mariscoides, Boltonia asteroides*, and other species not found on other lakes. .... **Natural Lake Shoreline Swamp (Lake Waccamaw Subtype)**
         4. Forest not on Lake Waccamaw; herb layer not containing the above species; herb layer generally dominated by *Hymenachne hemitomon*, occasionally by *Juncus* or other species. .... **Natural Lake Shoreline Swamp (Cypress Subtype)**
      3. Forest dominated by *Liquidambar styraciflua* or *Liriodendron tulipifera*, with a diverse mix of other species including *Taxodium distichum*, *Ulmus rubra*, *Quercus laurifolia*, *Quercus michauxii, Platanus occidentalis, Carya cordiformis*, and *Celtis laevigata*. .... **Natural Lake Shoreline Swamp (Rich Subtype)**

1. Vegetation not dominated by trees; dominated by emergent or floating-leaf herbaceous plants; trees, if present at all, sparse.
   5. Vegetation dominated by *Nuphar sagittifolia*. .... **Natural Lake Shoreline Marsh (Lake Waccamaw Pond–Lily Subtype)**
   5. Vegetation dominated by emergent herbaceous vegetation, sometimes with sparse trees or shrubs. ..... **Natural Lake Shoreline Marsh (Typic Subtype)**

NATURAL LAKE SHORELINE SWAMP (SWEETGUM SUBTYPE)

Concept: Natural Lake Shoreline Swamps are tree-dominated wetlands influenced by lake hydrology. The Sweetgum Subtype encompasses those dominated by *Liquidambar styraciflua*, with an acidic flora related to peatland communities.

Distinguishing Features: Natural Lake Shoreline Swamps are distinguished from other forested wetlands by occurrence along a large to medium permanent lake, by the influence of lake water levels, and generally, by wave action. They are distinguished from Small Depression Ponds by the size and permanence of the lake and presence of wave action, as well as generally by distinctive vegetation. The size criterion of Cowardin et al. (1979), 8 hectares (20 acres), may be used as a size threshold for recognizing Natural Lake Shoreline communities. Natural Lake Shoreline Swamps do not include upland areas or raised peatland areas that may border lakes but that are not influenced by their water and are indistinguishable from similar communities elsewhere.

The Sweetgum Subtype is distinguished by the dominance or codominance of *Liquidambar styraciflua*, or its predominance over *Taxodium* and *Nyssa*. The abundant *Persea palustris* and other species characteristic of peatlands also distinguishes it from other subtypes. The Sweetgum Subtype of Nonriverine Swamp Forest potentially shares such a general combination of flora but usually has more *Nyssa*, as well as being remote from water bodies and having nonriverine hydrology.

Synonyms: *Liquidambar styraciflua / Persea palustris* Forest (CEGL004481).
Ecological Systems: Southeastern Coastal Plain Natural Lakeshore (CES203.044).

Sites: Natural Lake Shorelines occur in wetland zones along the shores of natural lakes larger than 20 acres, with soils saturated and subject to fluctuations of the water table tied to lake levels. The Sweetgum Subtype appears to be associated with areas where water overflows from the lake, generally on the southern or eastern shore.

Soils: The Sweetgum Subtype occurs on organic soils, generally mapped as Croatan (Terric Haplosaprist), Dare (Typic Haplosaprist), or Dorovan (Typic Haplosaprist). It is possible that the soil is richer in mineral material or in nutrients because of water flow through the area.

Hydrology: The Sweetgum Subtype is permanently saturated and flooded seasonally or intermittently. Water levels may vary over periods of a few years in response to weather cycles but this subtype is generally not under water for extended periods in normal years.

Vegetation: The Sweetgum Subtype has a dense to open canopy dominated by *Liquidambar styraciflua*, often in combination with *Persea palustris, Nyssa biflora, Taxodium distichum, Acer rubrum,* or *Pinus taeda*. There may be a well-developed understory that is dominated by *Persea palustris* and may contain *Ilex opaca*, *Gordonia lasianthus*, *Magnolia virginiana*, or various canopy species. There is often a dense shrub layer of *Cyrilla racemiflora*, *Eubotrys racemosa*, or other species shared with peatlands or open wetlands. These may include *Lyonia lucida*, *Vaccinium formosum*, *Clethra alnifolia, Arundinaria tecta*, *Viburnum nudum*, *Morella caroliniana*, and *Ilex coriacea*. *Smilax laurifolia*, other *Smilax* spp., *Muscadinia rotundifolia*, or other vines are often

present. The herb layer may be sparse to dense but generally consists of only a few species, usually *Anchistea virginica* and *Lorinseria areolata*. In areas with dense canopy and shrub layer, herbs may be virtually absent.

Range and Abundance: Ranked G1. This subtype is endemic to North Carolina. Three or four examples are known.

Associations and Patterns: The Sweetgum Subtype is a large patch community, occupying significant portions of lake shores. It generally grades to Pond Pine Woodland or some other peatland community, but in at least one example it grades to Cypress–Gum Swamp along a swamp fed by lake drainage. Natural Lake Shoreline Marsh is often present on other parts of the shore.

Variation: Each of the handful of examples is somewhat different in composition.

Dynamics: Dynamics of the Sweetgum Subtype are similar to those described for the theme as a whole, including the potential importance of weather cycles. The Sweetgum Subtype tends to occur contiguous to peatland communities and probably is more subject to fire than other subtypes. Part of what probably is this subtype at Catfish Lake was burned intensely in a wildfire in the 1990s and its future composition is not yet clear.

The occurrence of *Liquidambar* in this community is interesting, since the species generally is completely absent in the adjacent peatlands and may be disjunct some miles from the nearest population. In the analogous case of the Sweetgum Subtype of Nonriverine Swamp Forest, the presence of additional mineral material in otherwise organic soils is believed to be important for the occurrence of the species. In the case of Natural Lake Shoreline Swamp, it may depend on the combination of stable organic soils with increased mineral availability due to water flow. The organic soils show evidence of input of new organic matter by water flow, but it is not clear if they are otherwise lake deposits or parts of the surrounding peat deposits that may pre-date the lake.

Comments: There is almost no published material on North Carolina's lake shoreline communities. The one exception is Brown (1911). There are, however, a number of unpublished reports that describe them. There are a few plot samples.

References:

Brown, W. 1911. Plant life of Ellis, Great, Little, and Long Lakes in North Carolina. Contributions to the U.S. National Herbarium 13:323-341.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C.

NATURAL LAKE SHORELINE SWAMP (RICH SUBTYPE)

Concept: Natural Lake Shoreline Swamps are tree-dominated wetlands influenced by lake hydrology. The Rich Subtype covers the very rare examples with a diverse canopy and a flora suggesting rich soils.

Distinguishing Features: Natural Lake Shoreline Swamps are distinguished from other forested wetlands by occurrence along a large to medium permanent lake, by the influence of lake water levels, and generally, by wave action. They are distinguished from Small Depression Ponds by the size and permanence of the lake and presence of wave action, as well as generally by distinctive vegetation. The size criterion of Cowardin (et al. 1979), 8 hectares (20 acres), may be used as a size threshold for recognizing Natural Lake Shoreline communities.

The Rich Subtype is distinguished from other subtypes by a diverse flora suggestive of rich soil conditions. *Liquidambar styraciflua* may be dominant in parts, but it occurs with *Liriodendron tulipifera, Carya cordiformis, Quercus laurifolia, Quercus michauxii, Platanus occidentalis, Celtis laevigata*, and other species. Lower strata also contain species suggestive of rich soils, such as *Asimina triloba*.

Synonyms: *Taxodium distichum - Liquidambar styraciflua - Platanus occidentalis / Asimina triloba* Forest (CEGL004424).
Ecological Systems: Southeastern Coastal Plain Natural Lakeshore (CES203.044).

Sites: Natural Lake Shorelines occur in wetland zones along the shores of natural lakes larger than 20 acres, with soils saturated and subject to fluctuations of water table tied to lake levels. The Rich Subtype is associated with mineral substrates and occurs on the north shores of lakes.

Soils: The Rich Subtype has loamy mineral soils, though they may be organic-rich. The two known examples are mapped as Fortescue (Cumulic Humaquept) and Cape Fear (Typic Umbraquult). The vegetation suggests high base saturation and high fertility.

Hydrology: The River Subtype, where known, appears to have a range of hydroperiod, from permanently saturated and potentially flooded for long periods in lower parts, to probably seasonally saturated in the higher parts. Water levels may vary over periods of a few years in response to weather cycles.

Vegetation: The Rich Subtype has a dense canopy dominated by *Liquidambar styraciflua* or *Liriodendron tulipifera* in higher parts, with *Taxodium distichum* dominant closer to the lake. The two examples are fairly different. In one, a diversity of other hardwoods is present, including *Ulmus rubra*, *Quercus laurifolia*, *Quercus michauxii, Platanus occidentalis, Carya cordiformis*, *Celtis laevigata*, *Acer negundo*, and *Juglans nigra*. In the other, *Liquidambar styraciflua* dominates and *Ulmus americana, Platanus occidentalis, Nyssa biflora*, and *Taxodium distichum* are present. In both, the understory is dominated by *Asimina triloba*. In one, there is also *Carpinus caroliniana, Morus rubra, Prunus serotina, Magnolia virginiana*, and even *Juglans nigra*. Shrubs are sparse except nearer the lake shore, where *Cephalanthus occidentalis, Cornus stricta, Salix caroliniana*, and *Itea virginica* may be present. Vines are abundant, including *Smilax rotundifolia,*

Smilax glauca, Toxicodendron radicans, Muscadinia rotundifolia, Vitis aestivalis, Parthenocissus quinquefolius, Hydrangea (Decumaria) barbara, Campsis radicans, and even more at present, the exotic *Lonicera japonica*. The herb layer is now heavily dominated by the exotic species *Microstegium vimineum* and *Stellaria media*. A diversity of other herbs may be present, including *Arisaema triphyllum, Athyrium asplenioides, Boehmeria cylindrica, Carex* spp*., Commelina virginica, Dichanthelium commutatum, Glyceria septentrionalis, Juncus effusus, Saururus cernuus, Stachys floridana, Sphenopholis obtusata, Parathelypteris noveboracensis,* and *Viola affinis*.

Range and Abundance: Ranked G1. This community is endemic to North Carolina. Only two examples are known.

Associations and Patterns: The Rich Subtype is a large patch community, occupying portions of the lake shore. Natural Lake Shoreline Marsh borders other parts of the lake. No natural vegetation remains bordering the examples on the landward side, but it likely was Nonriverine Wet Hardwood Forest.

Variation: The two known examples appear quite different, though this may be due to the lack (or loss) of the highest zone in the second example. Additionally, the example at Pettigrew State Park has two distinct zones that could be regarded as variants. The lower is dominated by *Taxodium distichum* but has sufficient flora of rich-site species to distinguish it from the typical Cypress–Gum Subtype. The higher zone is dominated by *Liquidambar* and *Liriodendron* and has a more diverse canopy. The Pungo Lake example appears more uniform and seems intermediate between these two, with *Liquidambar* dominant but *Nyssa* and *Taxodium* mixed with it rather than less water-tolerant species.

Dynamics: Natural Dynamics of the Rich Subtype probably fit those described for the theme as a whole, including the potential importance of weather cycles. Both examples are on lakes with artificial water control at the outlet. Additionally, both are bordered by heavily drained agricultural lands. The combination of fertile soils with edge effects from cleared inland areas as well as from the lake has made both examples subject to heavy invasion by exotic plants. Windthrow in recent hurricanes caused further canopy opening, which further exacerbated the invasion. *Lonicera japonica* covers the ground in large portion and drapes the trees. Where there is sufficient open ground, *Microstegium vimineum* and *Stellaria media* dominate the herb layer.

Comments: The Rich Subtype has interesting similarities to a Brownwater Levee Forest community.

References:

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C.

NATURAL LAKE SHORELINE SWAMP (CYPRESS SUBTYPE)

Concept: Natural Lake Shoreline Swamps are tree-dominated wetlands influenced by lake hydrology. The Cypress Subtype covers wetter examples dominated by *Taxodium ascendens,* occasionally *Taxodium distichum* or *Nyssa biflora*, usually with an open or very open canopy.

Distinguishing Features: Natural Lake Shoreline Swamps are distinguished from other forested wetlands by occurrence along a large to medium permanent lake, by the influence of lake water levels, and generally, by wave action. They are distinguished from Small Depression Ponds by the size and permanence of the lake and presence of wave action, as well as generally by distinctive vegetation. The size criterion of Cowardin et al. (1979), 8 hectares (20 acres), may be used as a size threshold for recognizing Natural Lake Shoreline communities. Natural Lake Shoreline Swamps do not include upland areas or raised peatland areas that may border lakes but that are not influenced by their water and are indistinguishable from similar communities elsewhere.

The Cypress Subtype is distinguished from the Lake Waccamaw Subtype and Rich Subtype, which may also contain substantial *Taxodium* or *Nyssa* canopy, by having limited species richness, with few herbs present. It usually occurs in nearly permanent standing water. The Cypress Subtype may grade into Natural Lake Shoreline Marsh or into open water by thinning of the canopy away from the shore.

Synonyms: *Taxodium distichum - Taxodium ascendens / Panicum hemitomon* Woodland (CEGL004466). Ecological Systems: Southeastern Coastal Plain Natural Lakeshore (CES203.044).

Sites: Natural Lake Shorelines occur in wetland zones along the shores of natural lakes larger than 20 acres, with soils saturated and subject to fluctuations of water table tied to lake levels. The Cypress Subtype occurs in deeper water, extending into areas that are permanently flooded. Shorelines may be eroding or accreting. Many lakes are bordered by peatlands, and some shorelines are on organic substrates.

Soils: Soils for the Cypress Subtype are generally not mapped; they are shown as water or as part of the adjacent map unit. Soils may be organic or mineral. Sandy soils on wave-worked deposits are also common, even adjacent to peatlands. Organic soils are often eroded edges of surrounding peat or muck deposits. On eroding shorelines, trees may occur on islands of peat, which are stabilized by their roots but removed by wave erosion around them.

Hydrology: The Cypress Subtype is permanently saturated and often is permanently flooded in at least part of its extent. Water levels may vary over periods of a few years in response to weather cycles.

Vegetation: The Cypress subtype has a dense to open canopy of water-tolerant trees, primarily *Taxodium ascendens*, but occasionally *Nyssa biflora*, *Taxodium distichum, Acer rubrum*, or *Chamaecyparis thyoides*. Shrubs are often present on tree bases, especially *Cyrilla racemiflora*, *Eubotrys racemosus*, *Vaccinium fuscatum*, *Clethra alnifolia*, and *Lyonia lucida*, sometimes with vines such as *Smilax laurifolia*, *Smilax walteri*, or *Muscadinia rotundifolia*. Occasional shorelines

may have other woody species, such as *Zenobia pulverulenta*, *Chamaedaphne calyculata*, or *Decodon verticillatus*. Some emergent herbs may be present in the water between the trees, especially *Hymenachne (Panicum) hemitomon*, *Juncus* spp., or *Xyris smalliana*. Other herbs may be present on the tree bases, cypress knees, or stumps, or in the shallowest water, including *Triadenum walteri*, *Boehmeria cylindrica*, *Rhexia nashii*, and potentially any of the species of the Natural Lake Shoreline Marsh (Typic Subtype). Howell (2015), in a floristic study of lake shores, found only a handful of species with moderate frequency: *Magnolia virginiana, Gordonia lasianthus, Gelsemium sempervirens*, *Smilax laurifolia*, *Anchistea (Woodwardia) virginica*, and *Tillandsia usneoides*.

Range and Abundance: Ranked G3. This may be an overestimate of abundance. The NVC association is attributed only to North Carolina, where only seven intact examples are known. There are 20 natural lakes in North Carolina, one in the Coastal Plain of Virginia, and none in other nearby states. They occur in three clusters: the Bladen Lakes, the peatlands of Croatan National Forest, and the peatlands of the Pamlimarle Peninsula and mainland Dare County.

Associations and Patterns: Natural Lake Shoreline Swamp (Cypress Subtype) may occur in the same lakes as the Sweetgum Subtype and may be associated with Natural Lake Shoreline Marsh (Typic Subtype). The latter may be present as a zone farther out in the water, or may be on a different part of the lake.

Variation: Each lake is slightly different, to varying degrees, but no variants are named.

Dynamics: The Cypress Subtype is wetter than most other subtypes. Since it often contains standing water and is adjacent to the open lake, waves are potentially important. Energy levels of shorelines vary, with some regularly washed by waves, others quiet. Some shorelines are undergoing erosion, causing the lake to expand and leaving a pattern of relict trees in the water, often with a scalloped edge of “headlands” and “bays” behind. In these cases, the trees may be relict, unable to reproduce in the current configuration.

Though not well documented, these communities probably undergo shifts in response to climatic cycles that affect lake levels. Persistent drought can allow a number of more upland species to establish, while high water periods may eliminate them. Even the dominant trees may not be able to reproduce other than in rare periods of low water. Some natural lakes have had their water levels stabilized by dams or weirs at their outlets, and the consequences of this for their shoreline communities are not well known.

Comments:

References:

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C.

Howell, N.D. 2015. Guide to the littoral zone vascular flora of Carolina bay lakes. M.S. Thesis, North Carolina State University.

NATURAL LAKE SHORELINE SWAMP (LAKE WACCAMAW SUBTYPE)

Concept: Natural Lake Shoreline Swamps are tree-dominated wetlands influenced by lake hydrology. The Lake Waccamaw Subtype is analogous to the Cypress Subtype but covers the unique calcareous example at Lake Waccamaw.

Distinguishing Features: Natural Lake Shoreline Swamps are distinguished from other forested wetlands by occurrence along a large to medium permanent lake, by the influence of lake water levels, and generally, by wave action. They do not include upland areas or raised peatland areas that may border lakes but that are not influenced by their water and are indistinguishable from similar communities elsewhere. The Lake Waccamaw Subtype is distinguished by the presence of numerous plant species not found in other subtypes, including *Sclerolepis uniflora*, *Cladium mariscoides*, and *Boltonia asteroides*. The presence of the endemic animals of Lake Waccamaw at seasonal high water levels also makes it distinctive.

Synonyms: *Taxodium distichum - Taxodium ascendens / Panicum hemitomon - Sclerolepis uniflora* Woodland (CEGL004465).
Ecological Systems: Southeastern Coastal Plain Natural Lakeshore (CES203.044).

Sites: The Lake Waccamaw Subtype occurs along the eastern and southern shore of Lake Waccamaw. It is generally flooded much of the time by lake waters but is exposed at low water levels. The lake water is somewhat calcareous.

Soils: Soils are sand, apparently clean, and presumably worked by wave action. The soil is not distinguished in soil mapping.

Hydrology: The Lake Waccamaw Subtype is permanently to seasonally flooded in normal years. Water levels may vary over periods of a few years, in response to weather cycles.

Vegetation: The canopy of the Lake Waccamaw Subtype is an open woodland of *Taxodium ascendens*. In the outer parts, the canopy is sparse and the community overlaps the structure of a Natural Lake Shoreline Marsh. There are a few shrubs, primarily *Alnus serrulata*, *Cephalanthus occidentalis*, *and Cyrilla racemiflora*. The herb layer is patchy, with dense beds of graminoids, areas of sparse emergent or submersed plants, and a number of species that are visible only when water levels are low and the soil is exposed. The denser areas are dominated by *Panicum hemitomon* and *Cladium mariscoides*. Two CVS plots have been sampled in this community, but the most thorough description is a site survey report by Richard LeBlond from 1994, a year with low water. Dominants in smaller patches include *Eleocharis olivacea*, *Sclerolepis uniflora*, and *Centella erecta; Boltonia asteroides* and *Ludwigia sphaerocarpa* are also abundant. A great diversity of other herbaceous species is present, at least at times and at least locally, including *Andropogon tenuispatheus*, *Andropogon virginicus* var. *virginicus*, *Brasenia schreberi*, *Dichanthelium erectifolium*, *Eleocharis microcarpa*, *Erianthus giganteus*, *Erigeron vernus*, *Eupatorium mohrii*, *Eupatorium semiserratum*, *Euthamia tenuifolia*, *Fuirena pumila*, *Hydrocotyle umbellata*, *Juncus abortivus*, *Juncus effusus*, *Lachnanthes caroliniana*, *Ludwigia brevipes*, *Lycopodiella appressa*, *Luziola fluitans*, *Lycopus angustifolius*, *Mitreola petiolata*, *Pluchea rosea*,

Pontederia cordata, *Rhexia cubensis*, *Rhynchospora* spp., *Sacciolepis striata*, *Sagittaria graminea* var. *graminea*, *Sagittaria stagnorum*, *Spiranthes laciniata*, *Utricularia* spp., *Xyris fimbriata*, and *Xyris smalliana*.

Range and Abundance: Ranked G1. This subtype is endemic to a single site, a portion of the shoreline of Lake Waccamaw, the only calcareous lake in this climatic zone.

Associations and Patterns: The Natural Lake Shoreline Swamp occurs along the eastern and southern shores of Lake Waccamaw, with the Natural Lake Shoreline Marsh on the more wave-influenced north shore, but swamp may also have been present on parts of the north shore before development. The adjacent uplands include sandhill and pocosin communities.

Variation: The single known example is somewhat heterogeneous.

Dynamics: The general dynamics of the Lake Waccamaw Subtype probably are similar to the Cypress Subtype but are generally not well known. Lake Waccamaw is similar to other lakes, subject to moderate to severe disturbance by wind, storm waves, and possibly fire, but generally stable. The shoreline where this community occurs appears to be in equilibrium, neither eroding nor accreting at a noticeable pace. Weather cycles or variation may be particularly important. Though Lake Waccamaw is regulated by a dam at its outlet, droughts can cause water levels to become very low, creating a drawdown zone similar to those in Small Depression Drawdown Meadows. A number of the plant species, including some of the rare ones, are shared with smaller depressional wetland communities of sinkholes, especially Small Depression Drawdown Meadow. It is not clear that the waters of Lake Waccamaw draw down more than those of other lakes, but the shallowness and extremely gentle slope of its bed may make for a larger drawdown zone. While the water of those smaller ponds is not believed to be calcareous, it may be less acidic than the peatland-influenced waters of other lakes. The input of ash from fires in the adjacent uplands may also make the mineral soils of the small depression edges more mineral-rich.

Comments: Lake Waccamaw is noted for its unique aquatic fauna, which includes several species endemic to this single lake, and several others nearly endemic (also occurring in the Waccamaw River and Big Creek or shared with Lake Phelps). This may be particularly remarkable if the lake is geologically young. Many, perhaps most, of the endemic animals probably occur in the vegetated shoreline community when the water is high. While no endemic plant species have been found, the distinctive flora of the Lake Waccamaw Subtype, compared to all other natural lakes, is remarkable. Howell (2015), in his floristic study of Carolina bay lakes (swamp and marsh communities together) found over 80 species not found in any other lake. Most other lakes in the study had no species unique to them and contained only a small fraction of the number of species found at Lake Waccamaw.

Lake Waccamaw is unique among North Carolina's lakes in having calcareous waters. Probably no other lake with similar water chemistry occurs north of Florida and south of the glaciated areas of the North. The water pH is 6.78-7.1 (Stager and Calhoun 1987), despite a substantial input of tannic water from a blackwater creek. Given the variability in tannin levels observed in the 2010s, it may be that the pH varies significantly from year to year. A small bluff of limestone is present on the north shore of the lake, but the calcium content of the water is believed to come primarily

from ground water input (Stan Riggs, personal communication). Stager and Cahoon (1987), studying sediment cores, concluded that the lake was younger than most bay lakes, perhaps as young as 15,000 years old and no more than 32,000 years, and had past periods when it was shallower than its current shallow depth. Diatom content indicated that the lake had always been calcareous and incipiently eutrophic.

Though Lake Waccamaw is generally called a Carolina bay, the argument for this is not compelling. Though oriented northwest-southeast, with a sandy rim on the southeast side, the shape and orientation are not quite the same as well-formed bays nearby. Unlike typical Carolina bays, it has a substantial watershed to the north as well as a sizeable outflow, and it has a bluff of marine sediments and limestone along its north shore.

Rare species:

Vascular plants: *Bacopa caroliniana, Boltonia asteroides* var. *glastifolia*, *Cladium mariscoides, Eriocaulon aquaticum*, *Ludwigia brevipes, Ludwigia sphaerocarpa*, *Luziola fluitans, Lycopus angustifolius, Spiranthes laciniata*, *Sagittaria filiformis*, *Sagittaria isoetiformis, Sclerolepis uniflora, Utricularia cornuta,* and *Utricularia resupinata.*

Vertebrate animals: *Etheostoma perlongum, Enneacanthus obesus, Menidia extensa, Fundulus waccamensis,* and *Noturus* sp. 1.

Invertebrate animals: *Amnicola* sp.1, *Cincinnatia* sp. 1, *Catinella waccamawensis*, *Toxolasma pullus*, *Leptodea ochracea*, *Lampsilis splendida, Lampsilis radiata, Lampsilis fullerkati, Lampsilis cariosa, Elliptio waccamensis, Elliptio folliculata, Elliptio fischeriana, Choroterpes basalis,* and *Procambarus braswelli*.

References:

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C.

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NATURAL LAKE SHORELINE MARSH (TYPIC SUBTYPE)

Concept: Natural Lake Shoreline Marshes are herb-dominated wetlands influenced by lake hydrology. The Typic Subtype covers all examples other than the Lake Waccamaw Pond-Lily Subtype, dominated by emergent herbaceous vegetation rather that floating-leaf plants.

Distinguishing Features: Natural Lake Shoreline Marshes are distinguished from other herb-dominated wetlands by occurrence along a large to medium permanent lake, by the influence of lake water levels, and by wave action. They are distinguished from Small Depression Ponds by the size and permanence of the lake and presence of wave action, as well as generally by distinctive vegetation. The size criterion of Cowardin et al. (1979), 8 hectares (20 acres), may be used as a size threshold for recognizing Natural Lake Shoreline communities. Natural Lake Shoreline Marsh is distinguished from Natural Lake Shoreline Swamp by lacking trees or having only sparse trees. However, *Panicum hemitomon* beds and other herbaceous vegetation are often present in openings between the cypress trees in the Cypress Subtype of Natural Lake Shoreline Swamp.

The Typic Subtype is distinguished from the Lake Waccamaw Pond-Lily Subtype by lacking the abundant *Nuphar sagittifolia* found in that subtype.

Synonyms: *Panicum hemitomon* - *Juncus* spp. Coastal Plain Lakeshore Herbaceous Vegetation (CEGL004307). Southeastern Coastal Plain Natural Lakeshore (CES203.044).

Sites: Natural Lake Shoreline Marshes occur in shallow water or drawdown zones on the edges of natural lakes larger than 20 acres.

Soils: Substrates are generally wave-worked sands but may be muck accumulations. This community is generally mapped as water in soil mapping.

Hydrology: Natural Lake Shoreline Marshes are permanently to seasonally flooded by the adjacent lake. They generally are subject to substantial wave action, at least when the water is high.

Vegetation: Natural Lake Shoreline Marshes are dominated by emergent herbs. *Hymenachne (Panicum) hemitoma* often dominates patches. A small set of water-tolerant species may be present, including *Eleocharis baldwinii*, *Eleocharis equisetoides*, *Eleocharis vivipara*, *Juncus pelocarpus*, *Kellochloa (Panicum) verrucosa*, *Rhexia nashii*, *Rhynchospora distans, Erianthus giganteus, Sacciolepis striata*, *Scirpus cyperinus*, and *Xyris smalliana*. A different example, at Lake Phelps, has patches dominated by *Juncus militaris* as well as *Hymenachne*, and a few dominated by *Eupatorium* sp. In addition to many of the species above, other species include *Andropogon cretaceus, Eupatorium perfoliatum, Utricularia subulata, Hydrocotyle umbellata, Eriocaulon aquaticum, Ludwigia alternifolia, Pontederia cordata, Nymphaea odorata, Sagittaria isoetiformis, Eleocharis microcarpa, Eleocharis robbinsii, Osmunda spectabilis, Luziola fluitans, Conium maculatum, Euthamia caroliniana, Triadenum tubulosum, Persicaria arifolia, Persicaria sagittifolia, Ptilimnium capillaceum, Rhexia petiolata, Typha angustifolia, Typha latifolia, Dulichium arundinaceum*, and several other species. Several shrubs are also present in this example, including *Cyrilla racemiflora, Cornus amomum*, and *Clethra alnifolia*. In many examples, sparse trees, primarily *Taxodium ascendens*, are present.

Range and Abundance: Ranked G1, but this may be an underestimate of abundance. There appear to be nine intact examples in North Carolina, making this the most abundant of Natural Lake Communities. The association is considered endemic to North Carolina, though it could possibly occur in Virginia.

Associations and Patterns: The Typic Subtype is a large patch community, occupying significant portions of lake shores. It may be associated with Natural Lake Shoreline Swamp of the Sweetgum, Cypress, or Rich Subtype. Otherwise, it is most often bordered by peatland communities.

Variation: The occurrence at Lake Phelps appears to be very distinctive, perhaps enough to be a distinct subtype. However, further study of Lake Phelps and nearby lakes is needed. For now, it is recognized as a variant.

1. Lake Phelps Variant contains *Juncus militaris* and the other distinctive flora described above. It is unclear if it is endemic to Lake Phelps or may occur at Pungo Lake or New Lake, or have once occurred at Lake Mattamuskeet. It is possible some of its distinctive character comes from artificial change in the lake level. However, the presence of numerous rare species, including at least one disjunct for a considerable distance, suggests a distinct character.

2. Typic Variant covers other examples, generally much less floristically rich, as described above.

Dynamics: Natural dynamics of the Typic Subtype are probably similar to other Natural Lake Communities, as described for the theme. Natural Lake Shoreline Marshes are wetter than Natural Lake Shoreline Swamps and may be exposed only in the later summer or only in dry years. Because they are usually flooded and border the lake, they are subject to substantial wave action. During storms, this may lead to reworking of the substrate and significant natural disturbance. Though all the lakes where it occurs are acidic and oligotrophic, the water movement may provide more nutrients than nearby communities.

Comments:

References:

Brown, W. 1911. Plant life of Ellis, Great, Little, and Long Lakes in North Carolina. Contr. U.S. National Herbarium 13:323-341.

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NATURAL LAKE SHORELINE MARSH (LAKE WACCAMAW POND-LILY SUBTYPE)

Concept: Natural Lake Shoreline Marshes are herb-dominated wetlands influenced by lake hydrology. The Lake Waccamaw Pond-Lily Subtype covers the unique community in Lake Waccamaw, dominated by *Nuphar sagittifolia*.

Distinguishing Features: Natural Lake Shoreline Marshes are distinguished from other herb-dominated wetlands by occurrence along a large to medium permanent lake, by the influence of lake water levels, and by wave action. The Lake Waccamaw Pond-Lily Subtype is distinguished by the dominance of *Nuphar sagittifolia*.

Synonyms: *Nuphar sagittifolia* - *Evriocaulon aquaticum* Lakeshore Herbaceous Vegetation (CEGL004297).
Ecological Systems: Southeastern Coastal Plain Natural Lakeshore (CES203.044).

Sites: The Lake Waccamaw Pond-Lily Subtype occurs only on the northern shore of Lake Waccamaw.

Soils: Substrates are generally wave-worked sands.

Hydrology: Natural Lake Shoreline Marshes are permanently to seasonally flooded by the adjacent lake. They generally are subject to substantial wave action, at least when the water is high. The water in Lake Waccamaw is calcareous.

Vegetation: The vegetation of this community is not well known. The community is generally dominated by a sparse to dense floating cover of *Nuphar sagittifolia*. *Eriocaulon aquaticum* may range from sparse to codominant, and *Sagittaria graminea* is often present. A single CVS plot in this community has no other species in the community other than sparse *Taxodium distichum* and epiphytic *Tillandsia usneoides*, but epiphytic *Epidendrum conopseum* has also been reported. *Colocasia esculenta* has become established in this community and is widespread. Some of the submersed aquatic species of the deeper lake waters, such as *Najas*, also occur.

Range and Abundance: Ranked G1. This subtype is endemic to a single site, a portion of the shoreline of Lake Waccamaw, the only calcareous lake in this climatic zone.

Associations and Patterns: The Lake Waccamaw Pond Lily Subtype is a large patch community, occupying significant portions of lake shores. Its natural associations are not known because its habitat is generally heavily altered by housing development along the lake shore. It may have been bordered by Natural Lake Shoreline Swamp or by Nonriverine Swamp Forest.

Variation: Only a single example is known.

Dynamics: The general dynamics of this community are similar to those of other Natural Lake Communities, but details are not well known. The north shore of Lake Waccamaw, where it occurs,

is subject to vigorous waves driven by sea breeze on most afternoons in the summer. Floating leaves may be better equipped than emergent stems to withstand this regular mechanical stress.

Comments: This community is not well explored. It occurs amid private docks and bordered by houses throughout its entire range. It appears to be genuinely low in species richness, in contrast to the diverse flora of the Lake Waccamaw Subtype of Natural Lake Shoreline Marsh. This may have to do with the deeper water and more intense wave disturbance, but the community may be more diverse than is known.

Even more than in the Natural Lake Shoreline Swamp community of Lake Waccamaw, the unique fauna of Lake Waccamaw likely occurs most of the time in this community. Many, perhaps most, of the endemic animals probably occur in the vegetated shoreline community when the water is high.

Lake Waccamaw is unique among North Carolina's lakes in having calcareous waters. Probably no other lake with similar water chemistry occurs north of Florida and south of the glaciated areas of the North. The water pH is 6.78-7.1 (Stager and Calhoun 1987), despite a substantial input of tannic water from a blackwater creek. Given the variability in tannin levels observed in the 2010s, it may be that the pH varies significantly from year to year. A small bluff of limestone is present on the north shore of the lake, but the calcium content of the water is believed to come primarily from ground water input (Stan Riggs, personal communication).

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