COASTAL PLAIN SEMIPERMANENT IMPOUNDMENT (OPEN WATER SUBTYPE)

Concept: Coastal Plain Semipermanent Impoundment communities are ponded wetlands produced by beaver dams or by long-established man-made dams that produce similar ponds. They include drained impoundments whose vegetation remains distinct from other floodplain communities. The Open Water Subtype covers the deeper portions of pond complexes, dominated by open water or by submersed, floating, or floating-leaved aquatic plants, with limited emergent vegetation. It is generally a zonal community, occurring in a complex with other subtypes.

Distinguishing Features: Coastal Plain Semipermanent Impoundment communities are distinguished by occurrence in the Coastal Plain in active or recently drained beaver ponds or in artificial ponds that have a similar environment and vegetation. Good mimics are usually old mill ponds that have long been unused. Larger reservoirs and smaller farm ponds do not seem to develop similar communities and have no natural community analogue. Other permanently or semipermanently flooded communities such as Oxbow Lake and the various Coastal Plain Depression Communities are generally readily distinguishable by occurring in closed basins without dams. Their vegetation usually is quite different, though recently formed Oxbow Lakes may look similar.

The Open Water Subtype is distinguished by the absence of substantial emergent vegetation or tree cover. Some examples have no significant vascular plant cover. *Nymphaea odorata* is the most typical plant, but *Utricularia* spp., *Lemna* spp., *Myriophyllum* spp., and others may dominate instead.

Synonyms: *Nuphar advena* - *Nymphaea odorata* Herbaceous Vegetation (CEGL002386); Atlantic Coastal Plain Small Brownwater River Floodplain Forest (CES203.250).
Ecological Systems: Atlantic Coastal Plain Small Blackwater River Floodplain Forest (CES203.249). Atlantic Coastal Plain Brownwater Stream Floodplain Forest (CES203.248). Atlantic Coastal Plain Blackwater Stream Floodplain Forest (CES203.247).

Nelumbo lutea Herbaceous Vegetation (CEGL004323) might potentially describe some of our examples. The NVC associations do not distinguish natural and pseudo-natural impoundments from artificial lakes and from other natural basins, apparently even from tidal rivers; hence the correspondence is only partial.

Sites: Coastal Plain Semipermanent Impoundments occur on the floodplains of blackwater or brownwater streams or rivers, rarely on tidal creeks. Beavers prefer second order streams (Snodgrass 1997), but they can use smaller or larger streams. On large river floodplains, beavers dam sloughs, tributary streams, or drainages from backswamps. Old mill ponds that mimic beaver ponds tend to be on relatively small streams. While beavers strongly prefer low gradient streams, very few streams in the Coastal Plain have high enough gradients to deter them.

Soils: Coastal Plain Semipermanent Impoundments can occur on any floodplain soil, though impoundment presumably modifies the preexisting soil if the pond lasts very long. Besides water saturation, depletion of oxygen, and development of a strongly reducing chemical environment, the still water of ponds traps sediment. It may allow clay or muck deposition where it would not

otherwise occur. An accumulated clay layer may persist even after the pond drains and is revegetated. Kroes and Bason (2015) noted that ponds could be significant repositories for carbon storage, and that, though sediments in channels tend to wash out quickly if the dam was breached, sediment stored in floodplains might remain in place for centuries.

Hydrology: The Open Water Subtype has deeper water than the other subtypes and is permanently flooded as long as the dam is maintained. Brief dam breaches may occur, but if they are not repaired, the Open Water Subtype quickly develops into other subtypes.

Vegetation: The vegetation of the Open Water Subtype consists of aquatic plants. Dominant plants may include free-floating plants such as *Lemna* spp., *Wolffia*, *Wolfiella gladiata*, or *Azolla caroliniana*; floating leaf aquatics such as *Nymphaea odorata*, *Nuphar advena*, or *Brasenia schreberi*; or submersed aquatic plants such as *Potamogeton* spp., *Cabomba caroliniana*, or *Utricularia* spp. Mat-forming floating plants such as *Hydrocotyle ranunculoides* or the introduced *Alternanthera philoxeroides* can occur but are less typical. Other, less common plants may include *Hottonia inflata*. Nonaquatic plants may be present as minor components, with a number of species potentially inhabiting any remaining stumps, logs, tree bases, or old tip-up mounds. Sparse *Taxodium distichum*, *Nyssa aquatica*, *Nyssa biflora*, *Acer rubrum* var. *trilobum*, or *Fraxinus pennsylvanica* may persist. A diverse community of animals may use the ponds, including frogs and toads, lizards, turtles, snakes, and birds which are not common in the surrounding forest (Metts et al. 2001).

Range and Abundance: Ranked G5. This community may be found wherever streams or rivers occur on the Coastal Plain. Beaver ponds are abundant in the Sandhills region, which has a high stream density, but is also the site of first reintroduction of beavers. They are scarce in the outer Coastal Plain. Similar communities may occur in all the Coastal Plain states.

Associations and Patterns: The Open Water Subtype usually occurs with other subtypes, though sometimes it may occupy most of a given impoundment. It is usually occurs in the middle of the impoundment and near the dam, where water tends to be the deepest. In shallow ponds, it may occur as a narrow sinuous body following the stream channel. On large river floodplains, such as the Roanoke River, beavers tend to build ponds in sloughs or in backswamps (Townsend and Butler 1996). In these settings, the middle of impoundments may be the Cypress–Gum Subtype, the trees persisting from a previous Cypress–Gum Swamp. There, the outer portions of the slough or backswamp, having been occupied by the less flood-tolerant trees of Bottomland Hardwoods communities, may be the location of the Open Water Subtype.

Coastal Plain Semipermanent Impoundments in general are bordered by floodplain communities. In the Sandhills, Streamhead Pocosin or Streamhead Canebrake may occur adjacent to them. A variety of upland communities may border them on the edges, though the Open Water Subtype more often grades to other Coastal Plain Semipermanent Impoundment communities.

Variation: The vegetation is extremely variable among examples and can be patchy and heterogeneous within individual ponds. The dominant plants may occur in any combination, and vegetation density can range from dense to sparse or nearly absent.

Differences between brownwater and blackwater examples should be examined; none have been identified to date, but detailed data are lacking. There must necessarily be differences among those of small and large stream systems, given the differences in flood regime.

Krues and Bason (2015) described a physical typology of beaver ponds that may be useful in describing their variation. The main pond forms, inundating (filling the floodplain), channel (flooding the channel only), and discontinuous (flooding part of floodplain and channel but with high ground on levees or rises) may be helpful, though additional types for sloughs and for backswamps in large floodplains would need to be added to these categories. The cluster configuration types they described also appear useful: pioneer (single pond), disjunct serial (several ponds nearby), and stair step serial (ponds running together).

Dynamics: Beaver pond dynamics are unique among North Carolina's natural communities, contrasting with the stable site-driven mosaic that makes up most of the natural community landscape. They are among the most dynamic of communities, appearing and potentially disappearing rapidly, and occurring on sites that previously supported very different communities.

Pond dynamics are dependent on the behavior of individual beaver families and on the dynamics of beaver populations. Each beaver colony consists of one breeding pair, along with subadult offspring and young. A given colony may maintain several ponds and several lodges or bank burrows. They are territorial, with a family excluding other beavers, so colonies are nonoverlapping. New beavers will not move into a site if adult beavers are present (Allen 1982). Snodgrass (1997), at Savanna River Plant, found colonies to be separated by more than 100 meters.

Individual ponds can form rapidly when beavers build a dam large and high enough to impound deep water. Most trees die quickly, though ponds in Cypress–Gum Swamps may retain their tree canopy and not become the Open Water Subtype quickly, or at all. Young examples of the Open Water Subtype have recently dead trees, which gradually fall and decompose, eventually leaving a largely open water pond. Stumps may persist for many years, providing microhabitats for nonaquatic plants as well as for animals.

Colonization by aquatic plants takes some time, though it is not known how long. Presumably this depends on proximity of populations and the abundance of dispersal vectors such as waterfowl. Beavers themselves could contribute to dispersal from nearby ponds as well. More mature ponds are generally believed to be more diverse, as aquatic species accumulate over time. Many old mill ponds predate the reintroduction of beavers, and their more diverse aquatic communities are believed to represent the vegetation that once would have occurred in the more persistent beaver ponds.

When a dam is abandoned, the deep pond usually drains quickly, and the Open Water Subtype succeeds to one of the other subtypes, eventually returning to a floodplain forest community if not impounded again. While drained ponds in the North may persist as wet meadows for 50 years or more (Wright et al. 2002), forest return generally appears much more rapid in most of North Carolina.

Beavers may directly affect the vegetation in and around ponds, though this is particularly poorly known in the Open Water Subtype. Beavers are generalist herbivores but have strong food preferences (Allen 1982, Rossell, et al. 2014). Though they are most widely known for eating trees and shrubs, they prefer herbaceous vegetation if it is available, including most of the aquatic species named above. While it has been suggested that their preferences among woody plants may influence forest succession in adjacent areas, a similar effect of selective feeding on herbaceous plants has not been suggested. However, it is at least conceivable.

The natural population dynamics of beavers and beaver ponds remain poorly known. No record remains of beaver populations and behavior in early European times in most of the country. Populations almost everywhere throughout the huge range of North American beavers are recovering from the heavy exploitation and often complete extirpation of the past. There is extensive literature on beavers, but relatively little specific to the South. Population dynamics may well be different where ponds do not freeze over in winter, where herbaceous food is often available year-round, and where landscapes and potential predators are different. Beavers were extirpated from North Carolina long ago and were reintroduced in 1939. They have now returned throughout most of the state, but at different times and rates. In addition, trapping and management to reduce their effect on forests, agriculture, and human infrastructure are widespread, and few ponds can be assumed to be free of such influences. An important question is how much populations naturally were controlled by predation, and how this affected the life span of colonies.

Beaver ponds are widely believed to create a shifting mosaic, functioning as a metapopulation, with creation of individual ponds followed by abandonment and succession, and new ponds created elsewhere as beaver move. While the situation is usually portrayed as random colonization followed by abandonment when woody food resources are consumed, the scenario is no doubt more complicated, with preferred sites occupied much of the time, marginal sites abandoned more frequently, and some areas unsuitable and rarely or never ponded. In the Roanoke River floodplain, Townsend and Butler (1996) found that most ponds were created in sloughs, and a fair number on the edges of backswamps next to natural levees (where woody food other than the undesired *Taxodium* and *Nyssa* were available). However, ponds in backswamps were larger, and amounted to slightly larger acreage. Fryxell (2001), working in boreal forest, found beaver occupancy to be complex, with a small number of ponds being source populations and a larger number being sinks that did not reproduce at replacement levels. About 20% of the ponds persisted through the 11 year study, but many pond sites were abandoned and recolonized repeatedly within the period. Rather than a shifting mosaic, the landscape appeared to consist of sites that were repeatedly reoccupied long before succession occurred, and abandonment appeared to have less to do with depletion of food than with marginal habitat that did not support consistent reproduction. The stable colonies had ponds with abundant aquatic plants, which might mean better food supply; however, it is unclear if those ponds are stable because they have more aquatic plants or if they have more aquatic plants because they are more stably maintained by beavers.

Crucial parameters that remain unknown are how much of a natural landscape would be occupied by which stages of beaver ponds at a given time, and how much of the landscape would ever be affected by them. Snodgrass (1997) found up to 27% of stream length affected by impoundments in some small watersheds, but much less in larger watersheds. Forty-one years after reintroduction, without management during most of that time, they had affected only 9% of stream length and

0.5% of the land area. He also found 0.1 square meter/ha/year newly impounded. Brzyski (2005), in the Georgia Coastal Plain, found only 0.07 colonies/km of stream, a very low density. Kroes and Bason (2015), in the Virginia and North Carolina Coastal Plain, found about 1 pond/100 sq. km. In the Adirondacks, Wright et al. (2002) found 26.7% of stream length affected, and 3.32% of the landscape. In all cases, it is unclear how fully beaver populations had recovered, nor how much ongoing trapping and other management was occurring. Some referred to human destruction of ponds.

In the modern landscape, beavers sometimes take advantage of man-made structures such as road fills, bridges, and culverts. This probably is caused simply by these structure constricting flow and increasing current, trigging the beavers' instinct to place dams there, but at such constrictions, a small dam can create a large and deep pond. Thus, some beaver ponds may be larger than individual ponds in the past, even while ponds overall are less extensive.

Comments: Beaver ponds are potentially important in larger landscapes. They have been called "ecosystem engineers," because they cause physical habitat change and create habitat that would not otherwise be present (Wright et al. 2002). Though the open water and marshy vegetation they create often contrasts less with the other Coastal Plain vegetation than it does with Piedmont and Mountain forests, they provide distinctive habitat that allows different animals and plants to persist in the landscape. Several studies have noted that, though species richness of plants is lower in beaver ponds than in the forests they replace, the presence of beaver ponds increases the species richness of the landscape as a whole (Bartel 2008, Bonner 2005, Metts, et al. 2001, Wright, et al. 2002). Modeling exercises in some of these studies have calculated what abundance of beaver ponds should provide maximum diversity. There is no reason to believe that this particular abundance is what would specifically be present naturally, but the presence of multiple species that depend on beaver pond habitat or artificial analogues shows that it was present in important amounts.

Beaver ponds also apparently provide important ecosystem services and may be important to local geomorphologic processes. They may help buffer stream flows, enhance ground water recharge, and reduce stream velocity. Snodgrass (1997), working in the Savanna River Plant of South Carolina, found that ponds on intermittent streams caused perennial flow in them downstream of the dam. Most importantly, they trap sediment. Kroes and Bason (2015) reported sediment accumulations of 15-20 mm/year in Piedmont streams, compared to 1.6-5.4 mm in unponded streams. Coastal Plain ponds trapped shallower sediment, but the larger surface area of the ponds led to similar total amounts. They noted that, while sediment trapped in channels is often lost quickly when a dam breaks, that deposited in the floodplain can persist. Even in the mountainous landscape of Glacier National Park, Butler and Malanson (2005) found that most ponds that catastrophically drained in severe thunderstorms lost little of their sediment before grass and shrubs stabilized the exposed pond bed.

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