PIEDMONT/MOUNTAIN SEMIPERMANENT IMPOUNDMENT (OPEN WATER SUBTYPE)

Concept: Type covers portions of Piedmont and Mountain floodplains affected by impoundment by beaver dams, along with occasional small man-made ponds that resemble them. This includes drained impoundments that are still distinguishable from pre-impoundment conditions.

Subtype covers portions of Piedmont and Mountain examples with open water, submersed, or floating-leaved aquatic plants but with little emergent vegetation.

Sites: Floodplains of streams or rivers. On larger river floodplains, beavers dam sloughs or tributary creeks. Beavers generally prefer second order streams (Snodgrass 1997), but can use smaller or larger, and this subtype is also common on large river floodplains. Beavers strongly prefer low gradient streams, and many Piedmont and especially Mountain streams are probably too swift for them.

Soils: Can occur on any floodplain soil, though impoundment presumably modifies the preexisting soil if the pond lasts very long. Besides saturation, depletion of oxygen, and reduction, the still water of ponds traps sediment, and may allow deposition of relatively pure clay over sizeable areas. 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: Permanently or nearly permanently flooded, with moderate to deep water.

Vegetation: This community may consist largely of open water with no visible macrophytes, or it may consist of sparse to dense floating-leaf or free-floating plants. *Nymphaea odorata* and floating *Sparganium americanum* are the most frequent species, and *Lemna* spp., *Azolla caroliniana*, *Wolffia brasiliensis*, and *Spirodela punctata* may dominate. Occasional ponds may have *Nuphar advena*, *Brasenia schreberi*, or *Nelumbo lutea*. Emergent plants, surviving trees, and plants rooted on stumps or logs may be sparsely present.

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).

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 non-

overlapping. 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 form rapidly when beavers build a dam large and high enough to form a deep pond. Most trees die quickly, though more water-tolerant trees may survive on the edges. 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 non-aquatic 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 too. More mature ponds are probably more diverse, as aquatic species accumulate over time.

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. If the pond lasts for a long time, sediment deposition may fill it, leading to succession from the Open Water Subtype to other subtypes. While drained ponds in the North may persist as wet meadows for 50 years or more (Wright et al. 2002), forest return is 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). 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. Crucial parameters that remain unknown are how much of a natural landscape would be occupied by which stages of beaver ponds at any given time, and how much of the landscape would ever be affected by them. Walter and Merrits (2008), in Pennsylvania, excavated stream sediment profiles below the European era deposits. They found that all exhibited multiple stable channels, organic-rich sediment across the width of the floodplain, and macrofossils of aquatic and scrub-shrub plants, all suggestive of beaver ponds even more than of the groundwater discharge they emphasized. They cited studies finding similar results in the Piedmont from South Carolina to Pennsylvanica. However, they did not address the question of how much of the time a given place was in a beaver pond versus a floodplain forest.

Snodgrass (1997) found up to 27% of stream length affected by impoundments in some small watersheds, but much less in larger watersheds. 41 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 these studies, 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.

While beaver pond dynamics are sometimes portrayed as random colonization events 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 quickly and spending less time ponded, and some areas unsuitable and rarely or never ponded. 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 whose colonies 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 that 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.

Range and Abundance: Ranked G4G5. This subtype occurs throughout the Piedmont and Blue Ridge, and presumably occurs in neighboring states.

Associations and Patterns: This community can be the only extensive community in a pond, but it more often a central zone with the Shrub Subtype or one of the marsh subtypes around the edges and at the upper end. In ponds where the beaver dam is within the stream channel, the Open Water Subtype may be confined to a narrow band in the channel.

Distinguishing Features: Semipermanent Impoundment communities are distinguished by vegetation and hydrology affected by impoundment by beavers. Small manmade impoundments are included if they produce a similar environment and vegetation, but most reservoirs in the Piedmont and Mountains bear little resemblance to natural beaver ponds and should not be treated as natural communities.

The Open Water Subtype is distinguished by the absence of appreciable emergent vegetation, consisting instead of unvegetated water, submersed plants, or floating-leaved aquatic plants.

Variation: Examples vary in types and in presence, of macrophytes, but no variants or patterns have been identified. The Mountain examples are more likely to have unvegetated open water, but such situations are common in the Piedmont too.

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 the categories. The cluster configurations of pioneer (single pond), disjunct serial (several ponds nearby), and stair step serial (ponds running together) also appears useful.

Comments:

Synonyms: *Nuphar advena* - *Nymphaea odorata* Herbaceous Vegetation (CEGL002386); *Nelumbo lutea* Herbaceous Vegetation (CEGL004323).
Ecological Systems: Southern Piedmont Large Floodplain Forest (CES202.324); Southern Piedmont Small Floodplain and Riparian Forest (CES202.323). South-Central Interior Small Stream and Riparian (CES202.706); South-Central Interior Large Floodplain (CES202.705).

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