The Missing Link:

The Ecology of the Serpentine and the Implications for East and North Ponds

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Executive Summary

During the fall of 2011, the Colby Environmental Assessment Team (CEAT) studied the Serpentine connecting East Pond and North Pond. East and North Ponds are members of the larger seven-lake system known as the Belgrade Lakes, located in central Maine. There are over 5,500 lakes in Maine that contribute $6.7 billion to the economy annually through activities including boating, fishing, swimming etc. Additionally, Maine's lakes are sources of municipal and agricultural water, act as flood buffers, and host a wide range of plant, animal, and fish life. Lakes in Maine are a crucial part society and should be studied and preserved.

Previous research efforts of CEAT have focused on the environmental and ecological parameters associated with a single lake in the Belgrade system. The significance of the linkages between the lakes is understudied. As a result, CEAT 2012 aims to investigate the interconnection between the lake systems of East and North Ponds. In order to evaluate the ecological interactions between East Pond, North Pond, and the Serpentine (the linkage between North and East Ponds), and to assess how these water bodies affect each other, CEAT 2012 conducted a comprehensive survey of the Serpentine environment. Studies including an in depth analysis of land use, surface water chemistry, substrate chemistry, fish communities, algal populations, and plant populations were conducted. In particular, the CEAT 2012 was interested in what role the Serpentine might play in the dynamics of algal blooms within East and North Ponds. The following is a brief summary of findings from the CEAT 2012 study of the Serpentine and its interactions with East Pond and North Pond:

- Spatial analysis revealed 34.5% of the North Pond watershed was rated as high erosion potential, while the East Pond watershed has only 27.4% of the watershed with high erosion potential. Erosion impact was estimated to be greater in the East Pond watershed with 39.4% of the land cover indicating high erosion impact, and only 27.8% of the land cover in North Pond showing high erosion impact. The Serpentine is directly adjacent to some of the largest areas of erosion impact and erosion potential. Erosion can have heavy impacts on lakes, and must be considered throughout the entire watershed- not just the immediate lake buffer zone.
- Water chemistry investigations show that many nutrients, including Ca, Mg, Al, and Fe, exhibit declining trends in concentration moving from the confluence towards North Pond. This finding supports the theory of a mixture occurring at the confluence with

variable input levels from input streams and from East Pond. The concentrations of Ca and Mg between the input streams and North Pond indicates that the majority of the water flowing over the dam originates from the input streams. Further, the concentrations of Fe and P support the hypothesis that the majority of water in the Serpentine is provided by input streams and not East Pond. The DO concentrations at the confluence also indicate a large component of post-confluence flow is input stream water.

- Biogeochemistry may explain the difference in occurrence and severity of algal blooms between East Pond and North Pond. North Pond is shallower, and experiences more wind fetch than East Pond allowing it to remain mixed throughout the summer. North Pond remains aerobic as a result of mixing; thus the Al:Fe ratio that regulates phosphorus and other nutrient cycling in sediment is a non-issue. East Pond however, is susceptible to anoxic conditions and therefore prone to release nutrients. Upstream sites S1 and S2 do not release many nutrients from the sediments, as is indicated by high TOC concentrations, high DO, and the presence of sphagnum moss. The nutrients entering the Serpentine and eventually flowing into North Pond remain in the water and do not settle out in the sediments. In sites I1, I2, SC, (and to a lesser extent in S3 and AD) there are low concentrations of DO, TOC, and phosphorus associated with organic matter. This is likely the result of higher amounts of inorganic sediment and higher rates of decomposition at these sites. This area of the Serpentine has lower concentrations of DO, indicating that it may go anoxic at times. However, releasable P at sites I1, I2, Sc, S3 and Ad is low; thus, even in anoxic conditions, there will not be a large-scale release of nutrients. Most of the phosphorus in the Serpentine is tied up in organic matter and will be released slowly as the organic matter decomposes.
- An extensive literature review in addition to CEAT 2012 water chemistry results, were used to compare the habitat requirements of the fish found in East Pond with the habitat characteristics of the Serpentine. This analysis revealed that 9 of the 12 species found in East Pond could use the Serpentine as effective habitat (species included: Chain Pickerel, bullhead, Largemouth Bass, Smallmouth Bass, Black Crappie, Pumpkinseed Sunfish, White Sucker, White Perch, and Yellow Perch). Brown trout and rainbow smelt are not thought to use the Serpentine based on their highly specific habitat requirements. The lack of information about golden shiner's habitat requirements makes it difficult to

determine whether it would utilize the Serpentine. Investigation of the biomanipulation project on East Pond in 2008 revealed some potential issues with the plan. The presence of White Perch in the Serpentine indicates that this water body could have acted as a shelter for White Perch during the mass removal, which might have lowered the effectiveness of the biomanipulation project. Additionally, it was noticed cyanophyta tend to be resilient to zooplankton grazing. Therefore, a biomanipulation project aimed at increasing zooplankton numbers might prove less effective than originally hoped.

- More algal genera were observed in East Pond than in North Pond or the Serpentine. The genera in East Pond represented the greatest number of phyla. North Pond, which does not bloom as frequently, had the second highest abundance of phyla and genera.
- In the Fen ecosystem adjacent to the Serpentine, 49 plant species were found present. The two most dominant species, based on abundance and frequency, were sphagnum moss and leatherleaf. Cotton grass, sweetgale, large and small leaf cranberries, and gramminoids were common, but with low dominance. The remaining 42 observed species were found in very low abundance and frequency. This indicates a species distribution with few very common species and a large number of very uncommon species. This observation is confirmed by Rank Abundance curves and Shannon-Weiner indexes showing the same pattern across the serpentine. Overall, species diversity trends slightly downward from the confluence to East Pond, and species richness clearly declines moving upstream from the confluence through the input streams. This finding could indicate nutrient loading from the agricultural land adjacent to the input streams. Sphagnum's high dominance indicates the substantial impact the fen has on decomposition in the Serpentine, as Sphagnum decreases decomposition in a number of ways. The substrate in the fen portion of the Serpentine supports the evidence of low decomposition with high concentrations of TOC. Low decomposition in the fen and high TOC in the substrate indicate that the fen acts as a nutrient and carbon sink in this freshwater ecosystem. This ecosystem service is particularly important in the context of global climate change. The fen provides very valuable carbon sequestration, creating yet another important reason to protect and preserve this ecosystem.

Further study is necessary to thoroughly assess the complex ecological relationships between the Serpentine, East Pond, and North Pond. CEAT 2012 suggests further study on surface-water flow through water bodies, because it is an important factor in determining nutrient concentrations in freshwater ecosystems. Additionally, an in-depth analysis of fish communities using an electro-shock boat is recommended to accurately determine fish species are present in the Serpentine, and to understand how these species may be impacting their ecosystem structure. A geomorphic study of the fen is also recommended to better understand how groundwater might impact nutrient levels across the entire ecosystem.