Arboretum Leaflets
Restoration Discovery Research
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How ponded cattail marshes can export phosphorus: A conceptual model

Wetlands designed to remove phosphorus (P) can instead discharge P, especially in the dissolved form. The following conceptual model illustrates how that conversion can take place. The model illustrates key findings of Leaflet 27, based on data obtained by six UW researchers (Doherty, Miller, Prellwitz, Thompson, Loheide and Zedler, manuscript in review). The focus here is on Swales II and III, which were the most different, with Swale II draining between inflow events and Swale III ponding water almost continuously during the study. Findings supported by extensive data are so indicated; likely mechanisms are labeled "hypothesis."

Swale II trapped total dissolved solids and nitrogen, and it exported less P than Swale III.

A1. Subsoil had thin clay and infiltrated more water than Swale III (data).

A2. Topsoil was usually aerobic and much of the soil P was insoluble and immobile (hypothesis)

A3. Plants grew a sparse canopy (data) and moved less soil P into aboveground biomass than in Swale III (hypothesis).

A4. Light penetrated the canopy and more light reached the soil surface and supported more moss and algal mats than in Swale III (data).

A5. Moss and algae stabilized the soil surface better than vascular plants. Moss withstood 60 psi in a Cohesive Strength Meter (data).

A6. Rainfall and runoff did not cause as much outflow of P in Swale II as in Swale III (data); i.e., **Swale II exported less dissolved P downstream than Swale III** (data).

Swale III was a NET exporter of P, primarily in the dissolved form:

B1. Soil contained P (data) and added P to that in the inflowing runoff (hypothesis). As noted in Leaflet 27, a 6-inch layer of topsoil was added to each experimental wetland.

B2. Ponding: A thick layer of clay in the wetland subsoil prevented water infiltration, and inflowing water formed a shallow pond (data).

B3. Dense cattails: Wherever nutrient-rich, shallow-water ponds develop, aggressive cattails will establish, dominate, and displace other species (data). Swale III held water almost continuously, despite the 2012 drought; it supported only 9 vascular plant species, while Swale II supported 29 species where the subsoil infiltrated water and dried between runoff pulses (data). Cattails were present in Swale II, but less aggressive than in Swale III (data).

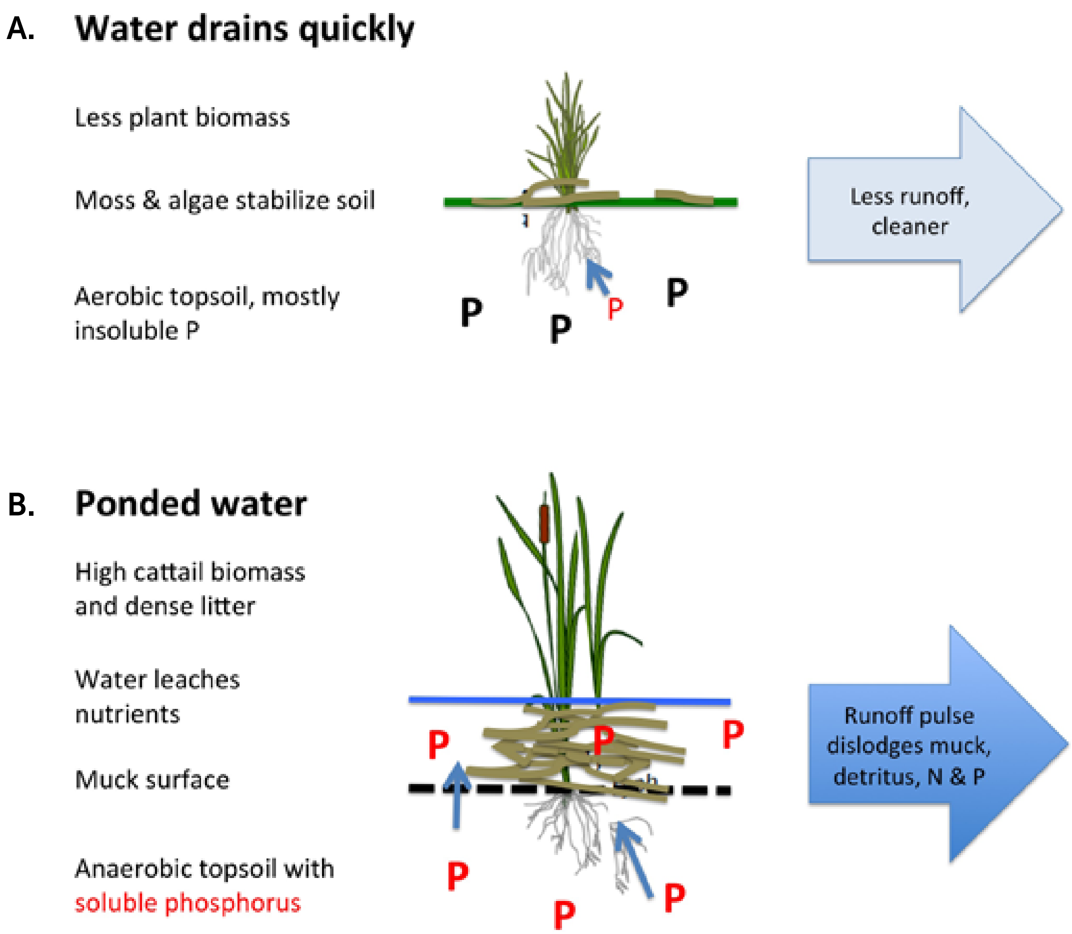
B4. Anaerobic (water-saturated) soil allowed phosphorus to become soluble and mobile; P was able to diffuse into the overlying water (hypothesis).

B5. Cattails took up P from water-saturated soil (extrapolated from microcosm experiments; Boers and Zedler 2008).

B6. Abundant biomass shaded the soil, hindering growth of understory vegetation, moss mats, and algal mats (data). Soil was loose, unstable muck (data), and P leached into the water column (hypothesis).

B7. Rainfall produced pulsed flows into the wetland, where the water picked up detritus, particulate and dissolved P and carried soluble P downstream (data). While both swales were net exporters of P, Swale III exported more than Swale II (data).

Figure 1. Conceptual model of phosphorus mobilization. **A.** Well-drained wetland; **B.** Ponded wetland with cattail monotype (see Leaflet 27). Plant silhouettes courtesy of D. Larkin; rest of illustration by J. Zedler based on data in Doherty et al. (in review).



This model is consistent with the findings of Doherty et al. (in review), as well as Prellwitz (2013) and Miller (2012). Additional papers are forthcoming.

Physical models of sedimentation and P removal do not incorporate this new knowledge of the role the biota. If the Arboretum's four shallow swales (3 of which infiltrate some water) are managed to have increased inflows and reduced outflows, they will form a single large pond during storm events, when **we can expect them to export phosphorus** (despite being designed to trap P). **Current plans for managing the swales should be reconsidered in light of new research and newly-identified risks.**

Please direct questions to J. B. Zedler (jbzedler@wisc.edu).

Literature cited:

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