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Linking Forest Communities and Water Quality

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Abstract
This two-page fact sheet describes preliminary results from a project studying how understory plant communities in forests and woodlands can improve water quality.

Disciplines
Forest Sciences | Natural Resources and Conservation

Linking Forest Communities and Water Quality

What we're doing

Stream pollution from nutrient and sediment runoff is a chronic problem in Iowa and the entire Midwest. Remnant forest ecosystems in this largely agricultural landscape could capture nutrients and sediment and help protect water quality. Native ecosystems are dynamic, with organisms adapted to the nuances of season, soil, and resources of a particular habitat. In a properly functioning natural system, these organisms tightly cycle nutrients so that little is lost.

Many human land uses can affect forests and limit their ability to function. We have been working to identify connections between land use, vegetation characteristics, and water quality. Some of our earlier work revealed that certain forest understory plants play a critical role in nutrient uptake, especially in early spring when crop fields are bare and trees have not yet leafed out. These herbaceous (non-woody) plants can also be useful indicators of ecosystem condition since they are sensitive to disturbance.

A fenceline shows differences in understory plant communities for a preserved site (left) and a grazed site (right).

In this project, we sampled plants and water associated with headwater streams in remnant forests that have been preserved as well as those in forests that are urban parks or have been grazed , all in Polk and Warren counties. We conducted field work from early spring through fall for two years to examine seasonal variation as well as compare the preserved and disturbed systems. We established vegetation plots in areas that drain to stream water sampling points to examine plant community composition and nutrient content.

Bi-weekly stream measurements of flow rate were averaged for spring, early summer, late summer, and fall.

We compared plant communities for different land use based on their diversity as well as on the floristic quality of the species present. Perennial herbaceous plants that are adapted to moist, closed-canopy forests are considered "forest specialists" (see Table 1) while plants that can take advantage of a variety of different habitats including old fields and ditches are called "generalists".

We are examining several measures of water quality, including sediment and nutrient concentrations (nitrate, total nitrogen, and total phosphorus). At bi-weekly intervals we measured stream size and flow rate to calculate the total discharge. We collected grab samples of water in the stream to analyze nutrient concentration and multiply those concentrations by the discharge of the stream to determine nutrient and sediment loads.

What we've found so far

- Preserved sites had higher proportions of native species.
- High-quality specialist species were replaced by weedier generalists, and urban and grazed sites have seen a loss of critical early-flowering perennials.
- Generally, preserved forests had more biomass, both shoots and roots, across all seasons than urban or urban sites.
- In urban and grazed sites, nitrate and total nitrogen concentration in water was higher.
- Urban streams generally had higher discharge and grazed sites had more variable flow rates from season to season, resulting in more total nitrogen being delivered downstream during high flow events than preserved sites.

Table 1. Average of floristic quality metrics across 3 urban, 3 grazed, and 3 preserved sites.

Floristic quality metrics	Urban	Grazed	Preserved
Total species	72	75	71
Native species	65	67	69
Average Coefficient of Conservatism	4.1	3.9	4.4
Herbaceous plants only	47	56	53
Early-flowering species	18	20	22
Closed-canopy specialists	24	22	30
Moist habitat specialists	25	28	33
Conservative species	8	8	11

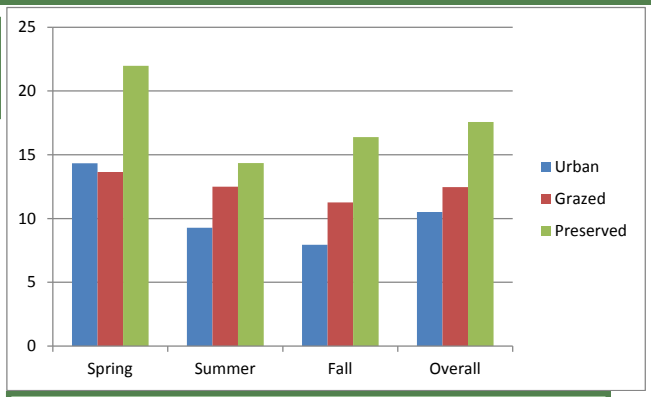

Figure 1. Seasonal mean herbaceous plant nitrogen content (kg/ha).

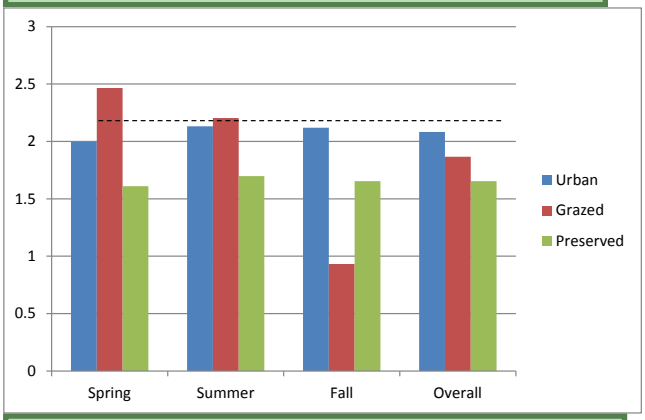

Figure 2. Seasonal mean stream water total nitrogen concentration (mg/L). Dashed line represents EPA reference criteria (2.18 mg/L) for streams and rivers in this ecoregion.

In addition, we have collected samples of aquatic organisms from the streambed. Many of these macro-invertebrates (large-bodied insects) can be used to evaluate ecosystem health because they are very sensitive to streambed conditions as well as stream water chemistry.

Preliminary results from data collected in 2010-2011 indicate that human land use can cause shifts in plant community composition. As communities are degraded, water and nutrients are less tightly cycled. Urban and grazed sites had higher total nitrogen (N) concentrations leaving the site in stream water in spring and summer (Figure 1), and higher soil N all year. In contrast, preserved systems had consistently higher plant N content in all seasons, as well as more understory cover and biomass (Figure 2). This is due in part to the conservative and specialist species that are more abundant in preserved forests (Table 1).

Some effects of people on urban forests are obvious (litter and debris such as this suitcase), and some effects are more subtle (note the invasive garlic mustard in the foreground).

Spring in healthy Iowa woodlands is marked by diversity on the forest floor and splashes of vibrant color.

Ongoing work

Phosphorus content of harvested plants will be evaluated relative to vegetation community and water data. Aquatic organisms that were collected in 2011 are being identified and assessed to compare aquatic communities across land uses. We are also studying the potential of restoring functionally important herbaceous plants that capture significant quantities of nutrients to identify possible means to reduce nutrient loss. We are hosting collaborative workshops for forest landowners and land managers to share our findings with those who can use the information as well as to learn from participants what questions they have and how we can help enhance forest ecosystem function across the Iowa landscape.

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