Alternative Urbanization Scenarios for an Agricultural Watershed: Design Criteria, Social Constraints, and Effects on Groundwater and Surface Water Systems

Richard C. Lathrop[1] and Kenneth W. Potter[2] (Co-Principal Investigators);
Jean M. Bahr[2], Kenneth R. Bradbury[2], Steven R. Greb[1], James A. LaGro Jr.[2], Edward B. Nelson[1], Peter Nowak[2], and Joy B. Zedler[2] (Co-Investigators)
[1]Wisconsin Department of Natural Resources, Madison, Wisconsin; [2]University of Wisconsin-Madison, Wisconsin

STORM WATER IMPACTS ON WETLAND DIVERSITY

Wetlands are sinks in the landscape. Disturbances throughout the watershed eventually affect downstream wetlands.

The effect on wetlands is twofold:

Invasive species become dominant and form monotypes (Kercher et al. 2004b). Reed canary grass (*Phalaris arundinacea)* is the most invasive plant in wetlands affected by stormwater inflows. **(A)**

A. Species-poor wetland invaded by reed canary grass (Photo by S. Kercher)

Species-rich native wetlands lose diversity. Our field, mesocosm and microcosms studies showed that plants native to Wisconsin's wet prairies are not very tolerant of increased flooding (Kercher and Zedler 2004a). **(B)**

B. Species-rich wet prairie (photo by Suzanne Kercher)

Reed canary grass is now found in natural wetlands, stormwater basins, drainage ditches, roadsides, streambanks, pastures. According to maps based on satellite imagery, **reed canary grass dominates >100,000 acres of Wisconsin wetlands.**

Why is reed canary grass (RCG) so invasive?

- Strains of RCG were widely planted
- RCG forms monotypes (>80% cover) and displaces natives (Maurer et al. 2003)

We learned that it can form a monotype because it has:

- three modes of reproduction (seeds, rhizomes, rooting branches)
- efficient growth (high volume/wt) (Zedler & Kercher 2004)
- broad tolerance of flooding, many adaptations (Kercher & Zedler 2004a,b)
- fast growth in high light (Lindig-Cisneros & Zedler 2002)

Mesocosm Experiments

Cause-effect relationships were tested using mesocosms with the following treatments:

- planted with species-rich prairie vegetation
- subjected to RCG invasion (by adding four plants)
- controlling water, nutrients, and sediments (alone and in combination - 3x3x3-factor expt) (Kercher and Zedler 2004b).

Field Experiments

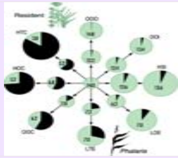
Subsequent field experimentation has shown that diversity loss is hard to reverse. Where stormwater effects persist, RCG is not controllable—even with repeated herbiciding, it regains dominance through germination from seed banks and resprouting from rhizomes not killed by control treatments.

Flooding opens the canopy; nutrients enhance growth (photos by S. Kercher)

Mesocosm Results

Mesocosms with excess flooding quickly loses native plant diversity, opening gaps in the canopy and allowing RCG to invade (Kercher and Zedler 2004a). Light then stimulates RCG establishment (Lindig-Cisneros and Zedler 2002). Nutrients and sediments (with adsorbed nutrients) then enhanced RCG growth (Maurer 2002, Kercher and Zedler 2004a).

Furthermore, synergistic relationships among flooding, nutrients and sediments increase RCG growth to twice the rate of additive effects!



This figure presents mesocosm results and illustrates the speed with which reed canary grass displaces native species under conditions similar to those produced by urbanization: i.e., flooding, nutrients, increased sediments. Canary grass is shown as black. Resident species are green; and the number of resident species is also indicated. Symbols indicate mesocosm treatment; i.e. 000 is the control and L0E indicates low nutrient addition, no sediment, and early season flooding. The inner ring shows 1st year results; outer shows 2nd year results.

Thus, under mesocosm treatment of high nutrient, organic sediment, and constant flooding, the canary grass comprises about 80% of the biomass and the number of natives has dropped to an average of ~4 species.

Wetland restoration efforts need to become more strategic.

We suggest that restorationists:

- Prioritize watersheds
- Prioritize positions within watersheds
- Prioritize sites
- Prioritize the approach: Use adaptive restoration where feasible
- Prioritize the methods to use/test (e.g., type of herbicide or timing of application)

INTRODUCTION

Urban development fundamentally alters the hydrologic cycle, causing economic and environmental damage.

The goals of this research were to fill critical gaps in our understanding of these effects and to extend or develop modeling tools that could be used to design and evaluate new mitigation strategies.

This research was conducted in southern Wisconsin, although findings are generally relevant to the entire Midwestern United States. Through this research we improved our understanding of the

- mechanisms by which altered conditions degrade wetland biodiversity;
- stratigraphic controls on ground water recharge and discharge;
- factors affecting the magnitude and distribution of phosphorus in soils at the urban fringe;
- barriers to the adoption of small-scale infiltration practices.

We also developed new models of small-scale infiltration practices, and used these models to demonstrate the potential benefits of these practices.

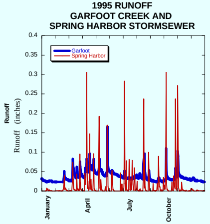
This poster focuses on wetland biodiversity and small-scale infiltration practices.

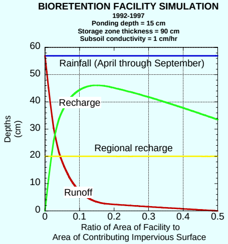
SMALL-SCALE INFILTRATION PRACTICES

The introduction of impervious surfaces and the compaction of pervious surfaces increase flood peaks and volumes. Ground water pumping decreases ground water levels, potentially threatening the long-term viability of the ground water supply. Pumping also reduces the flow of ground water to streams, lakes and wetlands, threatening ecosystems that depend on this source of water.

These impacts are illustrated by the plot of measured daily runoff from a rural watershed (Garfoot) and an urbanized watershed (Spring Harbor). Note that the runoff from Spring Harbor is much more flashy and frequently drops to zero.

Traditional storm water management practices do not address increases in flood volumes or decreases in ground water levels, and hence do not prevent the associated economic and environmental damages. The use of small-scale infiltration practices, such as soil amendments, grass swales, rain gardens, and bioretention facilities, make it possible to develop land with little or no harmful impacts on the hydrologic cycle.



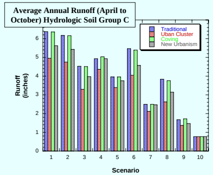


We tested the potential benefits of small-scale infiltration practices using newly developed models, RECARGA and IP. RECARGA is a continuous hydrologic model that simulates the performance of an individual infiltration practice, such as a rain garden. IP is a simpler model that can be used to evaluate the performance of a suite of infiltration practices at the scale of a lot or an entire development.

The adjacent figure shows RECARGA simulation results of a hypothetical bioretention facility in southern Wisconsin. The plot gives ground water recharge and spill from the facility for a range of facility sizes, expressed as a fraction of the contributing impervious surface.

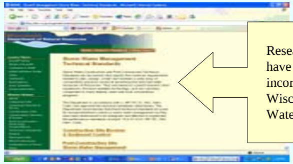
Note that a facility that has an area that is about 15% of the contributing impervious surface area reduces the spill to nearly zero and maximizes ground water recharge at a level that is about twice the natural recharge rate. **These results indicate that it is feasible to mitigate increases in runoff volume due to urbanization and partially mitigate the impacts of pumping.**

Below are the results of IP simulations of various development types and combinations of infiltration practices for a silt loam soil in southern Wisconsin.



Infiltration	Scenario									
Practice	1	2	3	4	5	6	7	8	9	10
None	x									
Improved lawn		x		x	x	x				
Roofs to rain gardens			x				x	x	x	
Driveways to lawns					x	x	x	x	x	
Reduced street with					x	x	x	x	x	
Grass swales					x	x	x	x		
Streets to rain gardens									x	
Predevelopment										x

OUTCOMES:



Research Results have been incorporated into Wisconsin Storm Water Regulations

Conserving ecosystem services through proactive decision making.

R828010