

Comparative Nutrient Losses from Lakeshore Riparian Areas in Northern Wisconsin

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Wisconsin Lakes Convention
March 30-April 1, 2010

Lower Ninemile Lake



**Wisconsin Department of Natural
Resources (WDNR),
Bureau of Integrated Science Services
United States Geological Survey (USGS)**



Kentuck Lake



Funding Support from:
**WDNR, Bureau of Fisheries Management and
Habitat Protection
WDNR Voluntary Contribution Fund
US Geological Survey**



Anvil Lake, Vilas County

Project Objective

Determine the effect of shoreline development (residential lawns) on surface, interflow, and groundwater hydrology and water quality



Butternut Lake

Lakeshore Development Impacts

- Density (houses/mile)
- Lot Improvement Footprint

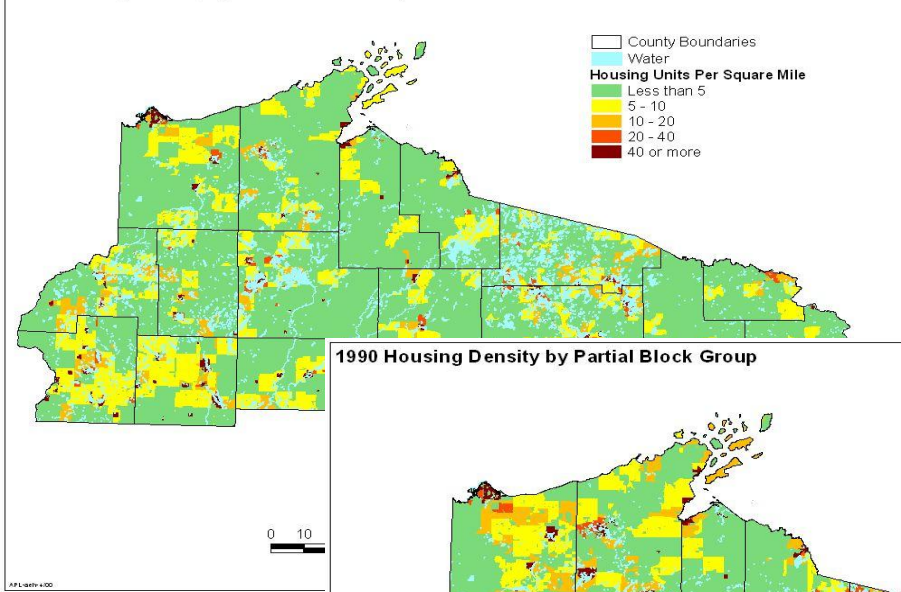
1940s



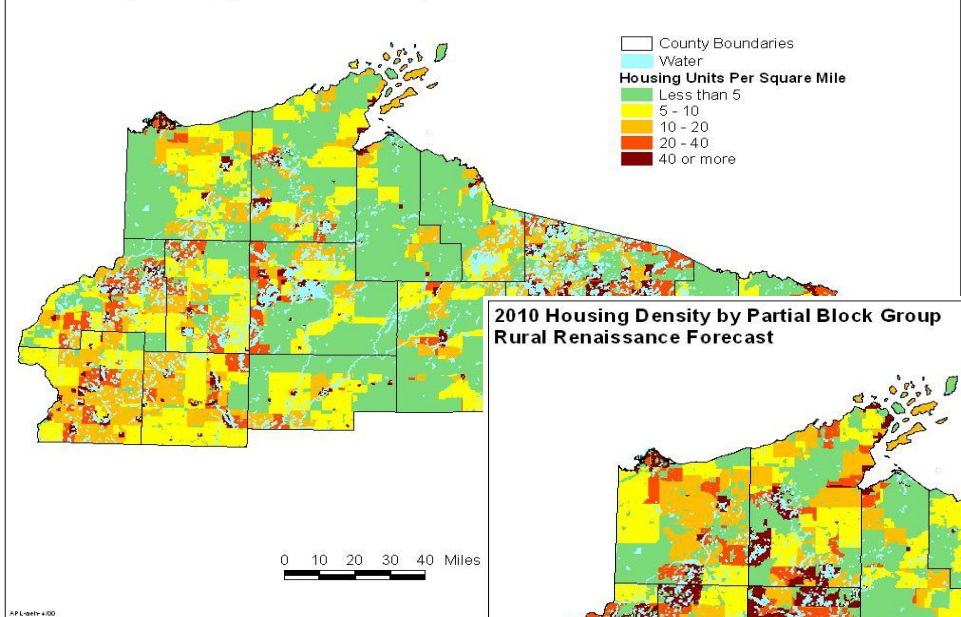
Today



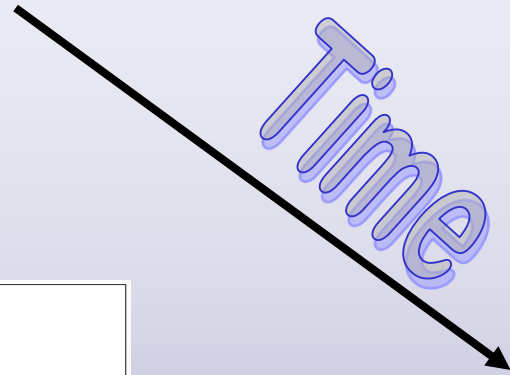
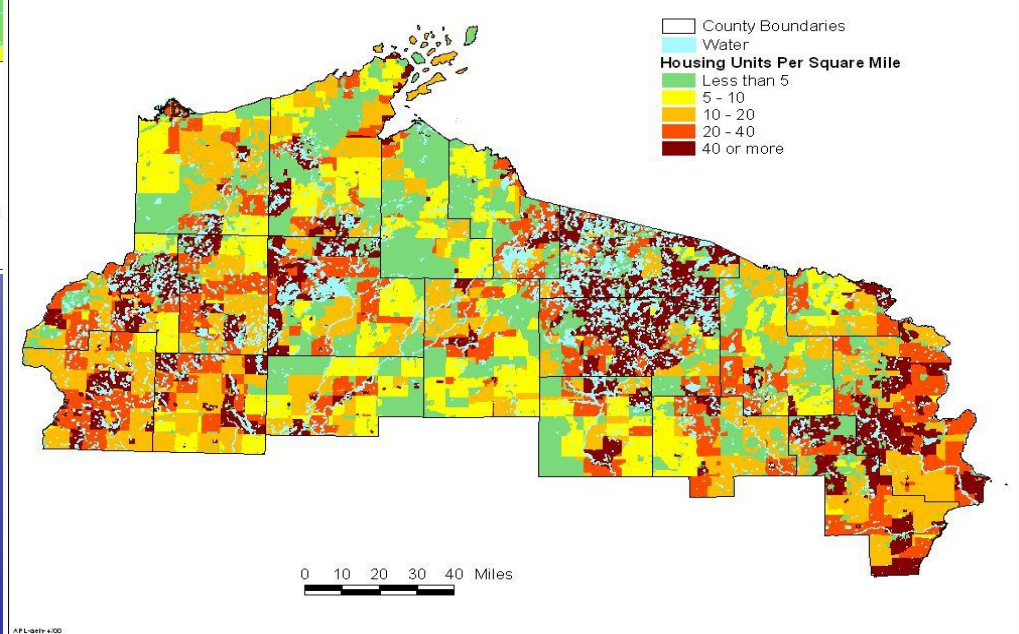
1940 Housing Density by Partial Block Group



1990 Housing Density by Partial Block Group



2010 Housing Density by Partial Block Group
Rural Renaissance Forecast



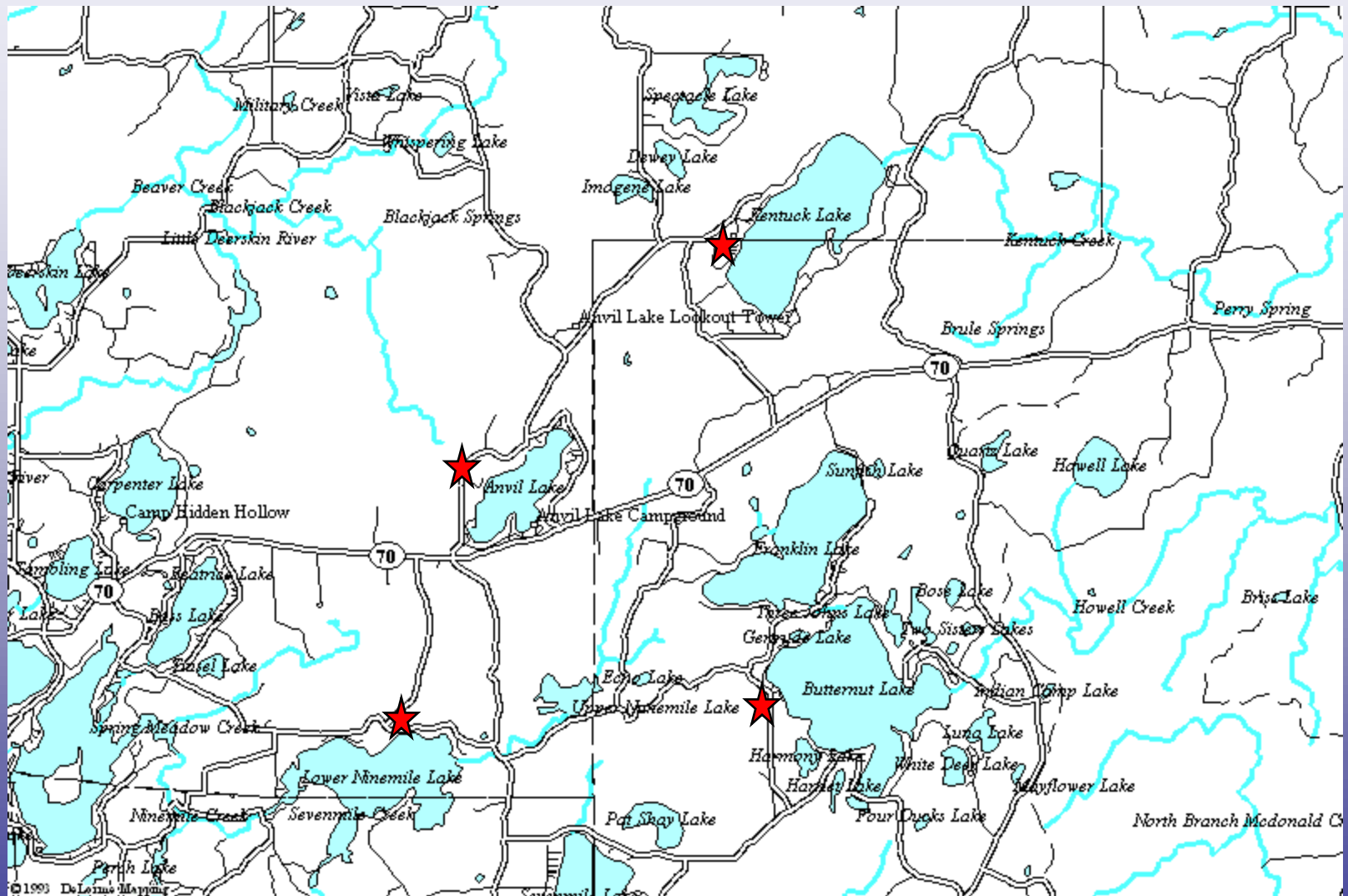
Study Design

- Paired Sites Forested “Natural” Site vs. Developed Home Site
- Four Pairs of Sites (8 total)
- All in Vilas and Forest Counties
- Two Years of Monitoring



Monitoring

- Three pairs with Groundwater and Surface Water Monitoring
- One pair with only Surface Water Monitoring (Anvil)
- Each site had 3 sets of three nested wells
- Surface water collector (sump design)
- Tipping Bucket Rain Gage/ Temperature
- Water Quality Analyses- Ammonia, Nitrate, TKN, Total Phos., Dis. Phos



Site Locations

Basin Characteristics

Site	Lake	Drainage Area (ft ²)	Aspect	Slope	Localized Slope	Vegetation
Becker Woods	Kentuck L.	108	E	0.10	-	mixed pine, maple
Purdy Lawn	Kentuck L.	1080	E	0.07	0.03	seeded, med. thatch
Gussick Lawn	L. Ninemile L.	975	S	0.14	0.20	seeded, light thatch
Gussick Woods	L. Ninemile L.	720	S	0.15	0.18	birch, white pine
Pfefferkorn Lawn	Butternut L.	440	E	0.17	0.22	sod, heavy thatch
Pfefferkorn Woods1	Butternut L.	420	E	0.16	0.13	cedar, pine
Pfefferkorn Woods2	Butternut L.	130	E	0.16	0.20	cedar, pine
Wear Lawn	Anvil L.	85	E	0.14	0.19	sod, heavy thatch
Wear Woods1	Anvil L.	400	E	0.24	0.16	maple, aspen
Wear Woods2	Anvil L.	385	E	0.23	0.31	maple, aspen
Wear Woods3	Anvil L.	365	E	0.22	0.38	maple, aspen

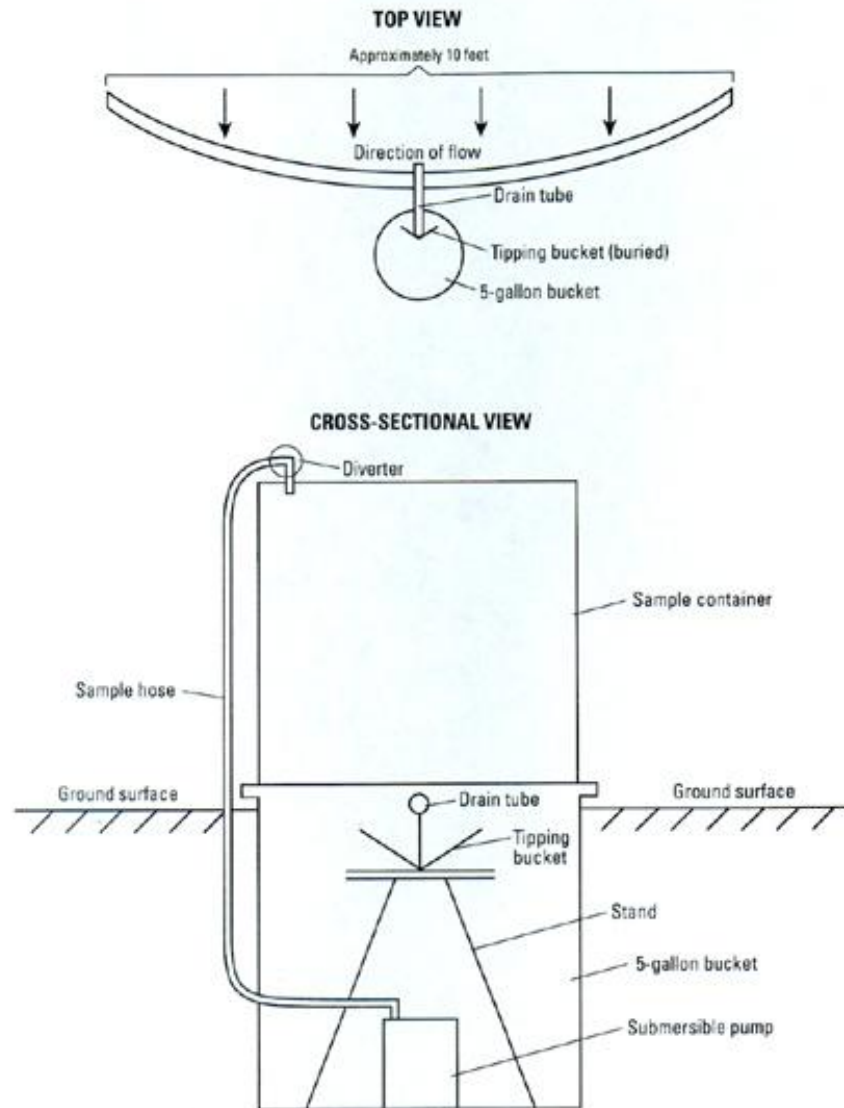
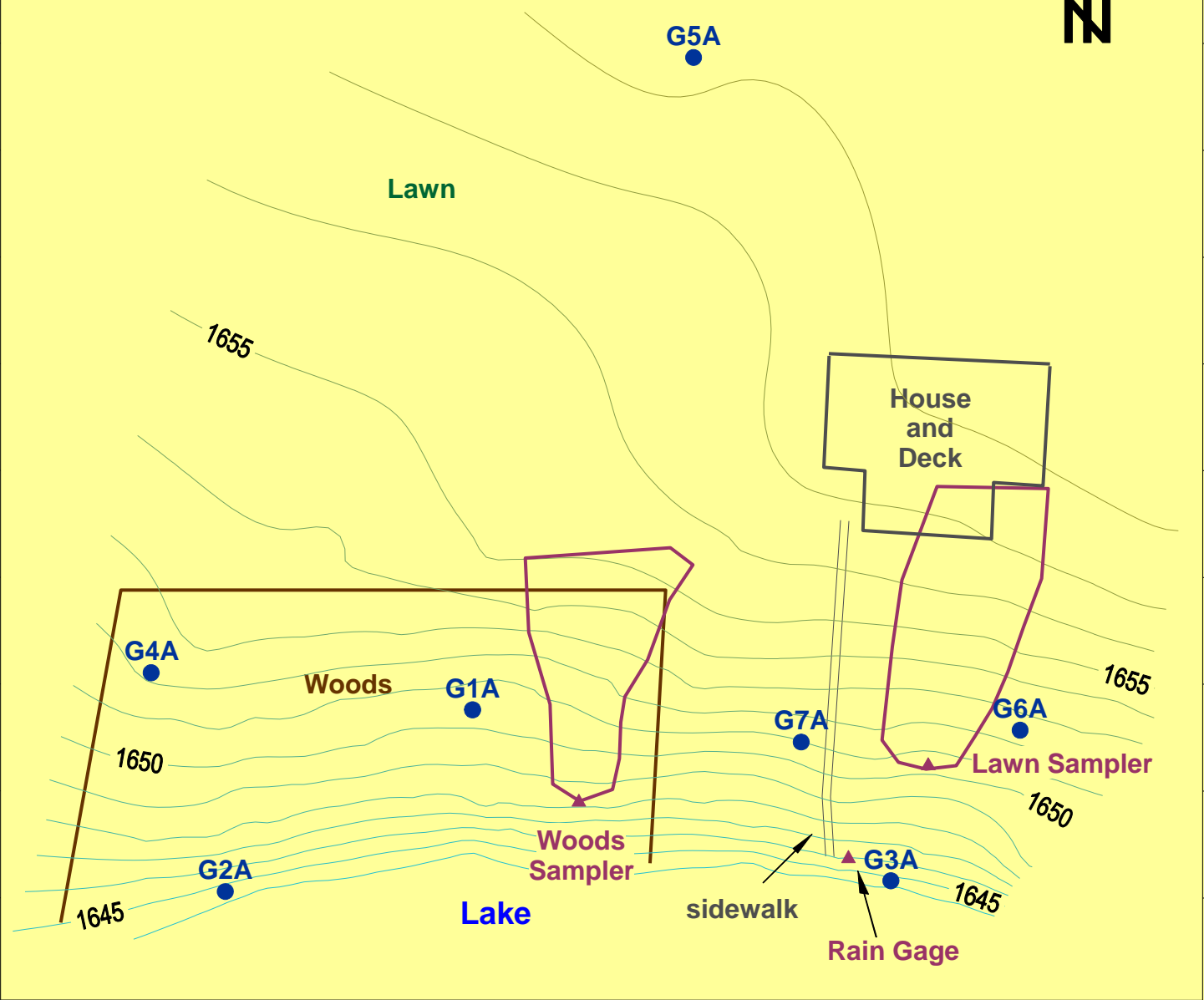


Figure 7. Schematic of automatic surface-water sampler.

Sampling Equipment

Gussick's Base Map

Scale: 1" = 30'









Examples of Lawn Sites

Gussick's residence, Lower Ninemile Lake



Weart Residence, Anvil Lake



Pfefferkorn Residence, Butternut Lake

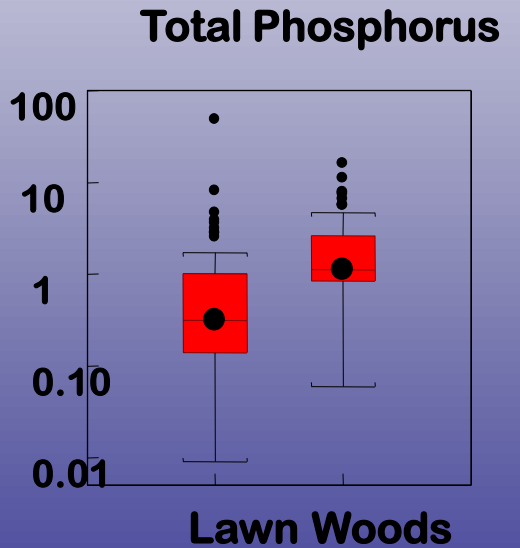
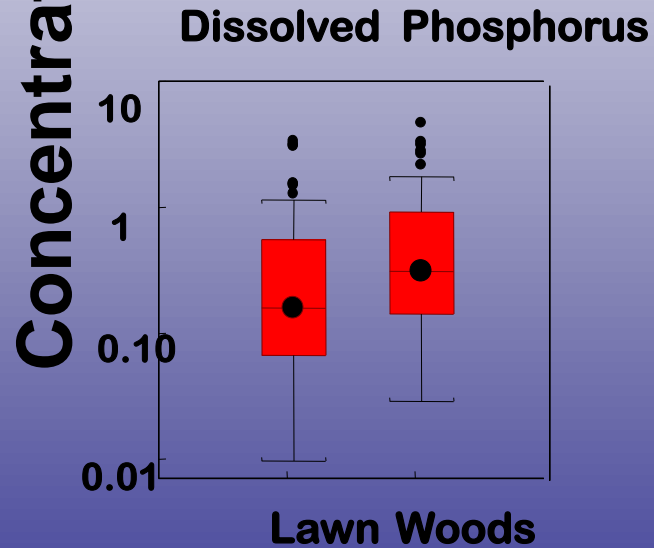
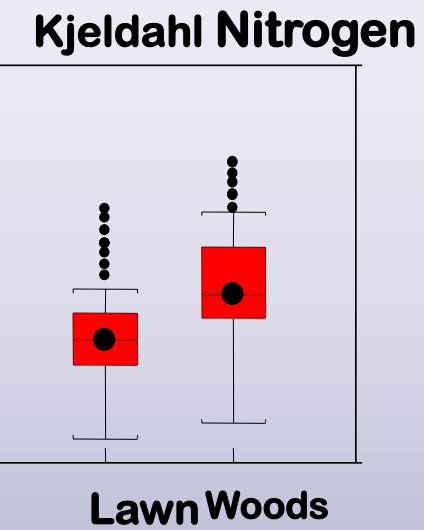
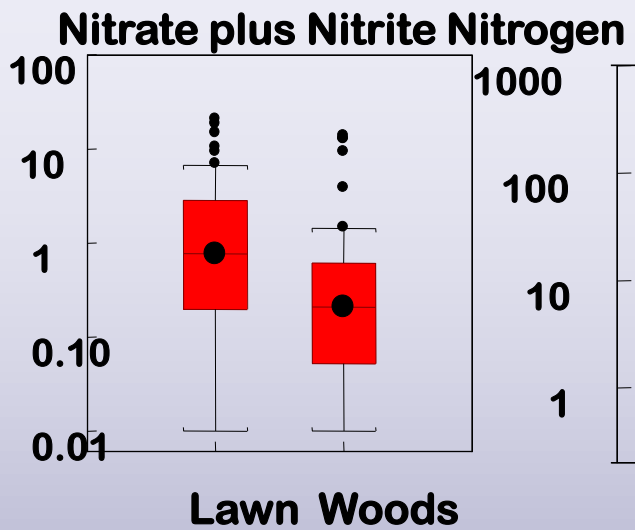
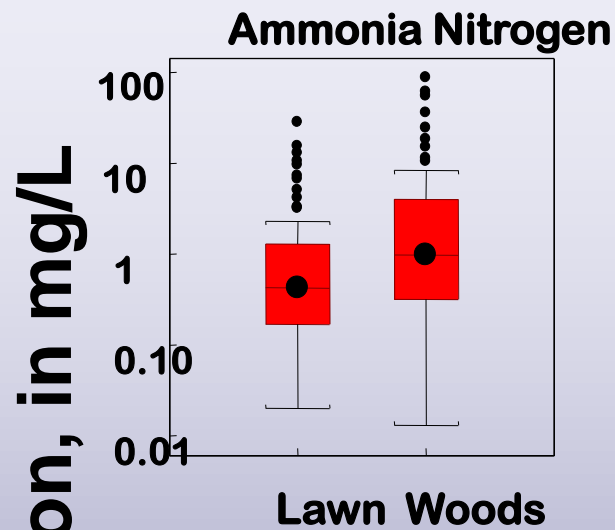
Hydrology

Surface Hydrology Results (2-year period)

Site	Total Precip ¹ (in)	Runoff Producing Rainfall	n	Runoff Volume (ml)	%Runoff from snow	Runoff/ Rainfall % (nonsnow)	Runoff/ Total Precip %
Purdy-Lawn	56.62	22.15	25	4607867	0.05	7.75	3.19
Pfeff-Lawn	56.52	19.89	14	117235	0	0.56	0.19
Gus-Lawn	58.38	19.65	24	1198966	0.33	1.77	0.89
Weart-Lawn	59.23	19.88	10	16915	0	0.42	0.14
Gus-Woods	58.38	5.34	6	22709	0.77	0.05	0.02
Weart- Woods 1	59.23	21.9	10	13125	0	0.06	0.02
Weart- Woods 2	59.23	11.12	5	4640	0	0.04	0.008
Weart- Wood4	59.23	20.27	12	14210	0	0.08	0.027
Pfeff -Wood 1	56.52	26.56	13	15155	0.099	0.05	0.027
Pfeff -Wood 2	56.52	27.71	19	45980	0	0.54	0.26

30 year average for same time period= 57.95 in.

Water Quality Concentrations



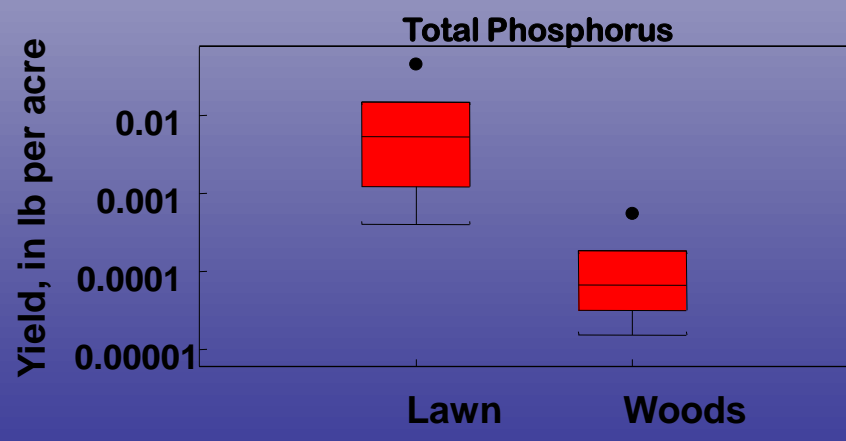
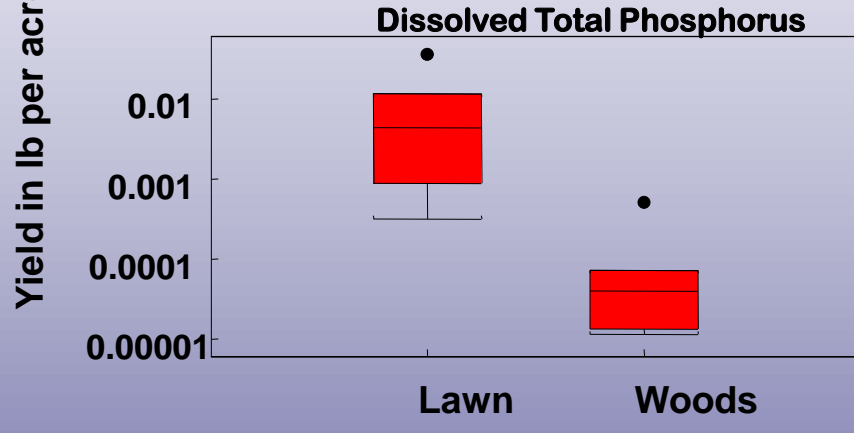
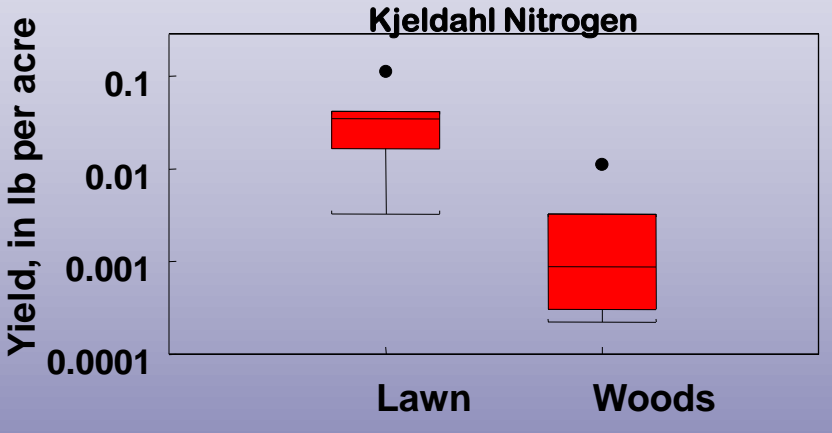
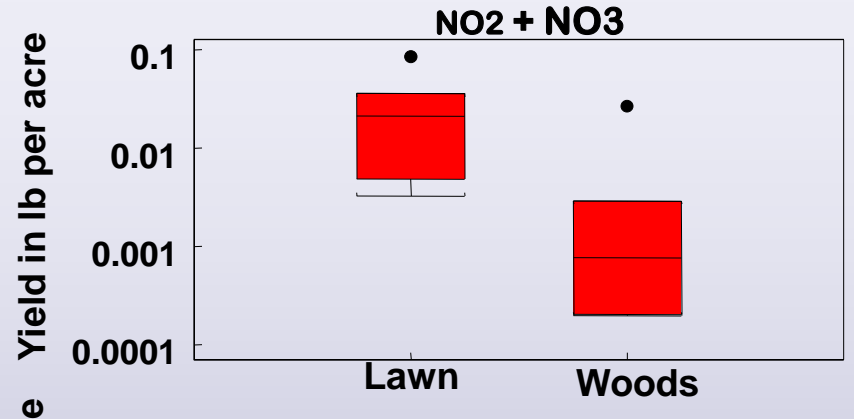
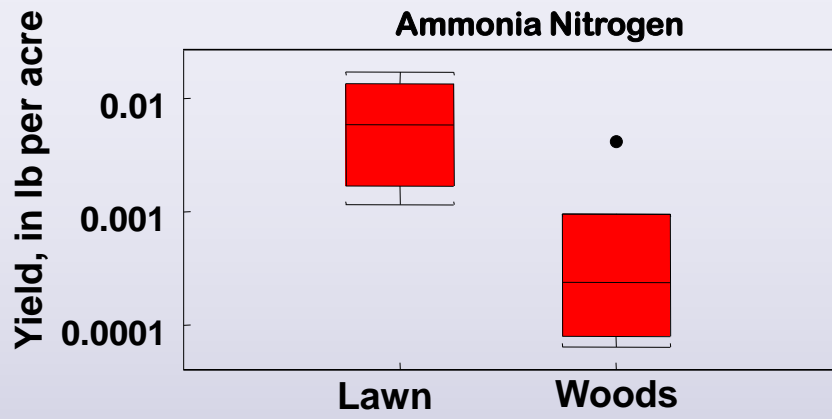
Comparison of Median Nutrient Runoff Concentrations with Past Studies (mg/l)

Citation	Landuse	NH3	NO3	TKN	D-P	T-P
Cole et.al.(1997)	Turf	4	3.5			1.0
King et.al.(2001)	Stream draining turf	0.03	0.5			0.13
Dennis (1996)	Residential					0.22
Garn (2001)	Fer. lawn	1.07	0.12	8.6	0.77	2.85
Garn (2001)	Unfer. lawn	0.63	0.14	5.1	0.38	1.8
Thomann (1987)	Urban			1.3		0.066
Bannerman et.al. (1996)	Urban	0.24	0.49	1.0	0.09	0.29
Barten (1997)	Lawn	3.6	1.5	5.8	1.0	1.45
NURP (1983)	Residential				0.14	0.38
Barten (2001)	Lawn			2.3	0.082	0.27
Our Study	Lawn	0.31	0.28	2.8	0.17	0.32

Garn (2001)	Forest	4.3	0.24	9.8	2.0	4.0
Thomann (1987)	Forest			0.85		0.014
Dennis (1996)	Forest					0.055
Our Study	Forest	0.98	0.21	7.4	0.33	1.12

Nutrient Yields

[Concentration x Water volume]



Gussick Paired Storms

Comparison of Median Nutrient Yields with Past Studies (kg/ha/yr)

Citation	Landuse	TKN	T-P
King et.al.(2001)	Stream draining turf		0.33
Dennis (1996)	Residential		1.75
Rechow et.al.(1980)		5.5	1.1
Panuska,Lillie (1995)	Urban		0.52
Thomann (1987)	Urban	5.0	1.0
Panuska, WiLMS	Rural Res.		0.1
Rechow et.al.(1980)	Residential	2.46	0.2
Barten (2001)	Lawn		
Our Study	Lawn	0.16	0.025
Panuska,Lillie (1995)	Forest		0.09
Thomann (1987)	Forest	3.0	0.4
Dennis (1996)	Forest		0.19
Panuska (WiLMS)	Forest		0.08
Our Study	Forest	0.015	0.003

Summary

- **Surface and groundwater samples collected over a two year period.**
- **Successful in obtaining a number of runoff samples.**
- **Mixed results in delineating differences in concentrations between lawn and woods runoff.**
- **Strong pattern of lawn yields exceeding woods yields (within and between sites).**
- **Location important in explaining differences in yield**



In cooperation with the Wisconsin Department of Natural Resources

Hydrology, Nutrient Concentrations, and Nutrient Yields in Nearshore Areas of Four Lakes in Northern Wisconsin, 1999–2001

Kentuck Lake



Lower Ninemile Lake



Butternut Lake



Anvil Lake

Water-Resources Investigations Report 03-4144

U.S. Department of the Interior
U.S. Geological Survey

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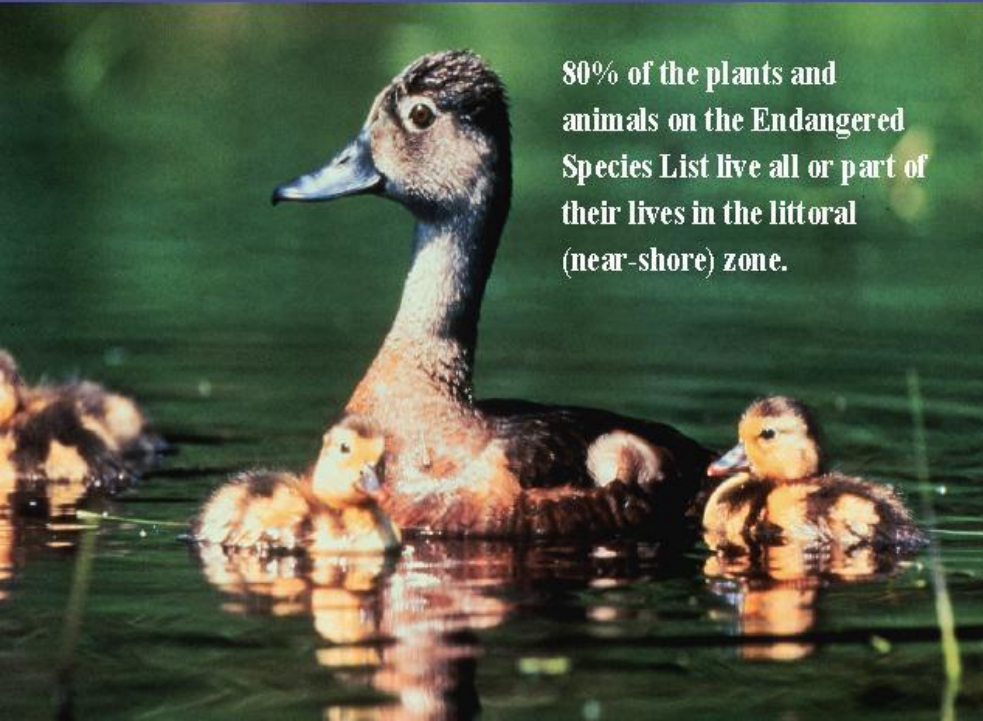
WRIR 03-4144



Impeding surface sheet flow
into buffer areas



The water's edge



80% of the plants and animals on the Endangered Species List live all or part of their lives in the littoral (near-shore) zone.

Acknowledgements
Sandy Gillum
Dave Graczyk
Randy Hunt

