New Jersey Water Resources Research Institute

Annual Technical Report

FY 2000

Introduction

Introduction

The New Jersey Water Resources Research Institute underwent a significant reorganization and revitalization this year, largely as a result of the five-year review conducted by the US Geological Survey. This review stimulated Rutgers University to make a major contribution to the support of the WRRI. The support is in the form of a half-time administrative assistant, funded by the NJ Agricultural Experiment Station, a pledge of financial support for conferences and undergraduate internships, and support for bookkeeping services from the Institute of Marine and Coastal Sciences (the unit of the university in which the WRRI is administratively housed), and matching funding from the central administration of the University to support information transfer activities and student support. These additional funds became available in January, 2001, and thus the activities of the Institute during this past fiscal year reflects the change in financial status of the institute during the second half of the fiscal year.

The research program of the WRRI, was funded this year entirely from the base allotment grant from the USGS. Two faculty-led projects included a study of the molecular mechanisms of mercury methylation (Barkay), reflecting serious mercury contamination problems that have resulted in fish advisories in the acidic waters of the southern part of the state, and a study of the occurrence of alkylphenolethoxylates (APEs) surfactants in wastewater efluents and surface waters of the state (Jahan). Graduate student projects included a continuation of a previously-funded study investigating the use of fish parasites as an index of water quality in the Pinelands ecoregion (Hernandez), a laboratory-scale model system to provide data for the validation of a model of MBTE degradation (Lefkowitz), and a study of the role of hydrology in determining the species richness of sedge savanna communities in the Pinelands (Palmer). In addition, an undergraduate intern was funded to further develop a geomorphological classification of Pineland streams.

During the second half of the fiscal year, the additional funding allowed us to develop an expanded information transfer program, as detailed in the program report.

Research Program

Basic Information

Title:	Factors controlling methlmercury degradation in Pine Barrens lakes
Project Number:	00-02
Start Date:	3/1/2000
End Date:	3/1/2001
Research Category:	Water Quality
Focus Category:	Toxic Substances, Geochemical Processes, None
Descriptors:	methylmercury accumulation, atmospheric deposition, in-lake methylation,microbial demethylation, mer genes, mercury contamination, sediment, aquatic food chain, photodegradation, microbial processes, demethylation
Lead Institute:	New Jersey Water Resources Research Institute
Principal Investigators:	Tamar Barkay

Publication

1. Barkay, Tamar, and Jeffra Schaefer. 2001. Metal and radionuclide bioremediation: Issues, considerations, and potentials. Curr. Opion. Microbiol. 4:318-323.
2. Schaefer, Jeffra, Ruth Dorn, and Tamar Barkay. 2001. Microbial factors controlling methylmercury accumulation in freshwater ecosystems in New Jersey, USA. Materials Geoenviron. 48:219-225. Also presented as a poster in 2 conferences.
3. Schaefer, Jeffra, Jerslow Letowski, and Tamar Barkay. mer-mediated resistance and volatilization of Hg(II) under anaerobic conditions. Geomicrobiology J. submitted for publication.

Factors controlling methylmercury degradation in Pine Barrens lakes and the Meadowlands

Problem and Research Objectives: Mercury concentrations in fish of the Pine Barrens lakes are elevated as a consequence of the atmospheric deposition of mercury (Hg) and in-lake methylation processes (NJ DEP, 1994;Ruppel *et al.*, 1994). A range of tissue concentrations of Hg in fish collected from different lakes suggests that the production of methylmercury (MM) is affected by factors that are unique to each lake. Recent work (Pak and Bartha, 1998) showed similar production rates of MM in the sediments of three Pine Barrens lakes suggesting that transport to, and/or MM degradation in, the water column, may be responsible for between-lakes variability. Availability of MM to the aquatic food chain might be controlled by degradation (and possibly production) of MM in the water column following the flux of MM from sediments. Our research addresses the degradation of MM in water samples and how it is affected by the physical-chemical and biological parameters in Pine Barrens lakes. Samples collected at the Meadowlands, a highly contaminated site where low MM/total Hg (Hg_T) concentration ratios in the water were detected, are included for the sake of comparison.

Two objectives address the hypothesis that MM production is controlled by its degradation in the water column:

(i) To relate the MM concentration and rate of its degradation to the MM/Hg_T ratio.

(ii) To determine if the abundance and expression of bacterial mercury resistance (*mer*) genes in the microbial communities of the lakes control MM production by stimulating its degradation. Enzymes encoded by these genes are known to degrade MM to volatile Hg(0).

Procedures and Methods

Mercury analyses: Total Hg is measured water samples (200 - 500 ml) in Dr. Reinelder's lab by the cold vapor atomic fluorescence spectrometry (CVAFS) technique (Bloom and Fitzgerald, 1988) using a Tekran 2500 CVAFS mercury detector. Dr. Reinfelder is currently setting up his lab for MM analysis. Data for MM concentrations reported here was obtained through a contract with Flett Laboratories, Inc., (Winnipeg, Manitoba).

Physical-chemical parameters: Hand held probes are used to measure pH, temperature, salinity, dissolved O_2, and conductivity in the field during sample collection. Total organic carbon is measured at the laboratory of Dr. Seitzinger at IMCS.

Microbiological and molecular parameters: Routine protocols are used for the enumeration of heterotrophic bacteria and assessment of community diversity(Barkay, 1987). The presence of *mer* genes and their expression are detected by protocols developed in our laboratory (Nazaret *et al.*, 1994). We are currently developing quantitative approaches for gene and transcript detection using a recently purchased quantitative PCR instrumentation.

Principle findings and significance

Samples were collected during Aug. 2000 and Apr. 2001from four Pine Barrens Lakes and from four sites in Berry's Creak in the Meadowlands. The most significant findings are summarized below:

I. An inverse relationship between the proportion of MM in total Hg (Hg_T) and Hg_T concentration has emerged from data collected to date (Fig. 1). It emerged from a large discrepancy in Hg_T concentrations (µg/L for Meadowlands and ng/L for Pine Barrens) with similar MM concentrations (ng/L in both study sites). Others have demonstrated this trend with samples collected from numerous environments. To the best of our knowledge, our hypothesis regarding the role of inducible microbial transformations in MM degradation, is, at present, the only plausible explanation for this "paradox".

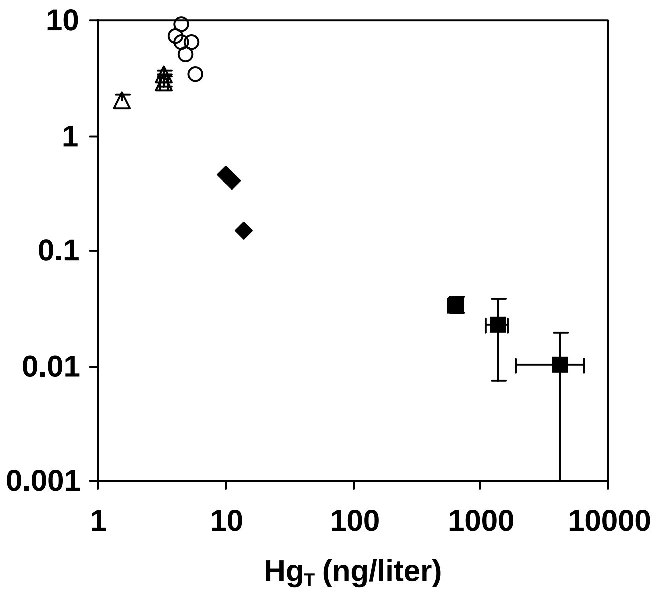


Fig. 1: The relationship between the percent MM in Hg_T and Hg_T concentrations in Pine Barrens samples collected in Aug. 00 (open circles) and in Apr. 01 (open triangles), and in Meadowlands samples collected in Aug. 00 (full squares) and Apr. 01 (full diamonds).

II. Initial analysis of the response of microbial communities to Hg suggests that in the highly contaminated water of Berry's Creek (Meadowlands) the communities are adapted to Hg stress while Pine Barrens communities are not (Table 1). This conclusion is based on: (i) there was a higher tolerance to Hg(II) among heterotrophic bacteria from Meadowlands samples, (ii) the diversity of the resistant bacteria was higher in Meadowlands communities than in Pine Barrens communities, and (iii) *merA* genes specifying the reduction of Hg(II) to Hg(0) were detected in biomass from the Meadowlands but not in biomass from the Pine Barrens (Fig. 2). Physical-chemical measurements showed that the Pine Barrens waters were acidified (pH 4 to 5), had low conductivity (< 50 µS/cm), and no measurable salinity while Meadowlands waters had a neutral pH, conductivity of about 900 µS/cm, and were slightly saline at 0.4 parts per thousand. Remaining parameters, TOC (0.5 – 1 mM) and dissolved O_2 (6.5 – 7 mg/L), were similar for Meadowlands and Pine Barrens samples.

Table 1: Microbiological parameters describing the response of the microbial communities in the Meadowlands and Pine Barrens Lakes to Hg (Aug. 00 sampling).

	Meadowlands sites:			**Pine Barrens sites:**	
Parameter	**MLU**	**MLM**	**MLD**	**PBH**	**PBB**
Total heterotrophs (CFU/ml)	NA[1]	$4.8x10^4$	$2.2x10^4$	NA	$1.6x10^3$
Hg^R heterotrophs (CFU/ml)	$2.8x10^3$	$4.2x10^3$	$1.8x10^3$	NA	
Diversity – heterotrophic community (H')[2]	NA	2.845	2.770	NA	2.659
Diversity – Hg^R community (H')	2.714	2.067	2.311	NA	0.000

[1]NA: Not available – Number of colonies observed was too low to allow determinations.
[2]Shannon-Weaver diversity index, calculated as:

$$H' = -\sum_{i=1}^{S^*} (P_i \ln P_i)$$

$$\text{Where: } P_i = \frac{\text{No. of colonies in a specific morphology group}}{\text{Total No. of colonies analyzed}}$$

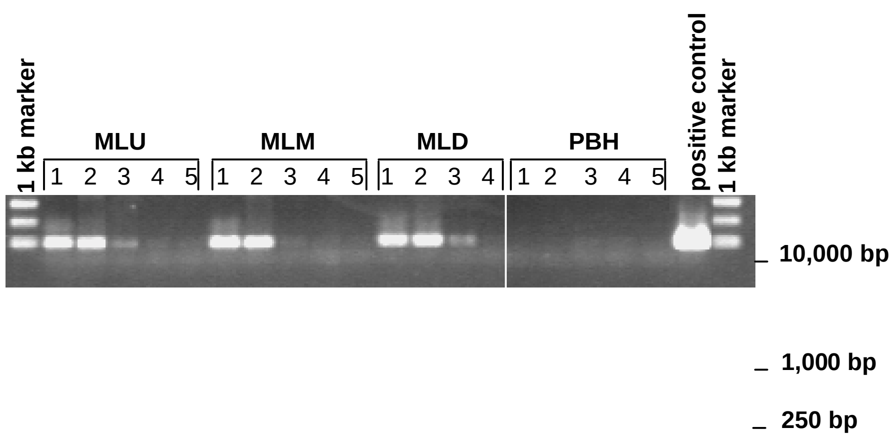


Fig. 2: Results of PCR amplifications using primers targeting highly conserved sequences in *merA*. Ten fold dilutions (dilution factors of 10^1 to 10^5, lanes marked as 1 through 5, respectively) of DNA extracted from the microbial biomass in Meadowlands water (MLU, MLM, and MLD) and in Harrisville Lake (PBH) were amplified and amplification products were separated on 1% agarose gel. Positive control: amplification of DNA from a plasmid carrying a known *merA* gene.

Summary and future directions

Our results show that (i) proportionally more MM accumulates in Pine Barrens Lakes where Hg_T, mostly from atmospheric deposition is at the ng/L concentrations than in Meadowlands waters, and (ii) low population densities of bacteria with the potential to degrade MM were detected in lake water. While these findings provide a tentative support to the hypothesis that in the Pine Barrens active microbial MM degradation is not induced due to low concentrations of inorganic Hg, further and more rigorous support is needed. This support will be obtained by, (i) measuring the rate of ^{14}C-MM degradation, (ii) quantitating *mer* genes and their expression in samples collected at Pine Barrens Lakes and the Meadowlands. The complete sets of data for all microbiological, molecular and physical-chemical parameters will be statistically analyzed to determine which of the measured parameters most significantly affect MM production.

Literature cited

Barkay, T. 1987. Adaptation of aquatic microbial communities to Hg2+ stress. *Applied and Environmental Microbiology* **53:**2725-2732.

Bloom, N. S., and W. F. Fitzgerald. 1988. Determination of volatile mercury species at the picogram level by low-temperature gas chromatography with cold vapour atomic fluorescence detection. *Analytica Chimica Acta* **208:**151-161.

Nazaret, S., W. H. Jeffrey, E. Saouter, R. Von Haven, and T. Barkay. 1994. merA gene expression in aquatic environments measured by mRNA production and Hg(II) volatilization. *Applied and Environmental Microbiology* **60:**4059-4065.

NJ DEP 1994. Preliminary assessment of HgT concentrations in fish from rivers, lakes and reservoirs in New jersey 93-15F. NJDEP.

Pak, K. R., and R. Bartha. 1998. Mercury methylation and demethylation in anoxic lake sediments and by strictly anaerobic bacteria. *Applied and Environmental Microbiology* **64:**1013-1017.

Ruppel, B., A. Stern, and M. Sheil 1994. Mercury concentrations in New Jersey fish. Report of the Toxics in Biota Committee NJDEP, Trenton, NJ.

Basic Information

Title:	Laboratory Scale model of the fate and transport of methyl tert-butyl ether in groundwater systems
Project Number:	00-04
Start Date:	3/1/2000
End Date:	3/1/2001
Research Category:	Ground-water Flow and Transport
Focus Category:	Groundwater, Models, Toxic Substances
Descriptors:	MTBE, methyl tert-butyl ether, groundwater, model, diffusion,
Lead Institute:	New Jersey Water Resources Research Institute
Principal Investigators:	Daniel Lefkowitz, Chris Uchrin

Publication

1. Daniel K. Lefkowitz, Mark Zambrowski, and Christopher G. Uchrin, Spring 2000, Fate and Transport of Methyl Tert-Butyl Ether in Groundwater systems: Preliminary Results, Effluents, Volume: 33, #5.
2. Lefkowitz, D.K., Zambrowski M., Uchrin C.G., Rutgers University, New Brunswick, NJ. Fate and transport modeling of methyl tert-butyl ether in groundwater systems. In Proceedings from the Society of Environmental Toxicology and Chemistry (SETAC), 20th Annual Meeting: Sustaining Global Environmental Integrity, November 14-18th 1999, Philadelphia, PA. pg 263, #PWA239. Lefkowitz, D.K., Zambrowski, M., Uchrin, C.G. Rutgers University, New Brunswick, NJ. Source area diffusivity of methyl tert-butyl ether (MTBE) in groundwater systems. In Proceedings from the Society of Environmental Toxicology and Chemistry (SETAC), 21st Annual Meeting. November 11-14th, Nashville, TN.

Title: Modeling source area diffusivity of methyl tert-butyl ether (MTBE) in groundwater systems

Problem and Research Objectives:

This research focuses on the development of a laboratory fate and transport model which will be critical for predicting source area concentration levels of the gasoline additive, Methyl tert-Butyl Ether (MTBE), in the soil atmosphere. Based on the data generated on fate and transport from an experimental laboratory model, it is possible to develop a mathematical model of the movement of MTBE to human receptors in a variety of soil types. Furthermore, the model developed here could be the focal point for risk assessments or exposure studies which would cover effects on human health and environmental health. The model will be able to provide estimations of the unsaturated zone concentration above an MTBE source, such as groundwater contaminated by a leaking underground storage tank. The advantage of the laboratory model is that important parameters can be validated in the laboratory system which reduce uncertainty in mathematical models. The soil gas concentrations predicted by the model can also be important for effective treatment processes such as soil vapor extraction and air sparging.

Methodology

The first study to be done is a batch study. A batch study involves placing a known amount of soil, water, and MTBE into a sealable vial of known volume. The soil only partially fills the vial, leaving free space above the soil, which is called the headspace. The headspace can be analyzed for MTBE (which volatilizes into the headspace from the liquid) by using a syringe to draw out a gaseous sample and then injecting it into a gas chromatograph (GC; HP 5890, with Flame Ionization Detector). Typically, only a gaseous sample is injected, and then the liquid/soil concentrations are back-calculated using Henry's Law. However, we have developed a method using a Suppelcowax column in the GC which allows us to inject both gaseous and liquid samples. The basic premise behind a batch study is to determine the soil concentration, that is, MTBE that has sorbed onto the solids. This is accomplished by using a simple mass balance: the difference between the initial liquid concentration and the MTBE in the headspace + liquid concentration is the mass on the solids. Initial results and previous studies have shown that MTBE can and will adsorb to some high organic matter soils.

A number of different soil types will be used in this study, which were selected to give a representation of the general soil series found in New Jersey. The first soil used in most of the experiments is Cohansey sand. This is a well-studied sand with a relatively high organic matter content (1.44%). Other soils may include the following: Neshaminy sand, an undetermined shale soil, a farm soil, an acid washed sand, and glacial till taken from the overburden of a fractured rock aquifer in Sussex county.

The final experiment proposed by this research is a flow-through column study. This phase actually consists of several experiments. The first experiment is an attempt to model the source area diffusivity of MTBE through the soil atmosphere. Here, four glass columns are set up of three different heights: 2’, 6’, and 8’ (two sets of each heights). An example of one of these series of columns is pictured in Figure 6. MTBE is injected into the base of the column (through the bottom sealable port), and samples are taken over time using a syringe from the top of the column (through a sealable port at the top) and immediately injected into the GC.

The study will be done at two different soil moistures: 2%, which is represented by air-dried soil (used to maximize porosity), and 33%, which represents field capacity, i.e., close to field conditions.

It is important to note that in the column systems, biodegradation will not be considered. As is shown in the literature due to time/kinetic considerations, as well as the high concentrations that are associated with a source area, we will assume that the loss due to biodegradation will be minimal compared to volatilization and adsorption.

The next column experiment will be done with the columns in a horizontal position. This will allow for the incorporation of gravity effects into the model, and can account for the horizontal movement of MTBE with groundwater.

In order to develop the extraction method, a number of sequential multi-phase experiments were performed. The goal of the first experiment was to select an appropriate extraction solvent and ideal GC column characteristics. An optimum solvent would separate well from MTBE chromatographically, have reasonable recovery (>90%), and be easy to work with. Similarly, an adequate column would be able to support a polar compound, allow for direct aqueous injection without damaging the column phasing, and optimize cost, separation, and sensitivity. These considerations were organized into a three-phase experiment, and were as follows:

- Phase I: Solvent Test
  (octanol, toluene, MEOH, 2-propanol, anhydrous ether, methylene cholride) / Column Test (Suppelcowax, RX100, Volcol)
- Phase II: Solvent extraction from water samples
- Phase III: Solvent extraction from soil samples

Phase I is the determination of the most ideal solvent and column characteristics, upon which Phases II and II are based. Phase II and III test the efficacy and practicality of Phase I. All tests were performed on a Hewlet Packard GC/FID (Gas Chromatograph with Flame Ionization Detector) 5890. The GC gas flow rates were: a carrier gas (N_2) flow rate of 10.53 ml/min, an air flow rate of 317 ml/min, and a hydrogen flow rate of 45 ml/min. The column pressure was maintained at 4 psi, and the injector, detector and initial oven temperatures were 200, 175, and 60^{o}C, respectively. The split ration was 1:4.5, and the temperature program was: 10oC/min up to 100oC, with an initial time of 3.5 minutes and a final time of 1 minute. The total run time was 8.5 minutes.

Phase I involved simply injecting the various solvents on the different columns using 2ml GC vials and a Hewlitt Packard (HP) 7673A autosampler. Phase II involved placing 5ml of solvent and 5ml of various water samples in a 20 ml vial, adding a 25µl spike of MTBE, sealing the vial with a septa and aluminum crimp top caps, and shaking. The shaking was done using a Burrell Wrist Action Shaker (Pittsburgh, PA) model 75, set to a speed of 6. Shaking lasted for 15 minutes, the vial removed, and contents allowed to settle for another 15 minutes. The cap with septum was removed and an aliquot of liquid was placed into the GC vial using a Pasteur Pipette.

Phase III, or the introduction of soil samples, was performed in a similar manner to Phase II. In this case, a 5 gram mass of each soil was put into a 20-ml vial. These soil samples were spiked with 25µl of neat MTBE. Following, 5 ml of solvent was added. The vial was sealed with septa contained in crimp top caps, and shaken as in Phase II. After settling, an aliquot of the supernatant liquid was taken using a Pasteur Pipette, and put into a 2-ml GC vial.

The second experiment determined the partitioning of MTBE in both toluene and water: specifically, the development of a partitioning coefficient, or K_{tw}. To determine partitioning, MTBE, toluene and water were placed in a sealable 20-ml vial, shaken, allowed to settle, and extracted using Pasteur Pipettes. A pictorial representation can be found in Figure 1. Initially, 5 ml of toluene and 5 ml of de-ionized (DI) water were input to the vial. Then a 25 µl volume of MTBE was injected via syringe, and the vial was sealed using a septum and a crimp top cap. The vial was then placed in the wrist-action shaker, agitated for 15 minutes, removed from the shaker, and allowed to settle for another 15 minutes. Then the crimp top was removed, and using a Pasteur Pipette, a 2 µl aliquot was removed from the two layers of liquid (water on the top and toluene below), and put into GC vials. These samples were then placed into the autosampler and run on the GC/FID. Additionally, appropriate blanks of both DI water and toluene were run, and an MTBE calibration curve was established. Thirdly, and always critical in method development, was the determination of detection limit for MTBE in both de-ionized water and toluene, and the introduction of surrogate, benzene for quality assurance purposes. Various concentrations of MTBE in de-ionized water and toluene were run on the GC, using the aforementioned HP autosampler and GC/FID. All samples were prepared in 100-ml vials and then distributed into 2-ml GC vials. Each of the nine different concentrations were repeated 10 times, along with toluene and de-ionized water blanks. The final stage tested of the method on actual field samples. This was done on a number of soils: a well studied reference soil, Cohansey sand, taken from the Kirkwood-Cohansey aquifer outcrop in Chattsworth, NJ (the characteristics of which can be found in Table 1), a local Rutgers University Farm soil, and soil obtained from Byrum Township, NJ (characteristics to be determined). The method is identical to
Phase III in the first experiment.

PRINCIPAL FINDINGS AND SIGNIFICANCE:

Several of the proposed experiments have preliminary results. As is seen in

Figure 1, MTBE partitions both to the water and vapor phase. As the concentration in the headspace decreases, the aqueous concentration generally increases until equilibrium (following Henry's Law).

Figures 2 and 3 demonstrate the uptake of MTBE to two different soil types. The data in Figure 2 are from experiments done using Cohansey sand, and in Figure 3, Neshaminy soil.

Results from the column study, in which MTBE vapor diffused through different lengths of glass columns filled with Cohansey sand, can be seen in Figure 4. It is interesting to note that the breakthrough times of MTBE were not linear with respect to length of column. Whereas the four foot column showed breakthrough of MTBE vapor at about five hours, the six and eight foot columns had breakthrough at 20 and 55 hours, respectively. This experiment will be run again at different temperatures, soil moistures and column lengths.

To further quantify the diffusivity of MTBE from a source area, more column experiments will be performed. The first is to change the soil type. We intend to use not only the Cohansey, but also a Neshaminy sand and a glacial till taken near Cranberry Lake in Byrum Twp., NJ. The column experiments at the different lengths (including duplicates of each) and soil moistures will be repeated for each soil type.

Following the vertical diffusivity experiments, we will orient the columns horizontally to determine the effect of gravity, and to investigate horizontal flow. The experiments will be repeated as before.

Results from the extraction experiment can be seen in Figures 5 and 6. Here, it is shown that toluene is an adequate extraction solvent both in recovery and separation from MTBE.

FIGURE 1. CONTROL RESULTS

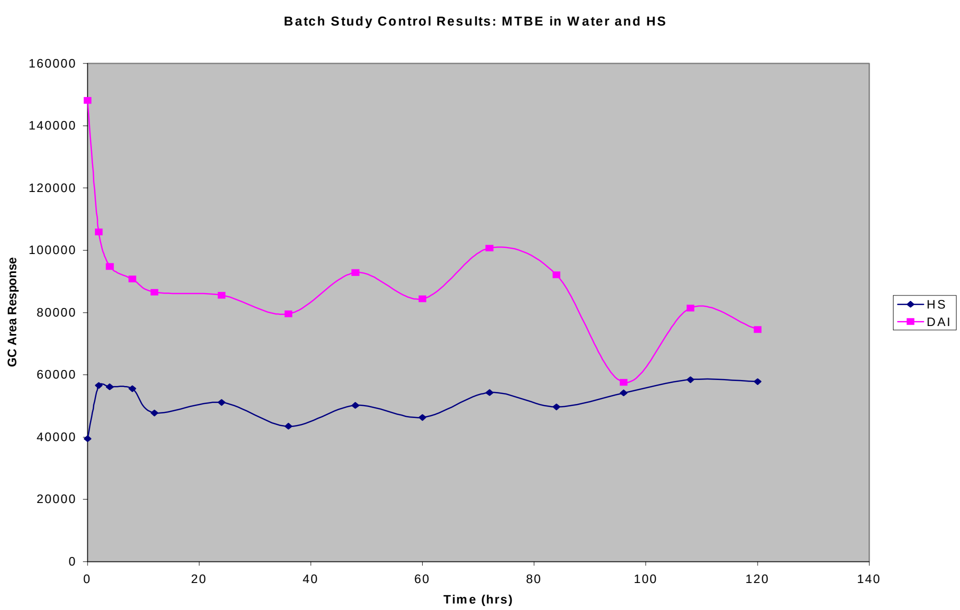


FIGURE 2. UPTAKE OF MTBE TO COHANSEY SAND

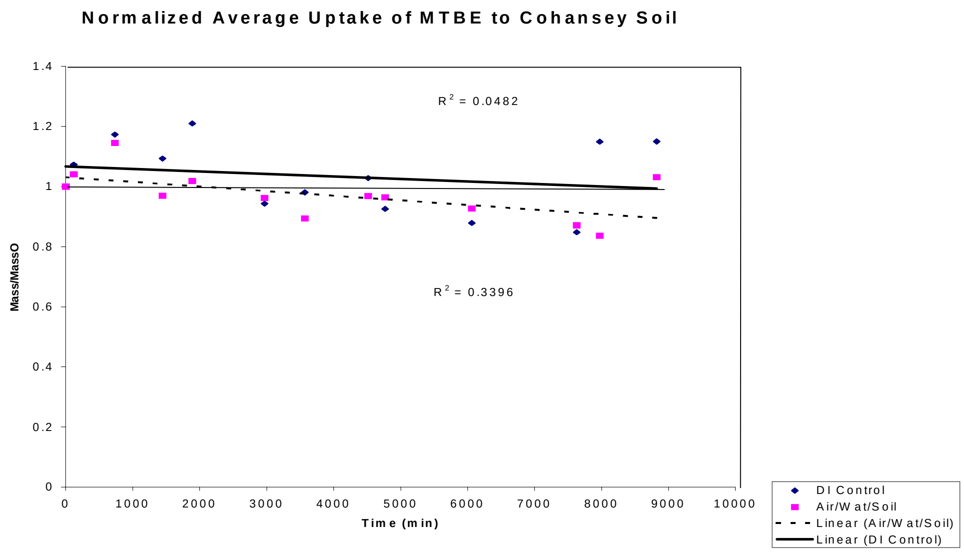


FIGURE 3. UPTAKE OF MTBE TO NESHAMINY SOIL

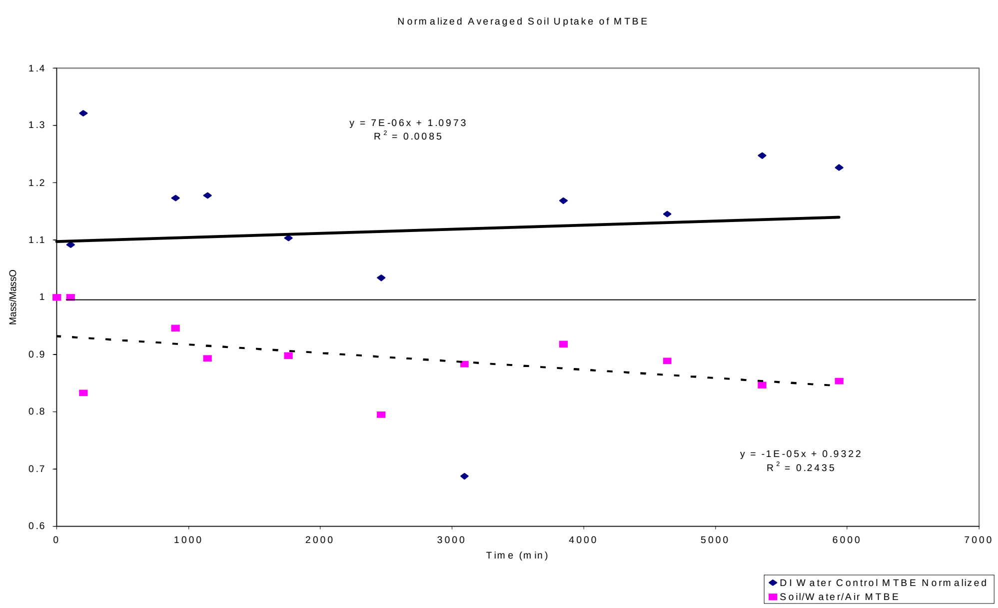


FIGURE 4. COLUMN RESULTS

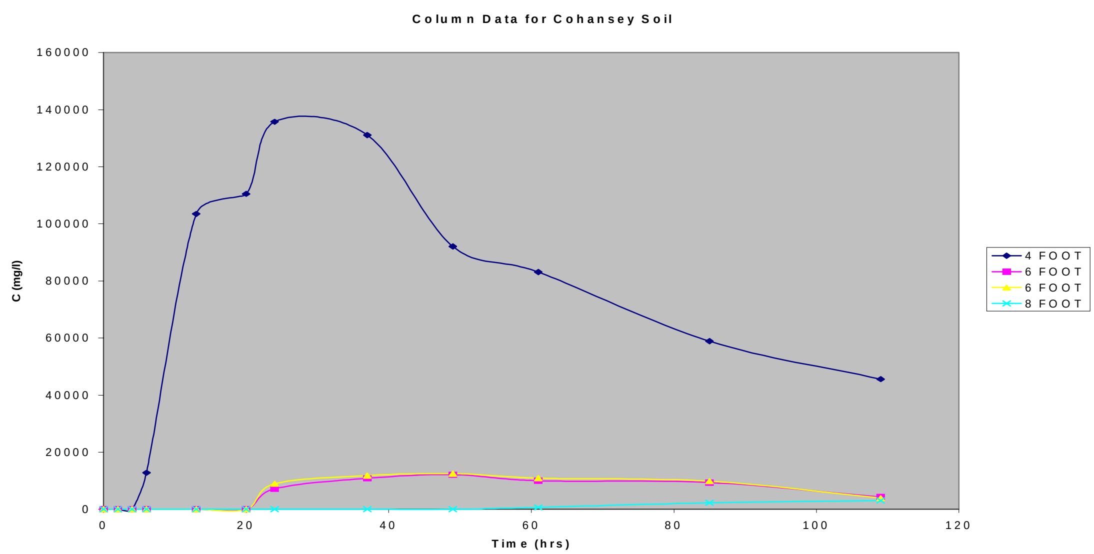


FIGURE 5. PHASE II RESULTS.

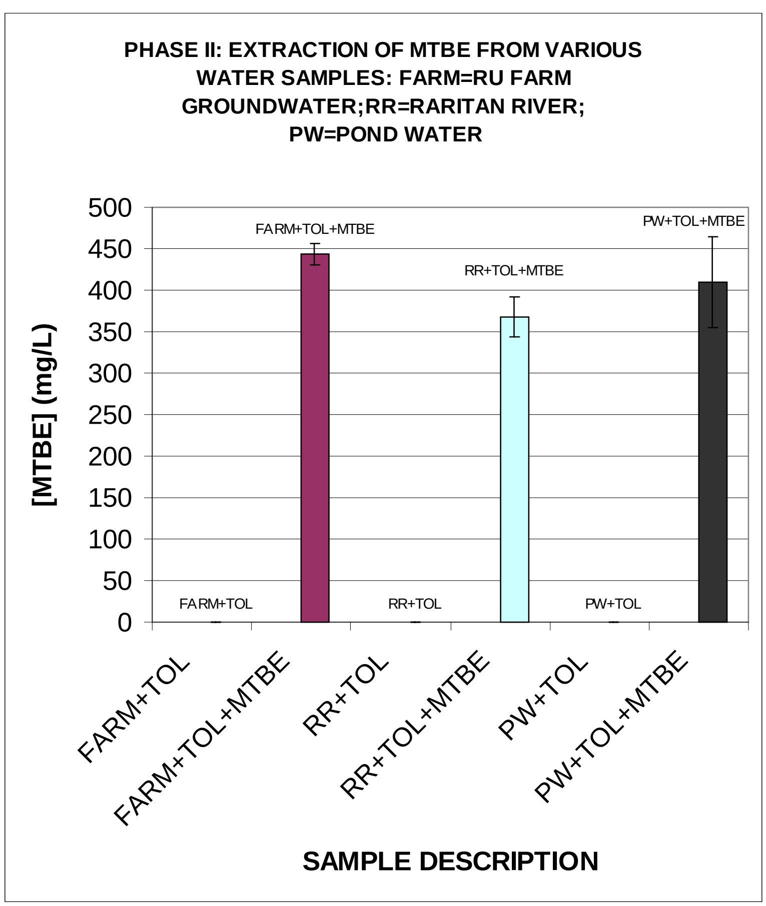
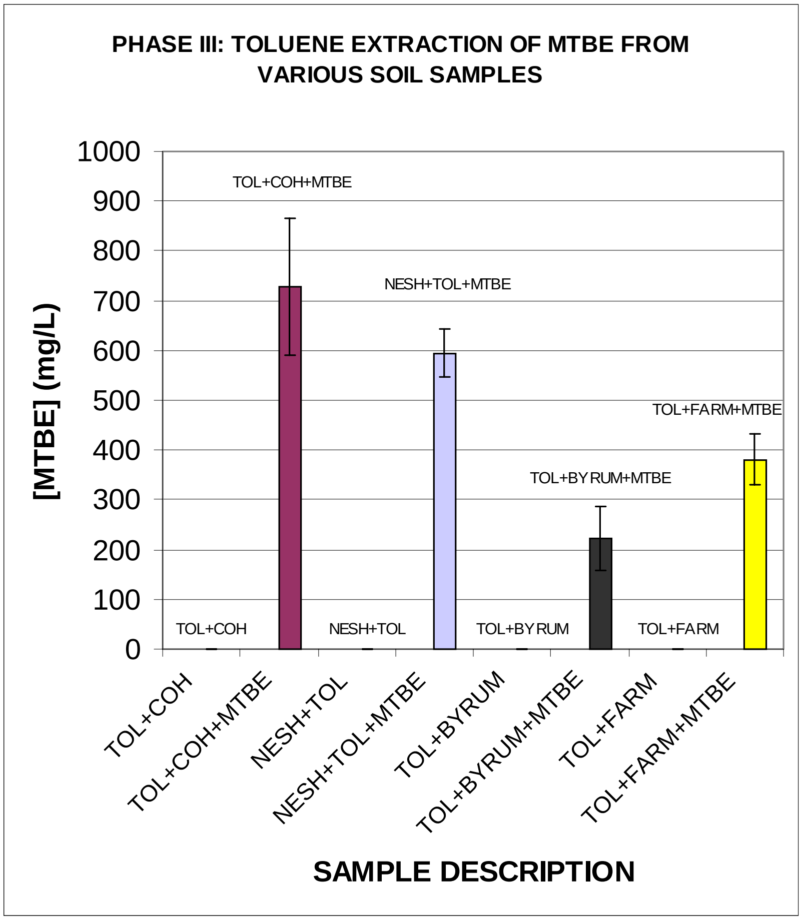


FIGURE 6. PHASE III RESULTS.



Basic Information

Title:	Hydrology and plant diversity in Pine Barrens savanna wetlands
Project Number:	00-06
Start Date:	3/1/2000
End Date:	3/1/2001
Research Category:	Climate and Hydrologic Processes
Focus Category:	Wetlands, Hydrology, Conservation
Descriptors:	hydrology, poor fens, microtopography, diversity patterns, savanna, ecosystem, flooding, hydrology, nutrient, community structure, nitrogen, phosphorus,
Lead Institute:	New Jersey Water Resources Research Institute
Principal Investigators:	Matthew Palmer, Joan G. Ehrenfeld

Publication

1. No publications have been submitted at this time

Document 2

Project Information:

Problem and Research Objectives:

Pine Barrens savannas are a unique and largely unstudied ecosystem type that occur along the river corridors of the New Jersey Pine Barrens. A preliminary community classification (Walz and Palmer, unpublished data; see Olsson 1979 for an earlier classification) describes several plant communities which fall along an apparent hydrological gradient. At the wet end of the gradient is a relatively low biomass/low diversity system dominated by aquatic or semi-aquatic vegetation (typically *Orontium aquaticum*, *Juncus pelocarpus*, and *Drosera intermedia*). At the dry end of the gradient is a relatively high biomass/moderate diversity system dominated by shrubs and grasses (typically *Andropogon glomeratus*, *Gaylussacia dumosa*, and *Pinus rigida*). In intermediate areas, a moderate biomass/high diversity system dominated by sedges, grasses, and forbs (typically *Rhyncospora alba*, *Muhlenbergia uniflora*, and *Lophiola aurea*) occurs. These savannas are associated with several rare species, including one federally listed species (*Rhyncospora knieskernii*) and one federal candidate species (*Narthecium americanum*) and are a very high conservation priority for the state of New Jersey (Tom Breden, NJ Natural Heritage Program, pers. comm.).

One of the most striking features about the vegetation of savannas is the distribution of species along a microtopographic gradient. Each of the communities described above has a distinct pattern of hummocks and hollows and an associated vegetation pattern. At the lowest topographic positions, hummocks tend to be small, low, and relatively species poor. In the mid-gradient, sedge-dominated areas, the hummocks are larger, more discrete and species rich. The hummocks at the highest points in the savanna tend to be the largest and the highest, and frequently support several shrub species. This research further investigated how these microtopography patterns relate to site hydrology and community structure.

While the majority of the savannas are on protected state land, they are still vulnerable to changes in hydrology that may be caused by development in the watershed. One of the major perceived threats to the system is succession to lower diversity shrubland or forest (McCormick 1979). Historical records (Stone 1911, Harshberger 1916) indicate savannas may have been more widespread than their current distribution. Shrub succession has been implicated in the recent decline of several savanna species, including *Narthecium americanum* (Dodds 1996). By studying the relationship of site hydrology and patterns of hummock development and community structure, we can establish the specific mechanism by which changes in hydrology might affect diversity within savannas.

This research initiated the establishment of a hydrologic record for a rare and unique wetland ecosystem in the state of New Jersey and examined the relationship between hydrology and some components of community structure. This research will advance scientific understanding of the relationship between flooding, microtopography, and community structure (including diversity). Further, it will aid future conservation and management decisions concerning New Jersey wetlands.

Methodology:

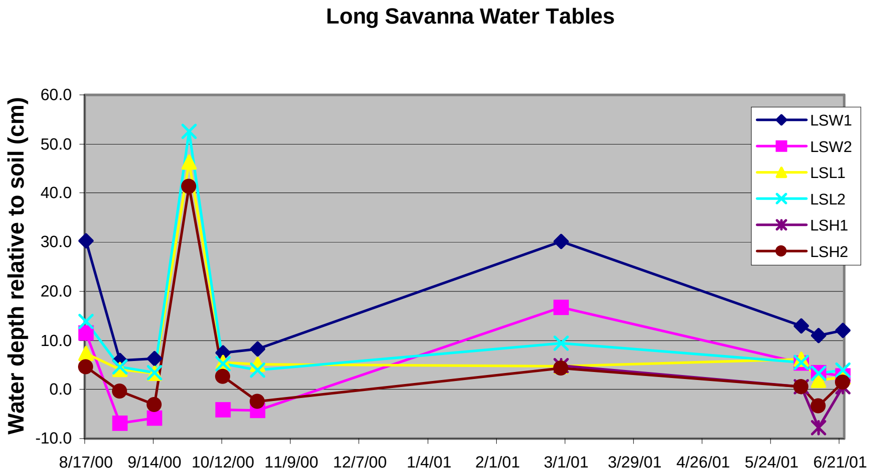
Hydrology**:** To document changes in hydrology through the season and across both community types and across sites, I installed a network of PVC water table wells in each of three sites on three different rivers (the Batsto, the Mullica, and the Nescohague). The water table wells are slotted along their length and inserted into the peat. By measuring the depth to water inside the wells, I can determine the elevation of the water table relative to the soil surface and to the water table in other points within the same site. Water levels were measured biweekly in late summer and autumn, sporadically over the winter, and biweekly again in the spring.

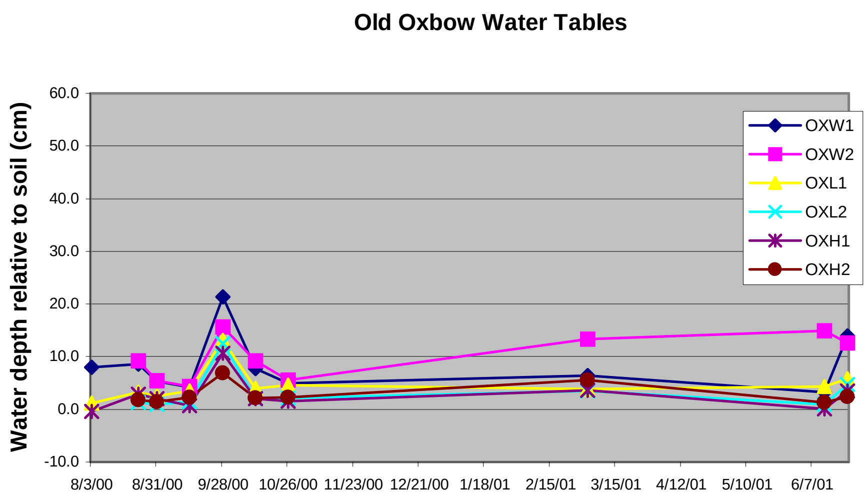
Microtopography: To characterize the microtopographic patterns of the different community types, I established 1 m^2 plots at random points on transects crossing through relatively homogeneous patches of continuous habitat. For each plot, I measured the dimensions (maximum length, maximum perpendicular width, and 4 height measurements) of the two largest hummocks within the patch. To quantify the surface heterogeneity, I measured the distance from the soil surface to a level line every five cm along two perpendicular 1m transects across the plot. The variance of these numbers was then used as an index of heterogeneity for the plot.

Vegetation: For each of the hummocks measured in the plots, I recorded presence/absence data for all bryophytes and vascular plants. I further recorded the species present in two comparably sized hollows for each plot. To consider vegetation patterns on the square meter-scale (as opposed to the hummock scale), I then recorded the presence of any species not already recorded on the sampled hummocks or hollows.

Principal Findings and Significance:

The hydrology data revealed two important and unexpected patterns. First, the sites are not deeply flooded during the winter and early spring (as expected) but are seasonally quite stable, with the water table near the soil surface for much of the year. Flooding related to particular storm events (e.g the mid-September high water in Figure 1) may be an important ecological factor, but the timing of these events is fairly unpredictable. Continued monitoring (including the use of automated datalogger wells which were installed in spring 2001) will allow me to develop a more complete record of the frequency and duration of flooding in these wetlands. The unpredictable nature of flooding in these habitats may have important consequences for the plant community (e.g. an early season flood may have different effects on seedling mortality than a late season flood), and this temporal heterogeneity may be an important part of maintaining the diversity within these systems.





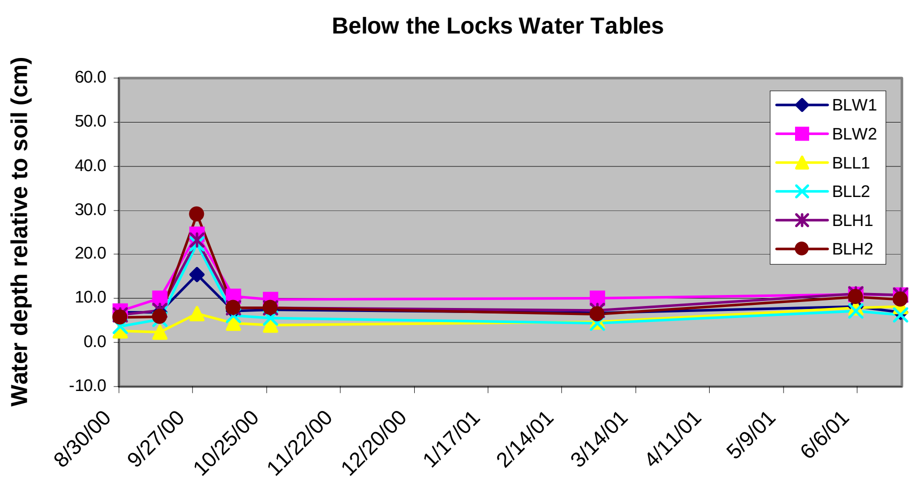


Figure 1. Water table data from three Pine Barrens Savanna wetlands.

The second important pattern which emerged from the hydrology data was that the water table was at or above the level of the soil in the hollows 94% of the time (147 of the 157 well readings). The water table was within 5 cm of the soil surface 98% of the time (154 of 157 readings). This indicates that the soil in these wetlands is saturated almost constantly, regardless of season or precipitation patterns. Other hydrology research (performed in collaboration with the NJ Geological Survey and the NJ Natural Heritage Program) indicates that these wetlands are groundwater fed, which explains their rather constant water table. The communities sampled usually lie along a gentle elevation gradient within the savanna and the well data support that this gradient is present in both the soil surface and the water table.

The distribution of community types along a site-wide elevation gradient largely fit the expectation that the communities a high degree of microrelief occur at the higher points along that gradient while the communities with low relief were at lower points along that gradient. One site, however (Below the Locks, on the Mullica River), had an atypical distribution of community types. One section of the site had high relief (large hummocks), even though it was at a lower relative elevation than the other portions of that site, and the highest measured elevation in that site was dominated by the low relief, small hummock community. This pattern require further investigation, but we do know that this particular site has had an extensive disturbance history that may have contributed to the current distributions of communities.

These results suggest that the distribution and maintenance of these communities are regulated to some degree by the regional water table. If the near-constant saturation and the frequent flooding are preventing the growth of woody plants (generally reviewed by Bedinger 1979 and under current investigation in these savannas), then the maintenance of groundwater flows and regional water tables are critical factors in preventing shrub succession and the associated loss of diversity.

The microtopography data show that the diversity varies significantly between all four landscape features measured. Species richness is highest (mean=18.3 species/hummock) on hummocks in the high relief community, followed by the low-relief hummocks (11.5 species). The high-relief hollows had an average of 7.3 species and the low-relief hollows were the most species poor at 5.3 species/hummock. All four means are significantly different from each other at the $p<0.05$ using the Student-Newman-Keuls test. This data supports the notion that microtopography is an important factor in determining species distributions and that both hummocks and hollows vary in species richness between community types.

Another pattern that emerged from the microtopography data was a hump-backed relationship between hummock size and species richness. While the sample size was insufficient to quantify the decline in species richness on the largest hummocks, the data do clearly show a sharp increase in species richness from the smallest sizes (about 0.025 m^2) to hummocks of about 0.3 m2. After that size is reached, species richness begins to decline. I am currently investigating this pattern further.

Finally, there is a clear hump-backed relationship between topographic heterogeneity and species richness (Figure 2). I interpret this relationship to mean that hummock development increases diversity to a certain point, beyond which continued hummock development facilitates a decline in diversity. I propose that this relationship is driven by changes in competitive interactions as hummocks grow beyond a certain size. I am currently investigating the role of hummock size in determining the strength of competitive interactions, and the role that hummock size may play in the effects of shrubs, which are limited to the largest hummocks. The data provided by the work reported here is a valuable starting point to a more comprehensive understanding of diversity and hydrology relationships within Pine Barrens savannas.

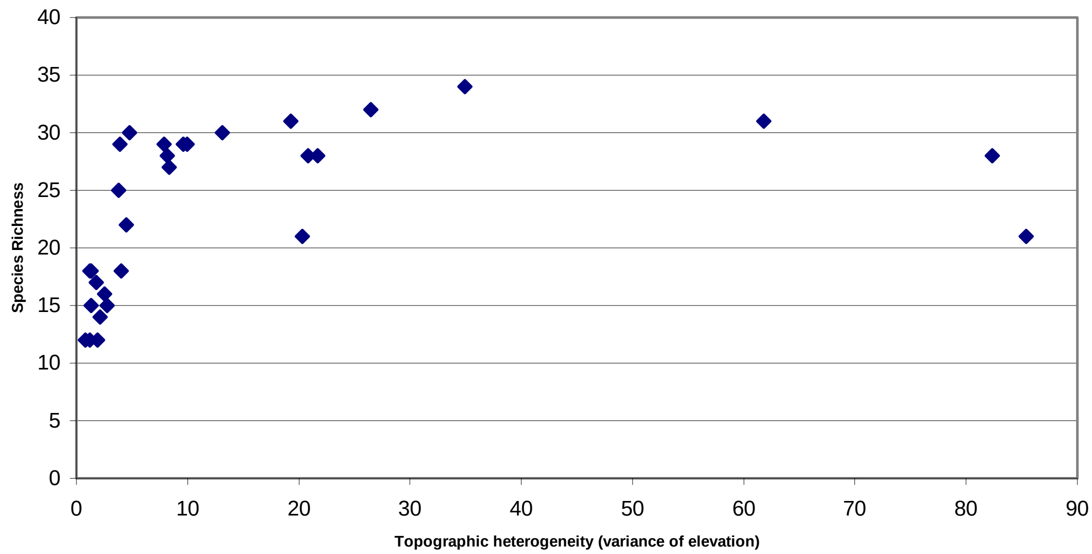


Figure 2. Topographic heterogeneity – species diversity relationship in Pine Barrens wetlands.

Literature Cited

Bedinger, M.S. 1979. Relation between forest species and flooding, in Wetlands Functions and Values: The State of Our Understanding. P.E. Greeson, J.R. Clark, and J.E. Clark, eds. American Water Resources Assoc., Minneapolis, MN. pp. 427-435.

Dodds, J. S. 1996. Influences of changes in hydrology and succession on Narthecium americanum populations in New Jersey. New Jersey Department of Environmental Protection, Division of Parks and Forestry, Office of Natural Lands Management, Trenton NJ.

Harshberger, J.W. 1916. The Vegetation of the New Jersey Pine Barrens: and Ecologic Investigation. Christopher Sower, Philadelphia PA.

Mitsch, W. J., and J.G. Gosselink. 1993. *Wetlands, 2e.* Van Nostrand Reinhold, New York, 722 p

McCormick, J. 1979. The vegetation of the New Jersey Pine Barrens. In *Pine Barrens: Ecosystem and Landscape,* R.T. Forman ed. Academic Press, New York, 601p.

Olssen, H. 1979. Vegetation of the New Jersey Pine Barrens: A Phytosociological Classification. In *Pine Barrens: Ecosystem and Landscape*, R.T. Forman ed. Academic Press, New York, 601p.

Stone, W. 1911. The Plants of Southern New Jersey, with Especial Reference to the Flora of the Pine-Barrens and the Geographic Distribution of the Species. Annual Report of the New Jersey State Museum, 1910. Pp.25-828. Trenton.

Basic Information

Title:	Role of Peat in the Development of River Morphology
Project Number:	00-07
Start Date:	3/1/2000
End Date:	3/1/2001
Research Category:	Biological Sciences
Focus Category:	Geomorphological Processes, Wetlands, Ecology
Descriptors:	stream geomorphology, peatlands, wetlands, NJ Pine Barrens, hydrology, streamflow, ecosystem, reach, type reach, pet
Lead Institute:	New Jersey Water Resources Research Institute
Principal Investigators:	Claude M. Epstein, Eric J. Baumgarten

Publication

1. A paper entitled "Application of Rosgen Analysis to the New Jersey Pine Barrens" has been accepted for publication in the Journal of the American Water Resources Association
2. Two conference lectures based on this research have been or will be given on this work. The first was in 2000 for an invited paper at a "Conference of Pine Barrens Research in the United States" given at Brookhaven National Laboratories. The second will be at this year’s fall conference on "Wetlands" given by the U.S. Environmental Protection Agency in Atlantic City.

Document 2 :

Project Information

Dr. Claude M. Epstein
Richard Stockton College of New Jersey

Objectives:

1. **Determine how the presence of peat in and adjacent to the stream channel effects stream channel morphology.**
2. **Determine how the presence of peat effects stream type used in Rosgen Analysis (D.L. Rosgen, 1996).**

Methodology:

1. **Select stream reaches along the Oswego River and its tributaries and at each reach determine Rosgen stream type, peat depth profile perpendicular to the stream channel, and survey the water table change from stream floodplain to stream channel.**
2. **Review parameters used in Rosgen analysis, particularly channel width to depth ratio, entrenchment ratio, sinuosity and stream slope, and see what departure from a typical stream type sequence occurs with the presence of peat in and adjacent to the stream channel.**

Principal Findings & Significance

1.) **Stream types for most streams analyzed using the Rosgen method progress from A- to B- to C- stream types from a stream's source to its mouth. A- and most B- types do not exist along the Oswego River stream network.**
2.) **The typical progression along the Oswego River & its tributaries is from dry gravelly sand sloughs to E7 and DA7 stream types to C7, DA5, and C5 stream types and ending in C4, C5 and B5c stream types.**
3.) **The presence of peat creates the E7, DA7 and C7 stream types. The presence of peat results in lower channel width to depth ratios and higher entrenchment ratios than found either upstream or downstream from them.**
4.) **Ground water recharge occurs along the upper reaches of the Oswego River and its tributaries. This is contrary to the expectation that streams are source of groundwater discharge.**
5.) **Anthropogenic activities result in departures from the expected "natural" stream types. These activities include dam and bridge construction, deposition of roadbed sediments in channels, ditching for flood control along roads, and cranberry agriculture.**

Code	W/D Ratio	Entrench. Ratio	Channel Material	Water Slope	Sinu-osity	Stream Type
Oswego Trunk Stream						
101	23.58	2.28	sand & gravel	0.0183	1.07	C4
102	20.23	1.44	Sand	0.0028	1.16	B5c
104	21.07	>3.39	sand & gravel	0.0088	1.04	C4
105	18.36	>2.63	gravelly sand	0.0058	1.14	C5
107	6.44	>5.26	peaty fine sand			DA5
107	7.96	>5.55	gravelly sand			DA5
108	3.80	>28.57	hemic peat	<0.0010		DA7
108	2.75	>24.27	sapric peat			DA7
108	7.74	>30.77	sapric peat			DA7
Buck Run						
201	10.56	6.55	Sand	0.00219	1.07	E5
Breeches Branch						
306	8.17	5.97	sapric peat			DA7
Papoose Branch						
401	15.00	>8.33	sapric peat		1.04	C7
402	29.54	>6.27	sapric peat	0.0050	1.04	C7
411	25.00	1.50	sapric peat		c1.01	DA7
Plains Branch						
501	5.05	>20.00	sapric peat	0.00539	1.08	E7
505	23.72	13.08	sapric peat &f.sand		c.1.01	DA7
506	31.70	5.88	sapric peat &f.sand		c.1.01	DA7
511	15.24	1.50	fine sand & peat		c.1.01	DA7
Dry Branch						
602	15.78	2.13	gravel & sand	0.0040	c.1.01	B4c/C4

Table . Rosgen Parameters of "Natural" Channel Reaches

Basic Information

Title:	Occurrence of Nonylphenolethoxylate (NPE) Surfactants and their Metabolites in New Jersey Rivers and Wastewater Treatment Plants
Project Number:	00-02
Start Date:	3/1/2000
End Date:	3/1/2001
Research Category:	Water Quality
Focus Category:	Toxic Substances, Waste Water, Water Quality
Descriptors:	Surfactants, Nonionic, Nonylphenol, Fate, Transport
Lead Institute:	New Jersey Water Resources Research Institute
Principal Investigators:	Kauser Jahan

Publication

1. Jahan K, J. Everett, J. Orlins, R. Hesketh, S. Farrell, M. Savelski, K. Hollar, L. Head and R. Ordonez (2001) " Research Experiences for Undergraduates in Pollution Prevention", Submitted for presentation and publication at the 2001 Mid Atlantic Fall Conference, November, Staten Island, New York.
2. Shah, V., Ordonez, R., K. Jahan. and R. Ramachandran "Nonlinear System Identification of Nonylphenol Biodegradation", Submitted for presentation and publication, 2001 IEEE CCA/ISIC Conference, Mexico City, Mexico, Sept. 2001.
3. Jahan, K, Marcus Roorda, Shira Perlis and Margaret Jacques, (2000) "Nonylphenol Ethoxylates in Sewage Treatment Plants", Submitted for presentation and publication, 2001 WEFTEC Latin America, San Juan, Puerto Rico.
4. Jahan, K, Marcus Roorda and Margaret Jacques, (2000) "Nonylphenol in Sewage Sludge", Accepted for presentation and publication, 2001 IWA Specialized Conference on Sludge Management, Acapulco, Mexico.
5. Jahan, K, Marcus Roorda, Shira Perlis and Margaret Jacques, (2001) "Nonionic Surfactants in Wastewater Treatment Plants", Accepted for presentation and publication, 2001 Water Environment Federation Annual Conference, Atlanta, GA.
6. Jahan, K, Marcus Roorda, Shira Perlis and Margaret Jacques, (2001) "Fate of Nonionic Surfactants in the Environment", The 6th International Symposium on In-Situ and On-site Bioremediation, San Diego, CA.
7. Jahan, K, Marcus Roorda and Margaret Jacques, (2000) "Nonylphenol and its Metabolites in Sewage Sludge", Proceedings of the Sixteenth International Conference on Solid Waste Technology and Management, Philadelphia, Pennsylvania.
8. Jahan, K. and Ahmed T., "Fate and Transport of Nonionic Surfactants in Wastewater Treatment Plants", Proceedings of the 32nd Mid-Atlantic Industrial and Hazardous Waste Conference, Troy, NY, June 2000.
9. None as work is still under progress

OCCURRENCE OF NONYLPHENOLETHOXYLATE (NPE) SURFACTANTS AND THEIR METABOLITES IN NEW JERSEY RIVERS AND WASTEWATER TREATMENT PLANTS

Problem Statement and Research Objectives:

Recently a certain group of widely used APEs were banned in Europe because scientists discovered that APE intermediates bioaccumulate in aquatic organisms. Recent evidence that some APE intermediates are estrogenic has intensified concern over their environmental and human health effects. Throughout northern Europe a voluntary ban on APE use in household cleaning products began in 1995 and restrictions on industrial applications are set to follow by the year 2000. APEs are nonionic surfactants made up of a branched chain ethylene oxide to produce an ethoxylate chain. The main alkylphenols used are nonylphenol (NP) and octylphenol (OP). Nonylphenol ethoxylates (NPEs) encompass about 80% of the world market, and octylphenol ethoxylates (OPEs) represent most of the rest. They have been used extensively for their effectiveness, economy and ease of handling and formulating for more than forty years. They function as emulsifiers, wetting agents and dispersants. The primary industrial uses of APEs are for emulsion polymerization and polymer stabilization in plastics and elastomers; cleaning, spinning, weaving, and finishing of textiles; wetting agents and emulsifiers in agricultural chemicals; and pulping and de-inking in the paper industry. Institutional use of APEs are confined to cleaning products, and most are found in commercial laundry detergents, janitorial products, and vehicle cleaners. In the household market, APEs are used mainly in laundry detergents and hard-surface cleaners. Most APEs enter the aquatic environment from wastewater treatment plant discharges. The United States produces 600 million pounds of NPEs, with a 2%-3% increase annually, which comprises half of the total NPE production globally.

Biodegradation accomplished by stepwise shortening of the ethoxylate chain creates a complex mixture of compounds that can be divided into three main groups: short-chain ethoxylates, alkylphenoxy carboxylic acids, and alkylphenols such as NP and OP. As the chain becomes shorter, the molecule becomes less soluble. The alkylphenoxy carboxylic acids and longer chain APEs are soluble in water; the shorter chain APEs are insoluble in water; particularly NP and OP, have low water solubility and tend to adsorb onto suspended solids or sediments. Most studies and regulations focus on NPEs, because these are the most widely used. Nonylphenol (NP), one of the breakdown products, is also approximately 10 times more toxic than its ethoxylates.

More research on the fate and transport of APEs in the environment is essential. This study attempts to characterize the occurences of NPEs in the river waters, sediments and wastewater treatment plants of New Jersey. This will be an extremely valuable supplemental study as the state of New Jersey has a strong industrial base comprising of pharmauceuticals, chemical manufacturers and food industries. All these industries are major users of this class of surfactants that are undergoing bans in Europe. The findings from these field studies at various wastewater treatment plants and rivers located in New Jersey will have a major impact on the regulatory aspects of APEs. Results of this study will be a significant contribution not only for researchers in New Jersey but all over the U.S. by indicating whether APE degradation products could be problematic or not. The results of this research will be significant in shaping the future of regulations on surfactant production, use and disposal.

Methodology:

Eight major secondary wastewater treatment plants were selected for this study. Plants selected are located in the north, central and southern parts of the state. The plants selected for this study are presented in Table 1 along with their location, average discharge and sludge treatment type.

Table 1: List of Wastewater Treatment Plants

Treatment Plant	Location	Discharge (MGD)	Sludge Treatment Type
Bergen County Utilities Authority	North	79	Anaerobic Digestion
Passaic Valley Sewerage Comm.	North	284	Zimpro Wet Air Oxidation
Rahway Valley Sewerage Authority	Central	30	Anaerobic Digestion
Middlesex County Utilities Authority	Central	140	Lime Stabilization
Trenton Sewer Utilities	Central	13.8	Anaerobic Digestion, Incineration
Atlantic County Utilities Authority	South	31	Aerobic Digestion
Camden County MUA	South	57	Lime Stabilization & Incineration
Gloucester County Utilities Authority	South	18	Aerobic Digestion / Incineration

Wastewater influent and effluent composite /grab samples were collected. Grab samples of sludge were collected from the wastewater treatment plants. Nonylphenol and Tergitol NP-4 standards were purchased from Fluka. All reagents (n-hexane, isopropyl alcohol, tetrahydrofuran) were HPLC-grade. Sludge/wastewater samples were analyzed for NP by normal phase HPLC. The HPLC analyses were carried out using a Hewlett Packard (Model 1190) liquid chromatograph consisting of an automatic injector, built-in diode array detector and a UV detector. The system was supported by Hewlett Packard HPLC Chemstation software. Wastewater samples (2 L) or sludge samples (2 grams) in 2-L of DI water were extracted using liquid-liquid extraction with 2 mL of cyclohexane in an exhaustive steam distillation unit (Model #6555-13, Ace Glass, Vineland, NJ). The entire procedure was adopted from the methods (ST-38.34-94) developed by C. Naylor (Huntsman Chemical, Austin, TX, USA). Samples were collected in summer and analyzed in triplicates. The wastewater influent and effluent samples were also analyzed for nonionic surfactants using the CTAS method (Standard Method). Key parameters in addition to conventional parameters such as pH, CBOD, COD etc. were identified. These included temperature and surface tension. Surface tension measurements were carried out because surfactants have the ability to lower surface tension and thereby stabilize the liquid film around air bubbles. Therefore, their presence can lower the oxygen transfer efficiency in the aeration tanks. Temperature measurements were required, as biodegradation of APEs is highly temperature dependent

Results:

The results of the CTAS studies in influent and effluent of wastewater treatment plants in New Jersey is presented in Figure 1.

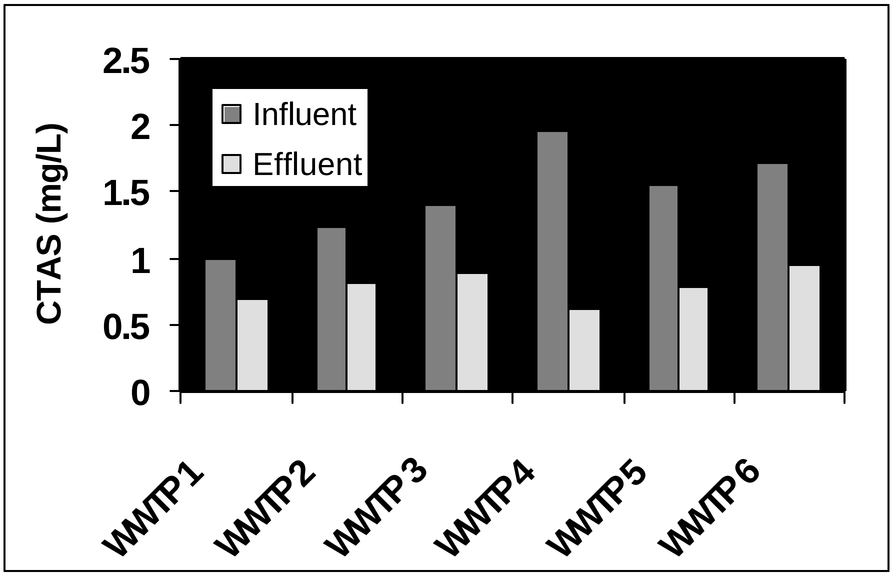


Figure 1: Nonionic surfactants in wastewater treatment plants

The corresponding surface tension data is reported in Figure 2.

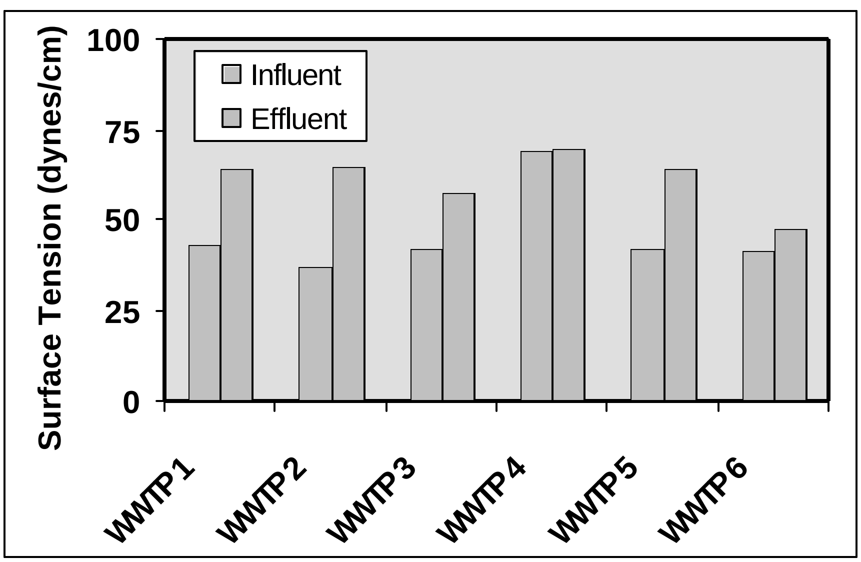


Figure 2: Surface tension in wastewater treatment plants

Monitoring data from the wastewater plant indicate that the nonionic surfactants are not being efficiently removed as compared to data reported from other studies. Current literature indicates that nonionic surfactants specifically the nonylphenol ethoxylates are significantly accumulated in digested sewage sludge and are also found in significant quantities in river sediments close to the wastewater treatment plant point of discharge. Currently analyses are in progress for measuring concentrations of nonyphenol and mono- and di- nonylphenol ethoxylates in wastewater, sludge, river water and river sediments.

Basic Information

Title:	NJ Pinelands Native Fish Biology: Parasites as Biological Tags
Project Number:	00-05
Start Date:	3/1/2000
End Date:	3/1/2001
Research Category:	Biological Sciences
Focus Category:	Ecology, Methods, Water Quality
Descriptors:	native fish, parasites, biological indicators, bioindicators. biotic integrity, banded sunfish, disturbance, habitat degradation, helminths, Phyllodistomum, ecosystem
Lead Institute:	New Jersey Water Resources Research Institute
Principal Investigators:	Alexander D. Hernandez, Michael V. K. Sukdeo

Publication

1. Hernandez, A.D., J. Bunnell, R. Zampella and M.V.K. Sukhdeo (In Prep. to be submitted to Freshwater Biology). Parasite diversity as a measure of habitat degradation and stream integrity.
2. Hernandez, A.D. and Sukhdeo, M.V.K. 2001. Environmental disturbance and the incidence of parasitism in local and invasive fish species. American Society of Parasitologists, Albuquerque, New Mexico.

PROBLEM AND RESEARCH OBJECTIVES:

We examined the parasites that infect native and non-native fish from streams in the Mullica River, which is watershed located within the New Jersey Pinelands. The Pinelands is a region of over 1 million acres of forests and farms nestled in the center of one of North America's most populous regions; it lies between the New York City and Philadelphia metropolitan areas. High acidity and low concentrations of dissolved solids are, among other variables, characteristic of minimally disturbed streams in this region. However, an increase in urban and agricultural landscapes near forestlands threatens the preservation of Pinelands biodiversity by reducing stream acidity and increasing dissolved solid concentrations. These environmental changes are directly linked to the degradation of native fish species habitat, and may subsequently disrupt the life cycle of their parasites. In addition, these changes can permit the invasion and survival of non-native Pinelands fish species introduced by people living adjacent to the Pinelands. It has been suggested that introduced species could displace some native species through direct biotic interactions (e.g. competition). However, it is not known whether introduced fish species could displace natives indirectly by also introducing parasites that are more pathogenic to the native fish species.

Our main objective was to investigate whether parasites are useful as indicators in the study of river health or biotic integrity, specifically in streams in the Mullica River watershed. We address changes in the diversity of parasites infecting banded sunfish (*Enneacanthus obesus*) living in modified and low-impact streams. In addition, we compare the diversity of parasites infecting introduced centrarchid fish (e.g. bluegill sunfish, pumpkinseed sunfish, and largemouth bass) and banded sunfish living in modified streams. We address the questions of whether parasites infecting fish are good indicators of ecosystem function, and if they should be included in studies that assess river health. Our rationale is that the integration of several different measures of river health, including parasite diseases, should be explored. The study of river health now acknowledges the value of multiple scientific perspectives over a simple scientific tradition or in one particular group of taxa.

METHODOLOGY:

Fish sampling

Fish were collected from modified and low-impact streams using seine or electroshock. Abiotic parameters including pH and conductance were collected. Data on fish sex, total length and weight, and prevalence and intensity of infection for each parasite species was recorded.

Examination for parasites

Each fish was given a unique accession number based on its species name and site of collection. Fish sex, total length (mm), and weight (g) were recorded before necropsy. The entire fish was examined for parasites using standard parasitological methods. Parasites were identified to genus when possible, and otherwise to family using the keys of Hoffman (1999).

Data Analysis

Taxonomic richness is frequently used as a robust indicator for assessing biotic integrity in rivers and, because its usefulness has been demonstrated in the past, we chose to use parasite species richness (S) as one of our measures of diversity. Each host sampled was considered a replicate within each site. Thus, we calculated an S value for each host and, subsequently, a mean S value (and its variance) for each site or type of host (i.e. native or introduced fish species). Statistical comparisons were made using Kruskal-Wallis test since data failed a normality and equal variance test. When possible, a post-hoc multiple comparisons test was done (Dunn's Method). Significance for comparisons was set at $\alpha=0.05$.

PRINCIPAL FINDINGS AND SIGNFICANCE:

A combined total of 13 different parasites were found in fish examined, and of these, 12 were identified to genus. The presence of these parasites in fish meant that the other intermediate or definitive hosts in the life cycle of each parasite were present in the streams. Of the 13 parasite species, only 4 occur in low-impact streams, and modified streams have all 13 species (Table 1). Standard methods of diversity (e.g. species richness) reflects the greater diversity of parasites that are found in centrarchids in modified Pinelands streams (Figure 1). The increase number of parasites in modified streams may be a direct result of thee greater number of non-native (introduced) host species that live there. The increase number of fish in modified streams is a direct result of the environmental changes occurring due to land use patterns by humans.

In modified sites, introduced fish have a greater diversity of parasites than native banded sunfish (figure 2). When parasite diversity was compared between banded sunfish (natives) in modified and low-impact streams, we found significantly greater diversity in those fish from modified streams (Figure 3). Some of the parasites that don't occur in low-impact streams are infecting the native banded sunfish in modified sites. Clearly, host switching is possible for these parasites, but it is not known whether they are more pathogenic in the native fish. Studies that measure the direct cost of increased parasitism on native versus introduced fish are needed.

Fish disease or condition is already incorporated into IBI, but there are more types of parasites occurring in fish besides those visible on the skin and these should be considered as well. Multimetric indices are being used by various state and federal agencies in the U.S., and in various geographic regions throughout the world. These indicator programs are snapshots of population and community structure, but the next generation of indicator programs must examine how well ecosystems are functioning. Parasites can fulfill this role admirably because many have complex life cycles that require movement through hosts at multiple trophic levels. Examination of fish for parasites and the presence of certain types of parasites in the fish, demonstrates that not only are all ecosystem components present, but that these components are functioning properly. The presence of these parasites in the fish cannot occur without the presence of the appropriate intermediate hosts. Our results suggest that the higher number of parasite taxa with complex life cycles present in fish from modified sites reflects that all of the appropriate intermediate hosts are present and that the functional relationships between all of these organisms are working.

Table 1. Parasite species found in low-impact (pristine) and modified (disturbed) Pinelands streams.

PRISTINE STREAMS	DISTURBED STREAMS
Acanthocephalus sp.	*Acanthocephalus* sp.
Phyllodistomum sp.	*Phyllodistomum* sp.
Cystidicola sp.	*Cystidicola* sp.
Nematode 2	Nematode 2
	Fessisentis sp.
	Neoechinorhyncus sp.
	Crepidostomum sp.
	Clinostomum sp.
	Neascus sp.
	Pisciamphistoma sp.
	Posthodiplostomum sp.
	Ascaridida
	Pseudophyllidea

Figure 1. Parasite species richness in centrarchids from modified (disturbed) and low-impact streams (pristine).

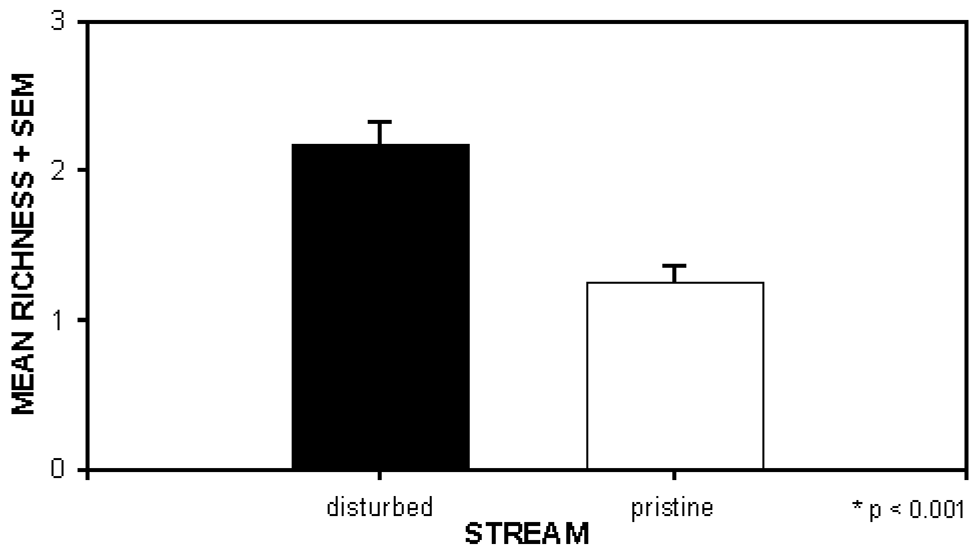


Figure 2. Parasite richness between native and introduced centrarchid fish found in modified streams of the New Jersey Pinelands.

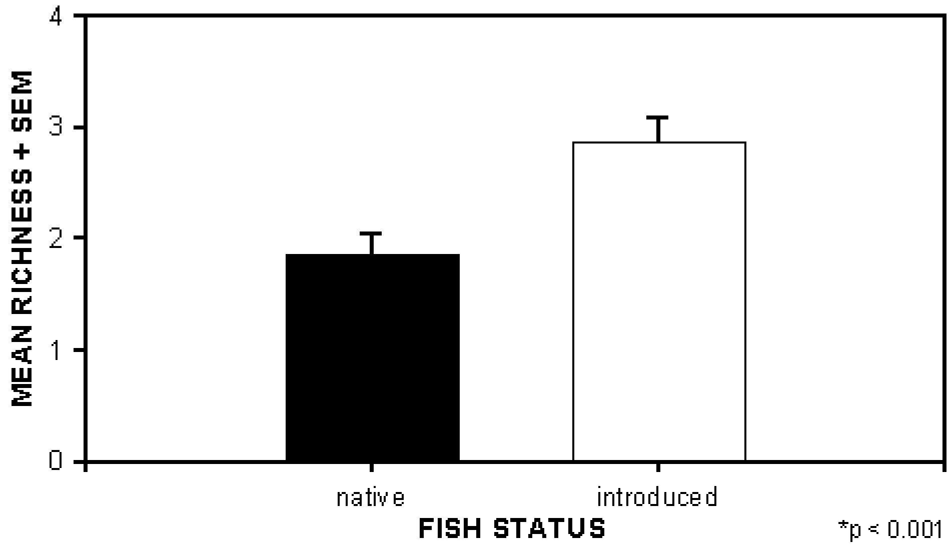
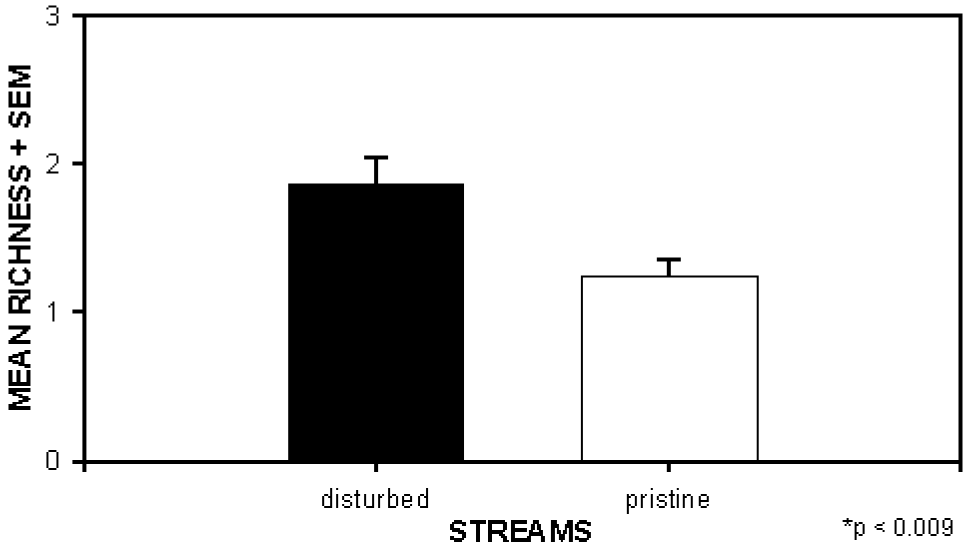


Figure 3. Parasite species richness in native centrarchids from modified (disturbed) and low-impact streams (pristine).



Information Transfer Program

Basic Information

Title:	Information Transfer Program
Start Date:	3/1/2000
End Date:	3/1/2001
Descriptors:	newsletter, New Jersey Flows, watershed management, website, Common Waters
Lead Institute:	New Jersey Water Resources Research Institute
Principal Investigators:	Joan G. Ehrenfeld

Publication

Information Transfer Program

(note: The Director was on sabbatical leave during fall semester, 2000, (July – December) and therefore was not actively involved in maintaining an information transfer program during this period. The activities listed below represent activities for the period January 2001 – May 2001.)

(a) Administrative Assistant

As a result of the matching funds committed to the WRRI by the University, I was able to hire a half-time administrative assistant for the program. I was fortunate to locate Ms. Jeannine Der Bedrosian, who has not only a broad-based background in water science (water chemistry, aquatic biology), but a strong personal interest in and commitment to water resource protection. She has considerable experience in organizing school-based stream monitoring programs, and is actively involved with the watershed management planning process. Her time is spent approximately 75% on information transfer activities and 25% on program and research administration.

(b) Newsletter

We started publication of a new quarterly newsletter, titled "New Jersey Flows," greatly expanding the content and scope of the publication compared to its previous version (produced until the budget cuts of the 1990's).

The newsletter is planned to carry several regular columns in alternate issues, including (1) an update on water-related research activities at the NJ DEP Division of Science and Research, (2) an update on water-related research activities at the USGS – Trenton District Office, (3) an article by the State Climatologist on notable aspects of recent weather, as it affects water resources, (4) an article describing one of the 20 watershed management units of the state, written by a member of the planning staff for that unit (our goal is to acquaint readers with the diversity of watersheds present in the state), and (5) a brief article by the P. I. of a recently-completed project, describing the research results in terms suitable for a lay audience. The other issues are planned to explore one issue in some depth, with articles solicited from a variety of sources (depending on the topic).

We have produced two issues of the newsletter thus far, and are actively developing the materials now for the third issue. The first issue carried the research update and watershed description articles, and received a strong positive response from the public. The second issue was devoted to the propose changes in the rules for the Freshwater Wetlands Protection Act which NJ DEP is considering. These rule changes have provoked a considerable amount of public controversy. The newsletter carried an article by the lead administrator at NJDEP responsible for writing the rules, and commentaries on the rules by representatives of the environmental community, the home builders' association, and the environmental consulting community. The issue was highly successful in bringing to the public the range of issues that are at stake in wetland management, and the various arguments that are being advanced to modify the proposed rules.

The issue currently being assembled will follow the research update format. The fourth issue is planned to address water education programs for K-12 schools, and will again rely on articles written by a variety of people who are running different kinds of programs.

The newsletter goes out to a mailing list of about 1,200 names, including representatives of planning boards, environmental commissions, environmental consulting firms, etc. We are actively working on expanding this list.

(c) Seminars in Water Resources

We have planned to use some of the funding supplied by the University to support a series of seminars and professional visits by outstanding scholars in water resource issues. Dr. Joy Zedler, a leading wetland ecologist and expert in wetland restoration, was invited by a member of our Advisory Council to give the first such lecture this spring. She gave a public lecture on the Newark campus of Rutgers University, visited several sites of wetland restoration in the Hackensack Meadowlands with a group of scientists from the Hackensack Meadowlands Development Commission and the consulting company (Marsh Resources, Inc.) carrying out the restoration projects, spent a morning meeting with a group of managers from the NJ DEP who are responsible for implementing wetland management and restoration/mitigation programs, and spent several hours meeting with graduate students and commenting on their research activities. The visit was highly successful in bringing a high level of expertise to the managers, public representatives and academic scientists involved with wetland management in the state. This event was co-sponsored by the Meadowlands Environmental Research Institute.

(c) Common Waters Initiative

I organized an initiative at Cook College/NJ Agricultural Experiment Station to fund two new positions in watershed management/water resource protection. We brought together a broad consortium of people, including agricultural extension agents working with farmers and homeowners throughout the state, extension specialists in nutrient management, social scientists involved in the watershed management initiative in the state, water quality scientists, an EPA-Region II specialist who coordinates water resource activities in this region, representatives of the NJ DEP (from the watershed management division, the water quality group of the Division of Science and Research, and from the NJ Geological Survey), and also a representative of the USGS –Trenton District Office. This group put together a proposal to the University to fund a full-time extension specialist position in nutrient management and a full-time staff position in watershed management who will be responsible for developing outreach and information transfer programs across a broad cross-section of the population. The initiative was a result of discussions which I organized between the Dean of the Agricultural Experiment Station and representatives of the farm and watershed management communities. While we have not yet been informed about the formal acceptance of the proposal, it seems that the administration has become convinced of the need to greatly expand its commitment to water resource issues, and these new positions and programs will eventually become established. I expect that this initiative will result in our ability to develop a greatly expanded information transfer program.

(e) Internships at NJ DEP

In order to foster collaboration with state agencies involved in water resource management, we have agreed to support up to three student interns to work on water-related projects at the state. The first such intern has been selected to provide technical support to a newly-formed Lake Restoration and Management Task Force.

(f) Website development

The website for the Institute (http://njwrri.rutgers.edu/). has been maintained and updated.

(g) Conferences and Meetings

We are currently working on the organization of a major "water summit" meeting on water supply issues in southern New Jersey, where shortages and conflicts in demand are creating major political and economic problems. The conference is planned for October, 2001, and we expect both gubernatorial candidates to speak at the meeting. We are the primary organizers of the meeting; cooperators include the South New Jersey Development Council, USGS – Trenton, NJDEP, the NJ Farm Bureau, and several non-profit environmental groups.

We are also co-sponsoring a meeting planned for January, 2002, on Phragmites ecology and management; the primary organizers of the meeting (the New Jersey Marine Consortium) expects participants and attendees from throughout the country to attend.

We are also co-sponsoring the visit and public lecture of Wendi Goldsmith, CPG, CPSSc, President and Founder The Bioengineering Group, Inc. of Salem, Massachusetts on stream bank restoration and stabilization., planned for July, 10th, 2001.

(h) Representation at other meetings

I was invited to join the Water Quality Group of the New Jersey Farm Bureau, and have attended several meetings of this group.

I represented the WRRI and water quality issues at several meetings organized by the NJ DEP to explore research needs in environmental issues.

Ms. Der Bedrosian represented the WRRI at several watershed planning meetings, at a meeting of the Watershed Partnership of New Jersey, and serves on the Advisory Council for several of the Raritan Watershed Management Area planning groups.

USGS Summer Intern Program

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 RCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	6	0	0	0	0
Masters	0	0	0	0	0
Ph.D.	4	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	10	0	0	0	0

Notable Awards and Achievements

1) "Occurrence of Nonylphenolethoxylate (NPE) Surfactants and their Metabolites in New Jersey Rivers and Wastewater Treatment Plants" Kauser Jahan, Rowan University:

Shira Perlis, (2001), Daniel Bigler Award for Outstanding Academic and Research Record, New Jersey Water Environment Association

Shira Perlis, (2001), NJ ASCE and ASCE Student Awards for Outstanding Academic and Research Record

Marcus Roorda, Shira Perlis and Margaret Jacques "Fate and Transport of Nonionic Surfactants and Their Biodegradation Intermediates in Wastewater Treatment Plants", 1st Prize at the Annual NJWEA Conference Student Poster Competition, Atlantic City, NJ, May 2001.

Marcus Roorda, Shira Perlis and Margaret Jacques "Fate and Transport of Nonionic Surfactants and Their Biodegradation Intermediates", 1st Prize at the Annual NJAWWA Conference Student Poster Competition, Atlantic City, NJ, April 2001.

2) "Modeling source area diffusivity of methyl tert-butyl ether (MTBE) in groundwater systems," Daniel K. Lefkowitz and Chris Uchrin, Rutgers University:

This research, funded by the NJWRRI, was used as the basis of a successful application for a research-based individual scholarship given by the Air and Waste Management Association, Mid Atlantic Region. The Air Pollution Education and Research Program (APERG) scholarship is one of the largest of its kind in the country, and includes an award of $25,000. This prestigious award was renewed for 2001.

3) "Hydrology and plant diversity in Pine Barrens savanna wetlands," Matthew Palmer and Joan Ehrenfeld, Rutgers University:

The results of this research have been used by the New Jersey Natural Heritage Program, the New Jersey Natural Areas Program, and the New Jersey Geological Survey as a part of continuing research on savanna hydrology and community structure. In particular, the findings have been incorporated into draft management recommendations for the conservation of Narthecium americanum, a candidate for protection under the Endangered Species Act.

Publications from Prior Projects

1. Cole, Marlene; August, 2001. Components of ribbed mussel (Geukensia demissa) population dynamics vary with position in the tidal network. Ecological Society of America, Annua Meeting, Madison, WI.
2. Cole, Marlene; September 1999. A landscape model of ribbed mussel distribution in natural and ditched marshes. Princeton-Rutgers Ecology Symposium, Princeton University, Princeton, NJ.
3. Cole, Marlene; August 1999. Effects of mosquito control ditches on the distribution of ribbed mussels (Geukensia demissa) and salt marsh cordgrass (Spartina alterniflora) across the salt marsh landscape. International Association for Landscape Ecology 4th World Congress, Snowmass, CO. August 1999.
4. Carletta, Mary Anne, Judith S. Weis, and Peddrick Weis. 2001. Development of Thyroid Differences between Mummichogs (Fundulus heteroclitus) from a Polluted Site and a Reference Site. Annual Meeting of the Hudson/Delaware Chapter of SETAC, West Chester, Pennsylvania, 10-11 May 2001.
5. Carletta, Mary Anne, Judith S. Weis, and Peddrick Weis. 2000. Response to Thyroid Hormone Exposure in Juvenile Mummichogs (Fundulus heteroclitus) from a Polluted vs. a Reference Site. Atlantic Coast Contaminants Workshop 2000 (Endocrine Disruptors in the Marine Environment: Impacts on Marine Wildlife and Human Health), Bar Harbor, Maine, 22-25 June 2000.
6. Carletta, M.A., J.S. Weis, and P. Weis. 1999. Thyroid Function in Juvenile Mummichogs (Fundulus heteroclitus) from a Polluted vs. a Reference Site. Society of Environmental Toxicology and Chemistry (Sustaining Global Environmental Integrity), Philadelphia, Pennsylvania, 14-18 November 1999.
7. Carletta, Mary Anne, Judith S. Weis, and Peddrick Weis. 2001. Development of Thyroid Abnormalities in Mummichogs, Fundulus heteroclitus, from a Polluted Site. Pollutant Responses in Marine Organisms (PRIMO 11), Plymouth, UK, 10-13 July 2001.
8. Wiegner, T.N. and S.P. Seitzinger. 2001. Photochemical and microbial degradation of external dissolved organic matter inputs to rivers. Aquatic Microbial Ecology 24(1): 27-40.
9. Strom, P.F. & Phanida Prommasith. 1998. Nitrification in Potable Water Distribution System Biofilms. Invited Presentation for "Drinking Water Research in New Jersey," NJ Section, American Water Works Association, Princeton, NJ.