New Jersey Flows

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*** SPECIAL PINELANDS EDITION ***

The Kirkwood-Cohansey Project

Introduction by Robert Zampella, Ph. D.,
Chief Scientist, New Jersey Pinelands Commission

The Kirkwood-Cohansey aquifer underlies most of the New Jersey Pinelands. The ground and surface waters associated with this aquifer are among the most important factors influencing the structure and function of the Pinelands ecosystem. Our ability to understand the ecological consequences of altered hydrologic regimes associated with human activities, such as water-supply diversions, was advanced by the Gibson Bill (N.J.P.L. 2001 c. 165). The bill directed the Pinelands Commission, in cooperation with the United States Geological Survey, Rutgers University, the New Jersey Department of Environmental Protection, and the United States Fish and Wildlife Service, "to assess and prepare a report on the key hydrologic and ecological information necessary to determine how the current and future water supply needs within the pinelands area may be met while protecting the Kirkwood-Cohansey aquifer system and while avoiding any adverse ecological impact on the pinelands area." The bill appropriated $5,500,000 for the preparation of the aquifer assessment by the Pinelands Commission.

Scientists from the cooperating institutions and agencies completed a research plan for the aquifer assessment and the plan was approved by the Pinelands Commission in October 2003. The research plan addresses two major questions. First, what are the probable hydrologic effects of ground-water diversions from the Kirkwood-Cohansey aquifer on stream flows and wetland water levels? Second, what are the probable ecological effects of induced stream-flow and ground-water-level changes on aquatic and wetland communities? The approach used to answer these two related questions includes several coordinated steps. A detailed investigation will be conducted to characterize the hydrology and hydrogeology of representative areas, including hydraulic interactions between the aquifer system, streams, and wetlands. Results of this investigation will provide the information needed to construct, calibrate, and verify high-resolution ground-water-flow models that can be used to predict the probable hydrologic changes resulting from ground-water diversions. Hydrologic investigations will be coordinated with and provide the foundation for ecological studies.

The ecological research focuses on several key aquatic and wetland species and communities that will serve as ecological indicators. Forested wetlands, such as Atlantic white cedar swamps, red maple swamps, and pitch pine lowlands, intermittent ponds, frog and fish assemblages, and macroinvertebrate communities are among the targeted ecological indicators. The objectives of the ecological research are to develop models relating community gradients, the distribution of individual species, and nutrient-cycling processes to natural and induced changes in stream flows and water levels. These models will be linked to mapped landscape features such as wetland coverage, water-table maps, and topography. The resulting landscape-level ecological models will be used in conjunction with the hydrologic models to determine the probable ecological effects of different water-diversion scenarios. In addition to establishing ecological thresholds for assessing changes in aquatic and wetland communities due to water diversions, the results of the project can be used to prepare regional and site-specific well-siting and operational criteria for minimizing ecological impacts.

The hydrologic investigations will focus on three drainage areas, including the McDonalds Branch, Pump Branch and Albertson Brook, and Morses Mill Stream basins. Wetlands studies will be conducted in these three watersheds as well as in the East Branch Bass River and Skit Branch basins. The Batsto River is the primary focus of the stream community studies. The entire project is to be completed by 2009. *

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The Director's Chair

by Joan G. Ehrenfeld, Ph.D., Director, New Jersey Water Resources Research Institute
Rutgers, The State University of New Jersey

This issue of *Water Flows* is dedicated to the New Jersey Pinelands, a remarkable part of south Jersey with abundant high-value water resources of all kinds. It features an in-depth introduction to the Kirkwood-Cohansey project, a large, multi-investigator evaluation of the potential impacts of water withdrawals on water resources of the region.

Aquifer Study in Full Swing

By Allison M. Brown, Ph.D.
Pinelands Commission Research Scientist

The New Jersey Pinelands Commission has embarked on a scientific study of the Kirkwood-Cohansey Aquifer, the massive underground body of water that sustains the New Jersey Pinelands.

To what extent can the Kirkwood-Cohansey Aquifer continue to support the needs of a growing population without negative impacts to the aquatic and wetland communities that depend on it? To answer this important question, a diverse team of scientists have planned a study that will identify the impact of groundwater withdrawals on stream flows and water levels and determine the effects that such withdrawals would have on aquatic and wetland communities. Results from the study will be used to predict ecological responses to various water demand and development scenarios, and ultimately allow the Commission to make more informed land-use planning decisions.

Robin Van Meter installing a water-level observation well.

Conceived fifteen years ago, and authorized by legislation passed in 2001, the Kirkwood-Cohansey Project Work Plan has evolved into one of the most comprehensive studies of its kind, setting new standards for land- and water-use planning. The $5.5 million study is funded through the New Jersey Water Supply Bond Act of 1981. The Pinelands Commission approved the work plan in late 2003 and the project is expected to continue through the year 2009.

The Kirkwood-Cohansey Study is a multi-agency effort involving cooperators from United States Geological Survey (USGS), Rutgers University, United States Fish and Wildlife Service (USFWS), New Jersey Department of Environmental Protection (NJDEP), as well as the New Jersey Pinelands Commission. Six carefully selected stream basins are the focus of the study. These are located within the watersheds of the Rancocas Creek and the Mullica River, two major Pinelands waterways.

Most study sites are located on public lands associated with Brendan T. Byrne, Wharton, and Bass River State Forests, and The Richard Stockton College of New Jersey.

Cooperating scientists have already initiated work on most of the twelve study topics outlined in the project work plan.

Hydrologists from the USGS have installed instrumented wells in various streams. These shallow observation wells continuously monitor water levels at hourly intervals. The data obtained from the wells will show trends in water level fluctuations. The USGS is also developing a hydro-geologic framework for each study area by compiling information on existing wells. A site has been selected in Byrne State Forest to be used by USGS for monitoring weather conditions, including evapotranspiration.. Data collected at this site will be used in determining recharge to the aquifer system.

Helonia bullata

Allison Brown measuring tree-canopy cover in a wetland forest plot.

The USGS has also selected several sites for monitoring stream discharge and has teamed up with the Pinelands Commission to study the effect of variable stream flow on fish and macroinvertebrates. Several study sites have been selected within three stream systems.

Biologists from USFWS are conducting a study of swamp pink (*Helonias bullata)* a federally listed endangered plant. Study plots are being selected, and the plant's abundance and distribution relative to different water levels and other environmental characteristics will be evaluated.

For the Wetland Forest Community study, Pinelands Commission scientists have selected more than 200 vegetation plots in five study basins representing a range of different community types. Based on species composition, plots generally follow a gradient from upland community types (e.g. pinescrub oak woodland) to wetland community types (e.g. cedar swamp). Each plot will be characterized by a number of vegetative and environmental variables, including plant cover, soil moisture, and ground water level. To characterize water levels, observation wells are being installed in each of the 200 plots. Monthly water level data gathered over the next two to three years will be used to develop a hydrologic signature, or benchmark, for each community type.

An Intermittent Pond Vegetation Study has been initiated and will focus on 15 ponds in the Rancocas Creek and Wading River watersheds. The ponds are subject to seasonal periods of water inundation and drawdown, a process that affects plant distribution. Monthly water level data along with plant data will be related to differences in plant composition along hydrologic gradients. Because frogs frequent this habitat type, three of the ponds will be included in the Anuran-Larval Development and Recruitment Success Study. In this study**,** Commission scientists will place tadpoles in mesh enclosures along a gradient of deep to shallow water to determine an influence of water levels on tadpole development. In addition, Pinelands Commission planning staff have started to collect pertinent geographic data and compiling data on current and future water consumption patterns.

Scientists from Rutgers University will evaluate the potential for nitrogen release to wetland soils at different moisture levels and the impact that changes in soil moisture regimes might have on plant water stress and photosynthesis.

Rutgers scientists will also work with all the cooperators to apply data gathered from the component studies to the landscape scale. The USGS is managing the huge mass of data gathered by the different cooperators involved in the Kirkwood-Cohansey project. Commission scientists will continue to keep the public updated on the project. A Commission web page will be established for this purpose. *

This article originally appeared in ***The Pinelander Summer 2004 edition: The Newsletter of the New Jersey Pinelands Commission. Contact: Allison.Brown@njpines.state.nj.us***

The Kirkwood-Cohansey Workplan was developed through numerous meetings of the cooperating participants, who prepared a series of study topic drafts for final selection by the team. Preparation of a final, detailed work plan was coordinated by the Pinelands staff. The overarching goal was to develop an far-reaching, coordinated program. To that end, twelve study topics were selected:

1. Hydrology
2. Wetland-Forest Community Gradients
3. Swamp Pink *(Helonias Bullata)*
4. Intermittent Pond Vegetation
5. Anuran-Larval Development and Recruitment Success
6. Stream Fish and Macroinvertebrates
7. Ecological Processes: Nitrogen
8. Ecological Processes: Indicators of Physiological Stress
9. Landscape Models
10. Build-out and Water-Demand Scenarios
11. Data Management and Data-Analysis Coordination
12. Public Information and Final Kirkwood-Cohansey Assessment

Monitoring Evapotranspiration

by Robert S. Nicholson and David M. Sumner, Ph.D., Hydrologists, U.S. Geological Survey, New Jersey District

A quantitative understanding of hydrologic processes in the New Jersey Pinelands begins with the water budget. Water inputs to any area must balance water outputs plus changes in water storage over any period of interest. The characterization of seasonal or sub-seasonal hydrologic responses to changes in stresses (such as changes in recharge rates or ground-water withdrawals) requires a detailed understanding of the important water-budget components and how these components change over time. The quantification of hydrologic inputs and outputs is more straightforward for some components than for others. Continuous measurement of precipitation and streamflow, for example, is standard procedure. On the other hand, a water-budget component that historically has been problematic is evapotranspiration (ET). On a regional basis over the Pinelands area, ET has been estimated to account for the fate of about one-half of the annual precipitation; ET occurring over a particular watershed on a particular day is more difficult to quantify.

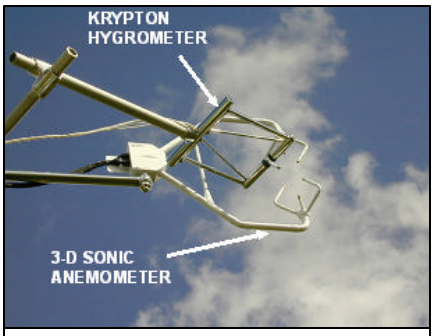

Figure 1. Instrumentation used to monitor evapotranspiration using the eddy correlation technique.

Figure 2. Installation of instrumentation on a tower for monitoring evapotranspiration in Brendan Byrne State Forest, Burlington County.

In Florida, where ET accounts for an even larger percentage of the water budget than in New Jersey, a substantial effort has been invested in monitoring ET using state-of-the art techniques in support of State and local water-management strategies. The U.S. Geological Survey (USGS) operates a network of 10 ET monitoring stations throughout Florida to measure daily ET using the eddy correlation technique. As part of the hydrologic investigations for the Kirkwood-Cohansey Project, USGS will measure ET at a wetlands site in the Pinelands using this same technique.

The general approach to measuring ET using the eddy correlation technique involves the placement of sensors above the evaporative surfaces where they can measure fluctuations in wind and water vapor, and allow computation of the ET originating from a fairly large landscape-source area. The time-averaged product of vertical wind speed and water-vapor density above the forest canopy equals the estimated vapor flux from the land/vegetation surface to the atmosphere, or ET. The high-frequency sensors (Figure 1) are capable of making many measurements per second and can resolve rapidly changing conditions. The accuracies of the krypton hygrometer and the 3-dimensional sonic anemometer, however, are insufficient for the ET determination to permit reliance on absolute measured values. Instead, the technique exploits the concept that upward air movement must be positively correlated with vapor density in order for ET to occur. With a bit of algebraic manipulation, ET is shown to be equal to the covariance of these two variables. For the Kirkwood-Cohansey project, additional sensors will be used to collect meteorological and hydrologic data that provide the basis for determining ET using alternative methods, for understanding the relations between ET and other factors (such as water-table depth and soil moisture), and for estimating ET during periods when eddy correlation data are missing.

Measurement of vertical wind speed and vapor density above the forest canopy requires deployment of instrumentation on a tower extending above the forest canopy. The 24-meter tower situated in a pitch pine-dominated wetland area in Brendan Byrne State Forest, Burlington County, is shown in figure 2. After measuring ET at this site for 1 year, the instrumentation will be relocated to a different wetland site with different dominant vegetation, and ET will be monitored at the second site for the second year. Similar flux towers in several upland areas in the Pinelands currently (2004) are being operated by the U.S. Forest Service (USFS) as part of ongoing fire-management research. ET data collected from the USFS upland flux tower sites, in conjunction with data collected at the USGS wetlands flux tower sites, will be used to estimate ET over the project study areas. *****

For further information, contact Robert Nicholson, USGS Kirkwood-Cohansey Project Coordinator, at ***(609) 771-3925 or email rnichol@usgs.gov.***

Pinelands Hydrology

By Anthony S. Navoy Ph.D., Assistant District Chief,
U.S. Geological Survey, New Jersey District Office

The foundation of the aquatic, wetland, and related habitats of New Jersey's Pinelands is the underlying Kirkwood-Cohansey aquifer system, both literally and figuratively. The U.S. Geological Survey (USGS) along with the New Jersey Pinelands Commission, Rutgers University, U.S. Fish and Wildlife Service, and New Jersey Department of Environmental Protection is conducting an intensive study of this aquifer and the related Pinelands ecosystems. A primary component of the study being conducted by USGS is an investigation of the hydrologic-system characteristics that affect ecologically important hydrologic regimes and the relations among critical components of the hydrologic budget. To accomplish this goal, three basins will be intensively studied: McDonalds Branch, Albertson Brook, and Morses Mill Stream (fig. 1). These basins exhibit a range of hydrologic characteristics that represent the entire Pinelands area, thus the findings are transferable to the entire area.

The intensive hydrologic study has several key components that will be undertaken in the three basins. These are a determination of the hydrogeologic framework, the measurement of current hydrologic conditions, and the determination of an overall hydrologic budget. Using these components, a detailed understanding the interaction between the ground-water system and wetlands will be developed. A ground-water flow model of each of the basins then will be developed and used to predict how possible changes in regional and local water use, and other related aspects will affect the hydrologic system. This information will be integrated with the ecological components of the overall study to provide a comprehensive understanding of the link between Pinelands hydrology and ecosystems.

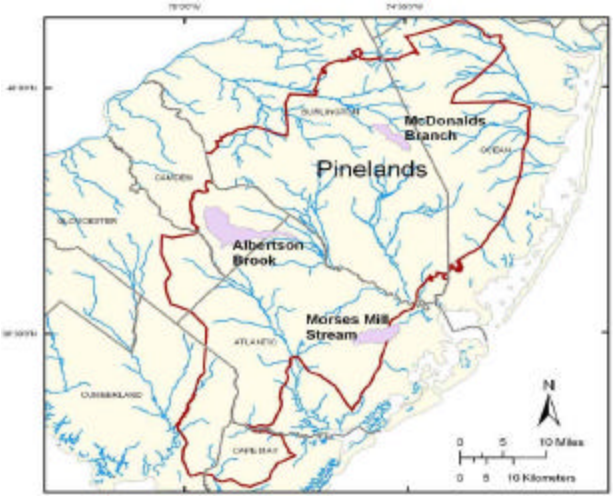

Figure 1. Location of intensive-study basins within the Pinelands

Hydrogeologic framework

A hydrogeologic framework is a conceptual "picture" of subsurface materials of an area, including their composition, orientation and hydraulic characteristics. Development of a hydrogeologic framework in an area such as the Pinelands is accomplished through analysis of drill-core and -cutting logs, borehole geophysical logs of electrical resistivity and natural gamma radiation, and surface geophysical measurements of ground-penetrating radar (fig. 2). Because the study is focusing on undeveloped areas, geophysical data were collected at the intensive-study locations. Seventeen test wells were installed to provide additional framework information. These data will be supplemented, wherever possible, with information from previously drilled wells.

Current hydrologic conditions and water budget

Hydrologic conditions in the intensive-study basins will be closely monitored during the study. These measurements will facilitate further analysis and provide a documentation of current conditions. A monitoring network based on the test wells has been developed in each of the intensive study basins for hydrologic purposes. A total of 140 wells and well points will be installed for this study. Water-level data are continuously recorded at 25 wells. Two synoptic measurements of the network wells and additional nearby previously drilled wells are planned. These synoptic measurements will be undertaken in the spring and fall of 2005 to correspond to high water and low water-level conditions.

Figure 2. Ground-penetrating radar survey equipment.

Stream gaging stations have been established at a downstream location in each of the intensive-study basins. These sites provide a measure of the amount of water leaving each basin. Additional streamflow measurements will be made within each basin. Staff gauges have been constructed at key locations, for example in close proximity to ecological reference sites, to facilitate measurement. A total of three continuous stream gages (fig.3) and eight staff gages have been set up.

A series of "seepage run" measurements will be made to quantify ground-water discharge to the streams (base flow). A seepage run is a series of flow measurements made on a stream in a synoptic manner. For a particular stream reach, the differential of a pair of upstream and downstream measurements will indicate the volume of ground-water discharge, providing that no other inflow or outflows are associated with that reach.

Evapotranspiration (ET) is a hydrologic process that removes roughly half of the precipitation that falls in a typical Pinelands basin. Because of the hydrologic significance of the process, it will be measured directly to determine its variability. The measurements are difficult and complicated to make, so measurements will be attempted at only two locations -- one in McDonalds Branch Basin and the other in the Morses Mill Stream Basin. ET rates will be determined using an eddy correlation approach for water-vapor density and wind velocity data collected from tower-mounted sensors above the forest canopy. The details of these measurement and interpretation techniques are summarized in an accompanying article. In addition to the measurements made on the tower, standard meteorological data will be collected at the tower sites. These data, together with those available from National Weather Service and Rutgers University data networks, will

be used to determine precipitation input to the study basins. The compilation of the ground-water level, streamflow, ET, precipitation, and other related data will allow for the development of a detailed water budget for each of the intensive-study basins. These budgets will provide the basis for additional quantitative analysis of the hydrologic system.

Aquifer-Wetland-Stream interaction

An assessment of the relative position of streams and wetlands within the hydrogeologic framework together with an analysis of ground-water levels (and changes) relative to wetland levels and streamflow, and an analysis of the "seepage run" data, is the first of a two-part approach to the analysis of the interaction. This first approach relies on data about the ambient conditions. The second part of the approach is to perform an "aquifer test" in each of the three intensive-study basins. These tests involving the short-term pumping of a well will stress the ground-water levels. Carefully collected data will indicate the streamflow and wetland water-level response to this stress, thus allowing for a quantification of the hydraulic and physical conditions controlling the interaction.

Figure 3. Stream gaging equipment shelter and data-transmission antenna in Albert-

Predictive capabilities: hydrologic models

A digital, 3-dimensional ground-water flow model will be developed covering each of the three intensive-study basins. The flow model will be constructed and calibrated using the data collected during the study. The key data components for calibration of the model will be derived from the water budgets of the intensive-study basins; of particular importance are the ground-water levels and the ground-water discharge to streams (base flow). The calibrated flow model will allow for more extensive evaluation of the functioning of the hydrologic system. Additionally, scenarios representing possible future conditions, such as increases in nearby ground-water pumpage or changes in precipitation, can be tested to predict the likely effects on Pinelands hydrology. This information will be used in a Pinelands-wide evaluation of ecology and hydrology that will be performed by Rutgers University.

Database

The hydrologic and ecological data collected by this study will be organized and stored in a database to maximize the benefit by insuring the ease of subsequent use of the data. This database can be used by other scientists, water managers and planners. *****

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Wetland-Forest Community Gradients

By Allison M. Brown, Ph.D.,
Pinelands Commission Research Scientist

For the Wetland-Forest Community Gradients Study, Pinelands Commission scientists are characterizing the full range of vegetation and environmental variables associated with wetland-forest community types typical of the New Jersey Pinelands. The purpose of the study is to determine how wetland-forest communities and associated plant-indicator species respond to changes in water regime (e.g., seasonal water-level patterns, mean and extreme water levels). For this purpose, 202--10 x 10 m plots representing nine major wetland-forest community types have been systematically selected in five different drainage basins using NJDEP Freshwater Wetlands data, aerial photographs, and field surveys. Based on species composition, the plots selected generally follow a dry – wet gradient from upland community types (for example, pine-scrub oak woodland) to wetland community types (for example, cedar swamp).

Allison Brown installing a water-level observation well.

To further characterize the vegetation associated with each of these plots, estimates of canopy cover, and under-story indicator species cover and height are being determined from point intercept data collected along five transects positioned perpendicular to the hydrologic gradient. Thus far, cover and height data have been gathered for the 70 plots (350 transects) in the McDonalds Branch drainage basin. In addition, stem and trunk diameters will be measured, and the historic impact of fire and other disturbances will be considered in each of the plots. Environmental conditions associated with each plot including depth-to-water table, impervious zones, soil moisture, soil color and texture, depth and percent of organic matter, and soil pH are being evaluated. Partial-record water-level observation wells installed in each plot have been measured monthly since March 2004. Water-level data collected from six instrumented continuous-record wells installed by the USGS will be used to estimate a continuous water-level record for each plot. Seasonal soil moisture measurements made monthly in a subset of 46 plots will be related to percentage organic matter and water level to estimate soil moisture for all plots. Soil texture and color, and the presence of impervious zones will be used to identify drainage characteristics associated with each plot.

These data, gathered over the next two to three years, will support the development of ordination and regression models needed to define a hydrologic signature, or benchmark for each wetland-forest community type and associated plant-indicator species. Predictions of community change due to natural and induced changes in the depth, duration, and frequency of saturation and flooding can then be made. *****

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Swamp Pink *(Helonias bullata)* As An Indicator

By Carlo Popolizio, U.S. Fish and Wildlife Biologist

The New Jersey Pinelands Commission is collecting key hydrologic and ecological information needed to determine how current and future water-supply needs will affect the Kirkwood-Cohansey aquifer system. The aquifer study is being implemented in cooperation with the New Jersey Department of Environmental Protection, Rutgers University, the U.S. Fish and Wildlife Service, and the U.S. Geological Survey. The purpose of the study is to determine: (1) the probable hydrologic effects of groundwater diversions from the Kirkwood-Cohansey aquifer on stream flows and wetland water levels and (2) the probable ecological effects of induced streamflow and groundwater-level changes on aquatic and wetland communities.

The U.S. Fish and Wildlife Service (Service) is providing a study to characterize the distribution and relative abundance of swamp pink (*Helonias bullata*) at Shinns Branch and Cooks Branch. Shionns Branch is in the Cedar Swamp Natural Area of Lebanon State Forest, in the headwaters of Presidential Lakes within the Rancocas Creek watershed, Woodland Township, Burlington County. Cooks Branch is in Greenwood Forest Wildlife Management Area, the headwaters of Bamber Lake within the Cedar Creek watershed, Lacey Township, Ocean County. Field studies have and will be conducted to determine the hydrologic regimes associated with swamp pink colonies and to assess the distribution and abundance of swamp pink plants along hydrologic gradients of the Kirkwood-Cohansey aquifer. Study results will be used to develop regression models describing potential changes in swamp pink distribution in response to modifications of the hydrologic regime.

Photo: Carlo Popolizio / USFWS, NJFO

Carlo Popolizio, U.S. Fish and Wildlife Biologist, collecting data on the federally listed swamp pink (Helonias bullata) at Cooks Branch, Greenwood Wildlife Management Area, Ocean County, New Jersey.

Swamp pink is a federally listed (threatened) wetland plant whose limited geographic distribution currently extends from New Jersey to Virginia. The majority of sites for this species are found on the coastal plain of southern New Jersey. Swamp pink is generally associated with water-saturated muck soils of hardwood swamps and Atlantic white-cedar (*Chamaecyparis thyoides*) swamps. Swamp pink is considered highly sensitive to alterations in hydrology.

Photo: Carlo Popolizio / USFWS, NJFO

A swamp pink (Helonias bullata) rosette at Cooks Branch, Greenwood Wildlife Management Area, Ocean County, New Jersey. The acronym identifies the site and transect, in conjunction with the observation number.

To date, the Service has completed data collection at Cooks Branch, with 835 sets of observations of swamp pink rosettes/clumps within belt transects 5 meters wide and of variable lengths. The general methodology is as follows:

- measure water level at the staff gage of each transect every 2 weeks;
- measure water level for the transect at the beginning of the day before gathering data;
- record the distance (to nearest 0.1 meter) of each rosette/clump along the center line;
- record the distance of the rosette/clump from the center line;
- record the number of rosettes in a clump;
- record the number of flowering stems per clump;
- record clump diameter along the short and long axes;
- record the distance from the base of the uppermost and lowermost rosettes to water;
- record presence/absence of tree canopy above clump with a spherical densitometer and, if present record species;
- take digital photo of clump with ruler and clump label;
- record all species (sphagnum, herbs, shrubs, trees) within the area formed by the drip line of the clump, extending from the base of the clump to the tree canopy;
- map the location of each rosette/clump within each belt-transect;
- record the location of stream-channel center for each belt transect;
- provide a complete species inventory for each belt transect, extending from 2 meters beyond the most distal swamp pink rosette/clump at either end of the transect; and
- register transect beginning and end points with a Global Positioning System (GPS) unit.

Data gathering will resume in late spring 2005 at Shinns Branch. The Service appreciates the opportunity to be a participant in the Kirkwood-Cohansey Project and looks forward to continuing to work with the New Jersey Pinelands Commission and other partners on this important endeavor.

Carlo Popolizio is the Service's principal investigator for this project. *****

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Intermittent Ponds

By Kim J. Laidig, Principal Research Scientist, Pinelands Commission

An intermittent pond study has been initiated as part of the Kirkwood-Cohansey project and will focus on 15 ponds in the Rancocas Creek and Wading River watersheds. Intermittent ponds are shallow wetland depressions that are usually inundated with water during most of the year and then frequently dry in the latter part of the growing season. Pinelands intermittent ponds support open-water, emergent-herb, and shrub-dominated plant communities. Rare plants are often found in these ponds. Annual and seasonal variations in water depth are associated with the distribution of plant species and vegetation zones found in intermittent ponds. Beginning from the pond perimeter, plant zones found in an idealized Pinelands pond include communities dominated by pitch pine lowland forest, highbush blueberry, leatherleaf, sedges, emergent vegetation, and aquatic species. If the pond dries, the zone that previously supported aquatic species may support the growth of annual herbaceous plants.

Measuring pond water level for pond vegetation and larval frog studies

The intermittent pond study is being conducted to determine what hydrologic regimes are associated with plant zones found in intermittent ponds and to assess how these communities may respond to changes in seasonal and annual water-level patterns. In 2004 staff gages were installed at each of the 15 ponds to allow for biweekly water-level measurements. In addition, a continuous water-level recorder was installed at one of the ponds to allow for hourly water-level readings. Plant zones were identified for each of the ponds and monthly floristic surveys were conducted. Using a combination of digital aerial photo interpretation and in-field mapping with a GPS, the distribution of plant zones will be georeferenced. Elevation data will be collected during the wetter months to construct bathymetric maps of the ponds. Biweekly water-level data along with plant zone and bathymetry data will be used to characterize the seasonal hydrologic regimes of the plant communities found along hydrologic gradients. Appropriate site-specific and landscape-level ordination and regression models will also be developed to simulate potential changes in pond vegetation associated with altered hydrology. * ***Contact: (609) 894-9311 ext. 6542; kim.laidig@njpines.state.nj.us***

Burnt Pond is one of the study ponds for pond vegetation and larval frog studies

Anuran-Larval Development And Recruitment Success

By Kim J. Laidig, Principal Research Scientist, Pinelands Commission

Pine Barrens treefrog in the larval frog study

Intermittent ponds also serve as breeding grounds for several species of Pinelands anurans (frogs and toads). Pine Barrens treefrogs, northern spring peepers, and southern leopard frogs are among the most abundant species found in these pond habitats. The primary goal of the larval development and recruitment success component of the Kirkwood-Cohansey Project is to characterize the hydroperiod necessary for the successful development and transformation of tadpoles into frogs.

In 2004, nighttime vocalization surveys were conducted at 21 ponds from March through June to determine breeding phenology for each species present. Fifteen of these ponds were included as part of the pond-vegetation study. Southern leopard frog egg masses were collected in three ponds and the tadpoles were hatched. In four ponds, duplicate transects of enclosures representing 10 different water depths were installed and the enclosures were stocked with tadpoles. Pond-water depth was drawing down until the July storm flooded out the enclosures. The project was cancelled for 2004.

In 2005, the anuran study will focus on the 15 vegetation study ponds and a pool of 14 ponds in the Mullica River basin for which hydrology has been monitored since 1996. Replicate ponds will be selected to represent different hydroperiod scenarios. Nighttime vocalization and egg mass surveys will be used to estimate the timing of breeding events. Repeated tadpole sampling will be used to document the general timeline of the natural developmental process for anurans at the ponds. Surveys for recently metamorphosed individuals, or metamorphs, will determine recruitment success for a particular species. Appropriate models will be developed to relate recruitment success to the hydroperiod scenarios. * ***Contact: (609) 894-9311 ext. 6542; kim.laidig@njpines.state.nj.us***

Stream Fish and Macroinvertebrates

(excerpted from the Kirkwood-Cohansey Project Work Plan)

Fourteen native-fish species may be found in Pinelands streams, and several nonnative species are associated with waters characterized by elevated pH. Although native fishes are adapted to the shallow and slow moving waters that typify the Pinelands, the conditions associated with small headwater streams may limit the distribution of some species and influence species richness. Studies conducted in the Mullica River basin indicate that species richness increases with basin area up to around 25 km2, suggesting that smaller streams support fewer species. The native eastern mudminnow and banded sunfish were generally the most common fish encountered in the smaller streams within the basin. Lower species richness in headwater streams may be related to the intermittent nature of these habitats or to low dissolved oxygen concentrations associated with low flows.

Aquatic macroinvertebrates are a dominant component of the diet of most native Pinelands fish species. Current, substrate, and oxygen are among the most important factors influencing the distribution and abundance of stream macroinvertebrates. These three factors are interrelated, with current partly determining both sediment type and dissolved oxygen levels.

USGS scientists Jonathan Kennen and Melissa Riskin collecting fish samples in a Batsto River tributary

The stream-community study will address two related questions. First, how do stream fish and macroinvertebrate assemblages respond to variations in streamflow regimes? Second, how do site-specific habitat variables, such as temperature, dissolved oxygen, bank cover, stream vegetation, sediments, and channel morphology, interact with stream-discharge to effect fish and macroinvertebrate composition? The results of the field studies will be used to develop appropriate ordination and regression models relating community and species gradients to natural and induced changes in the streamflow regimes. *****

Ecological Processes: Nitrogen

By Joan Ehrenfeld, Ph. D., Rutgers, The State University
Dept. Ecology, Evolution, and Natural Resources

The Comprehensive Management Plan is based on the observations that Pinelands waters have exceptionally low concentrations of nitrogen, and that the characteristic plants and animals of wetlands and streams are adapted to very low levels of nitrogen. Extensive research conducted by Pinelands scientists and others have supported this idea, and have shown that even small increases in nitrogen results in the loss of the special organisms and ecological communities of the area and the establishment of cosmopolitan, weedy species.

Paradoxically, the wetlands that are so sensitive to excess nitrogen are potentially a large source of this element. Pineland wetlands typically have muck soils – thick deposits of organic matter that have accumulated over thousands of years. Under saturated conditions, the leaves, stems and roots of the plants decay only partially; this partly-decomposed material accumulates as peat (more fibrous) and muck (more fine-textured). Bound within this organic matter is substantial amounts of nitrogen, incorporated in the proteins and nucleic acids that had constituted the living plants and animals.

As long as these organic soils remain saturated, decomposition proceeds only very slowly, and this nitrogen remains bound within the organic molecules of the soil. However, if water levels are lowered and these soils are exposed to the atmosphere, the organic materials decompose rapidly, and the bound nitrogen is released in the inorganic forms of nitrate and ammonium. These forms are directly useful to plants and algae, unlike the organic forms, and they thus allow nitrogen-demanding weedy species to proliferate. Indeed, it has frequently been found elsewhere that when organic wetland soils are drained for agriculture, large amounts of inorganic nitrogen are released to surface waters and cause eutrophication.

Therefore, we hypothesized that the potential lowering of water tables due to withdrawals could potentially stimulate a large production and release of ammonium and nitrate into surface waters. This could occur if the surface sediments are exposed to air for prolonged periods, allowing oxygen to penetrate into the soils.

We are examining the potential for dry conditions in Pinelands wetlands to produce inorganic nitrogen through a combination of laboratory and field studies. In the laboratory, cores taken from three types of wetlands – cedar swamps, hardwood swamps, and wet pine swamps – are being incubated in small containers. Periodically, the containers are leached, and the nitrate and ammonium in the leachate is measured; this indicates how much of this mineral nitrogen has been produced since the previous leaching. Cores are being incubated under three conditions – saturated, 60% of saturation, and 30% of saturation. The cores will be incubated and periodically leached for approximately 6 months, until all the nitrogen that can be readily mineralized (converted to ammonium and nitrate) is used up. When these incubations are completed, a second set, using samples from the same sites, will be conducted, but these soils will be maintained under fluctuating conditions of drainage and saturation.

Finally, a field study will be undertaken to measure the actual amount of nitrate and ammonium being produced by these soils. These studies will be conducted in the plots being used for both the vegetation sampling and the studies of plant physiology. We will be able to determine if climate-driven periods of dryness result in the release of mineral nitrogen, and, if so, in which types of wetlands and under what kinds of hydrological conditions. *****

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Physiological Stress Indicators

By Ming Xu, Ph.D, .Rutgers, The State University University
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Grant F. Walton Center for Remote Sensing and Spatial Analysis

Dr. Ming Xu and Dr. Erik Hamerlynck, of Rutgers University, are tracking changes in plant physiological performance of four critical lowland shrub species in multiple locations. These sites span a soil moisture gradient from dry lowland pitch pine forest to Atlantic Cedar swamp communities in the McDonalds Branch watershed, located in Brendan T. Byrne State Forest. Predawn measurements of plant water potential are being used to track changes in plant water status in response to soil water content and water table depth measured across the gradient. These water status measurements are directly coupled to detailed photosynthetic gas exchange response curves that quantify changes in enzyme-level processes regulating carbon assimilation, and those that measure the plant's efficiency in using light to assimilate carbon dioxide. These species-specific measurements will provide insight into the mechanisms that may underlay vegetation responses to altered hydrological regime responses to altered hydrological regimes across the Pinelands region. *****

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Landscape Modeling in the Kirkwood-Cohansey

By Richard Lathrop, Ph.D., Rutgers, The State University
Dept. of Ecology, Evolution and Natural Resources
Grant F. Walton Center for Remote Sensing and Spatial Analysis

Lowered water tables will induce both short and long term impacts on the aquatic and wetland communities of the Pinelands. In the short term, as plants undergo water stress, their physiological state will be altered resulting in measurable changes in transpiration and photosynthesis. In the long term, the competitive balance will be altered, favoring some plant species over other species. In time, we expect that the vegetation community composition will change. However, many tree and shrub species are long lived and this transition to a new community state may take a number of years – well beyond the time frame of this study**.** The overall objective of the landscape modeling component is to extrapolate the results of the field sampling campaign to be able to estimate the impacts of water table withdrawal on natural community composition across the broader watershed to landscape scale and on longer time frames.

The landscape models will employ a community gradient approach to relate the distributions of community types or assemblages of an individual species to natural and induced changes in stream flow or depth, duration and frequency of saturation and flooding. These empirically derived models will be based on the field sampled data and assume that there is a stable equilibrium between the present vegetation characteristics and the underlying environmental characteristics. The objective of these models is to evaluate the expected effect of various scenarios of natural and induced changes in the duration and frequency of saturation and flooding on the spatial distribution of wetland types and indicator species (i.e., shifts in community types associated with changes in water-table patterns). These models will be linked to a GIS database of mapped environmental characteristics to map expected community composition across the landscape. *****

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Water Demand/Build-out Analysis

By Pinelands Staff

A realistic build-out analysis (zone capacity reduced in a logical way) is necessary to provide data for consumptive water demands (residential and non-residential use through inter-basin transfer of wastewater, agriculture by evapo-transpiration and irrigation loss). Furthermore, predictions on future water use by type of land use are necessary to adjust those build-out figures to arrive at consumptive loss.

Both the water demand and build-out component of the Kirkwood/Cohansey study relies heavily on the use of geographic data. Current zoning patterns, lot status data and tax assessment information are the foundation for the analysis. A Geographic Information Systems (GIS) is utilized to determine the amount of existing development in the Pinelands as well as the additional development that could occur in a build-out scenario.

The results of this analysis are then updated and corrected using tax data.

Pinelands staff has already completed a pilot layer for one municipality and will soon implement the same process for the rest of the Pinelands. Simultaneously, Pinelands staff is researching water usage habits in order to calculate water demand for the study area. Information from the United State Geological Survey, Rutgers University, the United States Department of Agricultural, utility authorities and other sources will be gathered to examine how much water is consumed in the region. For example, how much water does a single-family household use in a year versus a suburban office park (both now and in the future)? These types of data, along with agricultural and industrial uses will be compiled to determine the water demand in a build-out scenario. Conservation practices, water supply innovations and growth rates will also be examined to hone in on how water use will change in the future. *****

Stockton University Research Results for Oswego River Watershed in the New Jersey Pine Barrens

By Dr. Claude Epstein, Professor of Environment Studies
Richard Stockton College of New Jersey

The Oswego River near Calico Ridge in the winter

Over the last ten years, I have studied the relationship between surface water and groundwater in the Oswego River watershed. This has lead to several findings.

First, the upper reaches of the Oswego River, rather than being a focus of groundwater discharge surprisingly turned out to be sources of groundwater recharge. These reaches are losing stream that general typify arid climates.

Second, peat, producing muck soils, dominate the upper and middle reaches within the channels and along the banks of the Oswego River. This greatly increases the water holding capacity adjacent to the stream and reinforces these reaches as sources of groundwater recharge.

Third, Rosgen analysis was utilized to characterize geomorphological differences in the Oswego River watershed and revealed a consistent progression of stream types. This consisted of sloughs passing downstream to peat-lined single and multiple channel reaches (i.e., E7 and DA7) then to sandy and gravelly, high width to depth ratio, single channel reaches (i.e., C4, C5). Human disturbance was also revealed by Rosgen analysis.

Lauren Buyofsky, now a Stockton Environmental Studies graduate, aiding in surveying and Rosgen analysis along a reach of the Oswego River

Fourth, the impact of historical land use on the Oswego River geomorphology is currently being studied using Rosgen analysis, surveyed sections of surface topography and sediment thicknesses, stream velocity measurement, and sediment sieve analysis.

Much of this work has been published (Application of Rosgen Analysis to the New Jersey Pine Barrens, Claude M. Epstein, 2002, Journal of the American Water Resources Association, Vol.38, No.1, pp.69-78).

These studies were financially supported by the New Jersey Water Resource Research Institute and Richard Stockton College. The field work was undertaken by a corps of Stockton Environmental Studies students under my supervision. *****

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Ongoing Pinelands Water Research at Richard Stockton University

- Cromartie, William J. Development of a water quality/aquatic biota study of selected subwatersheds in the Great Egg Harbor Watershed. Atlantic County Office of Regional Planning and Economic Development. 2002-2003.
- Gliddon, Jason. Development of Improved Biomonitoring Protocol for the Great Egg Harbor River. WRRI Undergraduate Internship. 2002-2003.
- Maun, Lynn. Biomonitoring the Great Egg Harbor River. WRRI Undergraduate Internship. 2003-2004.
- Cromartie, William J, Claude Epstein, Ray Mueller Fred Akers and Tait Chirenje. Adams Branch Stormwater Remediation Plan - Phase One. NJ Department of Environmental Protection, Division of Watershed Management, contract to Stockton College in cooperation with the Great Egg Harbor Watershed Association. May to December 2004.

Rancocas Study Released by Pinelands Commission

A comprehensive report on the Pinelands portion of the Rancocas Creek Basin has been published by the Pinelands Commission. The report, which took two years to compile, details the water quality and ecological resources of a 243 square mile area within 16 communities in Camden, Burlington and Ocean Counties. The study relates environmental data to land use development, in order to ascertain the impact of land use activeties on water quality, wildlife, and the aquatic and wetland habitats.

The Rancocas study is the second such study released by the Pinelands commission and follows on the heels of the Mullica River Basin Study, released in 2001.

Data gathered will enable protection of ecological resources of the Rancocas watershed as well throughout the Pinelands area.

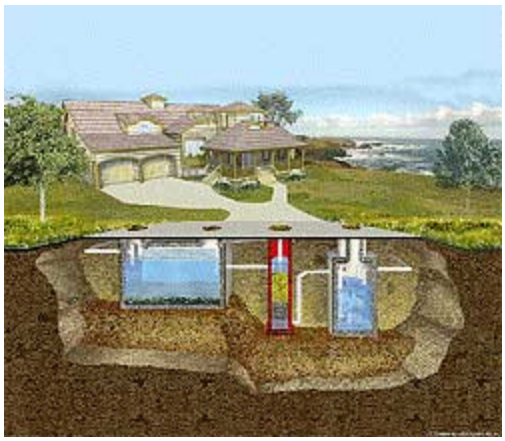
The culmination of two years of study, this project examined hundreds of species of plants, fish, toads, and frogs in addition to water quality parameters. Not surprisingly, it found a strong correlation between water quality and ecological resources characteristic of the Pinelands in areas with the least development. However, a substantial part of the study area did show the effects of land use and disturbance had resulted in ecological parameters which no longer resembled those characteristic to the Pinelands.

For further information contact the Pinelands Commission at ***(609)874-7300 or info@njpines.state.nj.us***

Advanced Onsite Wastewater Treatment Systems Authorized in the NJ Pinelands

By Ed Wengrowski, Wastewater Management Coordinator, NJ Pinelands Commission

Since it's inception in 1979, the Pinelands Commission has acted to preserve and protect the land and water resources of the New Jersey Pinelands. Of utmost importance is the estimated 17.7 trillion gallons of fresh water flowing through Pinelands streams and contained within the Kirkwood-Cohansey aquifer lying just beneath the surface of the mostly sandy Pinelands soils. These irreplaceable water resources are protected through a combination of stringent land use and water quality programs.



One such program uses a mass balance "Pinelands Septic Dilution Model", developed by K.W. Brown (1980), to calculate the assimilative capacity of the land i.e., its ability to attenuate nitrogen in wastewater via dilution. Based upon the model, conventional (and pressure dosed) residential septic systems, to which no nitrogen reduction is credited, require a minimum 3.2 acre lot to meet the Pinelands ecologically based 2 mg/l nitrogen standard at the property line. Residential development on lots smaller than 3.2 acres, down to a minimum one-acre, (the Pinelands minimum for un-sewered development) must use one of five advanced onsite denitrification technologies authorized through the Pinelands Alternate Design Treatment Systems Pilot Program.

The Commission established the residential wastewater pilot program in August 2002. Use of the technologies is being phased in during the subsequent five-year period. NJDEP has issued generic treatment works approvals authorizing local and county Pinelands Area health departments to approve the pre-engineered package treatment systems. Through a rigorous monitoring program, the Commission is evaluating the ability of these systems to meet Pinelands water quality standards. Initial results, although preliminary and still quite limited, suggest that the systems are indeed capable of meeting these rigorous water quality standards.

The approved technologies include sequencing batch reactors; recirculating sand filters; modified trickling filters; and fixed film activated sludge treatment systems. All rely on biological nitrification and denitrification processes employed by larger-scale community and municipal treatment plants and all combine aerobic and anaerobic phases in the treatment train. All of the technologies have been documented in the literature as being capable of removing up to 65% of total nitrogen and more than 95% BOD and TSS.

Without advanced treatment, wastewater from septic tanks contains high concentrations of ammonia that is toxic to aquatic life. In the natural aerobic environment, ammonia released from septic tanks is converted to nitrate that acts to fertilize surface waters (emerging via base flow) and may potentially lead to algal blooms and subsequent low dissolved oxygen levels. The advanced treatment systems remove up to 65% of the nitrogen, before it is discharged to groundwater, and convert it to inert nitrogen gas that is vented to the atmosphere. The treated wastewater is virtually free of ammonia and contains substantially reduced levels of nitrate. Advanced treatment coupled with dilution provided by minimum lot sizes, assures that nitrogen levels don't exceed Pinelands water quality standards. *****

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Wetlands Mapper - new version to be released 1/1/2005 by U.S. Fish and Wildlife Service
Beginning Jan. 2004, a new version of the Wetlands Mapper.will be available online. The new Mapper will have new tools and functionality based on comments and feedback. A complete tutorial and an online help area will assists users in navigating the new site. For more information see: ***http://wetlandsfws.er.usgs.gov/***

EPA Issues New Water Quality Trading Handbook - paper copies of the handbook at no charge from the National Service Center for Environmental Publications at (800)490-9198 or via email at ncepimal@one.net (please refer to the EPA document number EPA 841-B-04-001). Access and download the handbook at: ***www.epa.gov/owow/watershed/trading.htm.*** For handbook questions, contact Lynda Hall (202)566-1210

New Stormwater Illicit Discharge Detection and Elimination Manual - Center for Watershed Protection (CWP) and the University of Alabama, under a grant from EPA, have produced a comprehensive manual for municipalities that must develop and implement programs to find and correct illicit discharges to their storm sewer systems. Manual includes detailed information on creating and managing a program, and a comprehensive guide to field and lab protocols. Download the new manual and supporting materials free ***www.cwp.ord/idde_verify.htm***

Cohansey-Maurice watershed selected by USDA for Conservation Security Program 2005
11/02/04-USDA announced that the **Cohansey-Maurice watershed** is among the 202 watersheds that have been selected for the fiscal year 2005 ***Conservation Security Program*** sign-up to be held this winter. A map of the fiscal year 2005 watersheds is at ***www.nrcs.usda.gov/programs/csp***

Homeland Security Center: EPA announced, on 11/09/04, the establishment of a permanent ***National Homeland Security Research Center*** in Cincinnatti, OH with restructuring into three divisions, including ***Water Infrastructure Protection.*** For more information see ***http://www.ucowr.siu***

Pinelands Aquatic Research Continues In Many Venues

Pinelands Commission: Pinelands Watershed Studies

In the early 1990's, the Pinelands Commission initiated a long-term environmental-monitoring program to characterize the effect of existing land-use patterns on aquatic and wetland resources and to monitor long-term changes in these resources. The Mullica River Basin was the initial focus of the program. Studies conducted within the basin addressed land-use changes, the long-term status of Atlantic white cedar wetlands, and the relationships between land-use and water quality, stream flow, and the composition of wetland forest communities and plant, fish, and anuran (frog and toad) assemblages found in streams, impoundments, and intermittent ponds.

The watershed-based studies demonstrated that streams draining forested watersheds are typically acidic and nutrient-poor, whereas streams draining developed lands and upland agriculture display elevated pH and dissolved-solid concentrations. Biological communities in forested watersheds were characterized by native plant, fish, and anuran species, whereas nonnative plants and animals were found in streams draining developed lands and upland agriculture Similar trends were observed in a subsequent study of the Rancocas Creek basin. Commission scientists have completed similar surveys in the Barnegat Bay drainage, which includes the Toms River, and the Great Egg Harbor River and Tuckahoe River watersheds, and are currently analyzing the data from these studies. Ongoing watershed-based studies include a comparison of plant, fish, macroinvertebrates, and diatom assemblages found in streams draining forested watersheds and those draining active and abandoned cranberry bogs and an assessment of the relationship between land-use and biological communities in Pinelands lakes.

NJDEP Office of Science and Research Developes Algal Indicators:

Algal Indicators of Eutrophication for New Jersey Streams: The Inner Coastal Plain and Pine Barrens - Year 5

PRINCIPAL INVESTIGATORS: Karin Ponader and Donald Charles: Patrick Center for Environmental Research, The Academy of Natural Sciences; and Thomas Belton: New Jersey Department of Environmental Protection, Div. of Science, Research and Technology

The New Jersey Department of Environmental Protection is interested in developing algal indicators of stream and river eutrophication to assess relationships between extant water quality criteria (e.g., phosphorus and nitrogen concentrations) and overt signs of eutrophication to possibly be applied in a regulatory context as secondary criteria (narrative quantification) for identifying nutrient impairments. The statewide study was initiated in July 2000 by the Patrick Center for Environmental Research, then sequentially for all five physiographic provinces. Data from northern sites were successfully applied in 2004 towards the development of test indicator metrics for the Piedmont, Ridge and Valley, and Highland Provinces. Currently the project has been extended to the Coastal Plain including Pine Barren sites (including data collected by The Pinelands Commission scientific staff). However, because of the different geomorphology of the coastal plain rivers (low gradients; sandy and clay river bottoms), significant changes and adjustments in the sampling design and the methods for collection of algal samples were necessary (i.e., using diatometers as artificial substrates and epipsammic (sand)/epipelic (silt) substrata). The methodology and data outputs may assist NJDEP in the development of nutrient TMDLs; in the expansion of water quality monitoring to appropriate biological measures; assistance for Integrated Water Quality reporting and 303D listing/de-listing of nutrient impaired waters; as well as the potential for developing more scientifically defensible nutrient biocriteria and standards. ***Funding Source: NJDEP-DSRT: New Jersey Corporate Business Tax***

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Drexel University Pinelands Research Institute Studies Bioindicators and Water Quality

Drexel University through the Office of Pinelands Research (OPLR) is conducting a wetland monitoring study at the Warren Grove Range (WGR), Burlington County, New Jersey that focuses on the impact of military operations on surface water quality and potential impacts to local populations of Pinelands anurans (frogs and toads) and fish assemblages. Along with the water monitoring study, Dr. Walter F. Bien and Dr. James R. Spotila from the Department of Bioscience and Biotechnology at Drexel University in Philadelphia, Pennsylvania are leading a team of graduate students and fellow scientists in other research projects at WGR that focus on natural resource management, conservation biology, and Pinelands community ecology. See the OPLR website (***www.pages.drexel.edu/~maz26/OPLR***) for more information on Drexel's research at WGR.

The Warren Grove Range encompasses 9,416 acres of dwarf pine plains, pitch pine-scrub oak barrens, pitch pine lowlands, and associated wetlands which either discharge into the Oswego River, Wading River, or Bass River watersheds. The Oswego River borders the northern Range property and represents the largest wetland habitat within the WGR.

The quality of the watersheds within the Pinelands can indicate the level of disturbance and predict the effects upon native fish and anuran populations. Typically, streams draining from forest-dominated watersheds have a low pH (average pH 4.5) and are low in total dissolved solids (TDS). Native plant and animal species are well adapted to the natural low pH conditions of Pinelands streams; whereas, non-native species are identified with watersheds where water quality has been altered, namely increased pH and elevated TDS levels. Low pH conditions restrict non-native species from Pinelands waters.We identified 9 major drainages that discharge from WGR into the Oswego River, Wading River or Bass River watersheds.

We measured surface water quality in terms of specific conductance and pH at 31 sampling stations along these drainages and sampled fish species and monitored the calls of anurans at key sampling sites. Surface water quality data over three field seasons (2002-2004) was characteristic of undisturbed Pinelands water standards. Specific conductance and pH ranged SC 37-57 $\mu S\ cm^{-1}$ and pH 4.00-4.24 respectively. Anuran species occurring within the Pinelands are classified as restricted to the Pinelands, wide ranging, or border entrant species. Human impact may alter the water chemistry enough to allow border entrant species to out compete native species. Over the course of the study no breeding populations of border entrant species were identified at WGR. In addition, we sampled 10 of 13 native fish species known to occur in the Pinelands. We did not sample any non-native fish species (peripheral or introduced). These data suggest that military operations are not having a negative impact on surface water quality and subsequently on native anuran and fish species.

In USGS Research Projects and Data Networks in the New Jersey Pinelands

In addition to cooperating with the Pinelands Commission and others on the Kirkwood-Cohansey Project described herein, the U.S. Geological Survey is currently undertaking other hydrologic research projects that pertain, at least in part, to Pinelands issues. These projects are:

- New Jersey-Long Island National Water Quality Assessment
- Flow Characteristics and Basis for Development of Ecological Goals for New Jersey Streams;
- Ground-Water Supply Availability in Southern Ocean County
- Distribution of Radium and Related Radionuclides in Coastal-Plain Aquifers
- Quantification of Radium Mass loading and Radioactivity in the Shallow Aquifer from the Water Softening-Treatment Backwash Waste Stream that is Discharged to Septic Systems
- Effects of Land Use, Septic Systems, and Sewering on Distribution of Nitrate in Shallow Ground Water;
- Ground-Water Levels and Chloride Concentrations in the Major Artesian Aquifers of the Coastal Plain'
- Low Flow Characteristics of New Jersey Streams

The U.S. Geological Survey maintains an extensive hydrologic data network in New Jersey that includes ground-water and surface-water measurements at sites located in the Pinelands. Current hydrologic conditions from stations using satellite telemetry and historical data are available on the New Jersey District Office website, ***http://nj.usgs.gov/***. Many of the projects listed above and data collection stations in the network are undertaken in cooperation with other governmental agencies, such as the N.J. Department of Environmental Protection.

Publications prepared by the U.S. Geological Survey on research findings and data can be obtained online at the publications warehouse site, ***http://infotrek.er.usgs.gov/pubs***. Many publications are available for downloading and the arrangements for purchase of paper copies can be made. A continuing effort is underway to scan and make older reports available for download.

Study of Radio-Tracked Pinelands Timber Snakes Concludes

by Kim Laidig, Research Scientist, Pinelands Commission

A three-year study of timber rattlesnakes (*Crotalus horridus*) titled, "Assessing timber rattlesnake movements near a residential development and locating new hibernacula in the New Jersey Pinelands," was recently completed by the Pinelands Commission and the New Jersey Division of Fish and Wildlife's Endangered and Nongame Species Program (ENSP). The report was written by Kim Laidig and Dave Golden. The objectives of the study were to monitor timber rattlesnake movements in the vicinity of a partially constructed residential development in Evesham Township and to locate undocumented rattlesnake hibernacula throughout the Pinelands region. For the Evesham study, special consideration was given to the effectiveness of a 2.7-km fence and a culvert system intended to direct the movements of timber rattlesnakes away from the development and toward forested areas. For the Pinelands-wide study, determining the exact location of hibernacula was considered a crucial first step to providing protection to the area in the vicinity of the den.

Timber rattlesnakes were captured opportunistically for the Pinelands-wide study, implanted with radio transmitters, and released at the capture location. The snakes were not located again until early October when their general location was determined from a low-flying aircraft equipped with radio-telemetry equipment. Once their exact location was determined through ground searches, the snakes were then radiotracked every other day until they entered their hibernacula. The location of each hibernaculum was recorded using a global positioning system (GPS). Eleven timber rattlesnakes were captured for this portion of the study. Nine of these snakes were successfully tracked to seven different hibernacula. The locations of six hibernacula were previously unknown. The seven hibernacula were located in Atlantic white cedar swamps and all were located on publicly-owned land.

The more intensive Evesham study entailed locating transmitter-implanted rattlesnakes every other day until the snakes reentered hibernacula in the fall. The locations of each snake were recorded with a GPS. Five male and four female timber rattlesnakes representing a range of sizes were radiotracked for various time periods during the three-year study period. Telemetry data indicated that these rattlesnakes used extensive areas of forested uplands and wetlands within a 1500-ha area in and around the development. The two largest males had the largest activity ranges. Both snakes had total round-trip travel-distances of greater than 11 km in both years when they were tracked for the entire active season. A pregnant female traveled the shortest distance from the hibernaculum and was characterized by a reduced activity range. Core activity areas for several timber rattlesnakes, including an area intensively used by pregnant snakes, were located in areas that may be developed in the future. The fences did not prevent any of the transmitter-equipped timber rattlesnakes from entering constructed portions of the development. The culverts, however, were used by two timber rattlesnakes to move beneath a street to forested lands east of the development.

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NewsNote: On 11/12/04 the Pinelands Commission voted to certify an amendment to the Barnegat Township Land Use ordinance which will enable a unique measure to preserve and protect critical natural resources. Last year endangered northern pine snakes and other rare pant and animal species were discovered in an area planned for residential development. Radio-tracking of snakes and other natural resources data resulted in delineation of conservation areas that would be off limit to future development, through onsite transfer-of-development rights (TDR) program for property owners within the area. For more information see http://www.state.nj.us/pinelands/press.htm

Spotlight on Watersheds

Protecting The Coastal Plain Rivers In The Pinelands

By Fred Akers, Administrator,
Great Egg Harbor Watershed Association

In the 1960s a small group of individuals recognized and promoted the unique ecological values of the Pinelands region in southern New Jersey to the state and the nation. In 1978, the United States Congress signaled a new national direction for land-use planning by designating the New Jersey Pinelands region as a National Reserve, to be managed by an innovative program that provided an alternative to inclusion within the national park system. This was indeed a miraculous accomplishment.

Also in the 1960s, a national dialogue began to grow that recognized that rivers were being dammed, dredged, diked, diverted, polluted, and degraded at an alarming rate. These national concerns for rivers, water quality, and protecting the environment lead to the creation of the Wild and Scenic Rivers Act (1968), the National Environmental Policy Act (NEPA 1969), and the Federal Water Pollution Control Act Amendments of 1972 (Clean Water Act 1977).

With the passage of the Wild and Scenic Rivers Act of 1968, Congress called for the identification of potential wild, scenic, and recreational river areas within the nation. In 1976 the Department of the Interior initiated the Eastern Wild and Scenic Rivers Study in cooperation with state and local agencies. This ultimately led to the creation of a Nationwide Rivers Inventory (NRI), which identified those national rivers with potential eligibility to be included into the Wild and Scenic Rivers program. In order to be listed on the NRI, a river must be free-flowing and possess one or more Outstandingly Remarkable Values (ORVs). Scenery, Recreation, Geology, Fish, Wildlife, Prehistory, History, and Culture are some of the categories used to determine ORVs.

Since the NRI study process occurred at the same time as the study process for creating a National Reserve in the New Jersey Pinelands, portions of the major Pinelands rivers easily passed the eligibility study test and were included on the Nationwide Rivers Inventory by 1982. The Mullica River and most of its watershed tributaries, the Great Egg Harbor River and some tributaries, the Maurice River and some tributaries, and even the Toms River, are now on the NRI. There are also a number of other New Jersey rivers on the NRI outside of the Pinelands, including the Delaware and the Musconetcong.

In the mid 1980's, local citizens concerned about water quality and habitat degradation to the Great Egg Harbor River looked for a mechanism, in addition to the Pinelands Protection Act, to protect their river, and discovered that the Great Egg was eligible to be included in the Wild & Scenic Rivers Program. Motivated by development pressure, changed patterns of recreational use, threats to wildlife and historic sites, the prospects of substantial water withdrawals into public water supply systems, and water quality degradation, a public consensus was achieved to support the designation of the Great Egg Harbor River into the Wild & Scenic Rivers System by an act of Congress in 1992. This public consensus was the beginning of a river protection partnership between local citizens, environmental organizations, public officials in twelve Pinelands municipalities, 4 Pinelands counties, and state and federal agencies

In a similar but independent action, citizens along the Maurice River mobilized to protect their river from the threats of a hazardous waste landfill and other water quality degradations, and achieved a federal Wild & Scenic Rivers Program designation for parts of the Maurice River, the Menantico and Muskee Creeks, and the Manumuskin River by an act of Congress in 1993. Then Congressman Bill Hughes was a leader in these federal designation and protection efforts for two of New Jersey's Pinelands river systems, which are achievements almost as miraculous as the Pinelands National Reserve designation itself.

During the Eastern study process for the Nationwide Rivers Inventory list, there was a growing recognition that direct federal ownership would limit the number of rivers that could possibly be designated for permanent Wild & Scenic protection, and that there were many more rivers that possessed the ORVs required by the program and would qualify for designation in more developed areas of the country. So just like the Pinelands National Reserve designation was a partnership management innovation whereby the federal government would support a federal designation without federal ownership, the scope of the Wild & Scenic Rivers System was broadened to allow the federal designation of rivers and riparian lands that were publicly and privately owned, with a partnership approach to river management.

The Great Egg Harbor River was the first Partnership Wild & Scenic River to be designated into this special new program without any direct federal ownership or control, and the Great Egg is the only Partnership Wild and Scenic River to be designated as a Unit of the National Park System. As a cooperatively managed unit in the National Park System, the National Park Service selected the Great Egg Harbor Watershed Association (GEHWA) as the host organization to assist with the implementation of the *Great Egg Harbor National Scenic and Recreational Comprehensive Management Plan*, which was finalized and published in May of 2000. GEHWA was formed in 1989 to promote the protection of the Great Egg Harbor Watershed, and became incorporated as a 501-c3 not for profit organization in 1990.

The main stem of Great Egg Harbor River flows for 59 miles and drains over 300 square miles of land in the New Jersey's Pineland Reserve. The river corridor with its wide flood plains and winding channels passes through Folsom and Hamilton Townships and flows into Lake Lenape in Mays Landing. Below Mays Landing the river becomes a vast tidal estuary before forming the Great Egg Harbor Bay and joining with the Atlantic Ocean. The Great Egg Harbor Watershed is part of NJDEP's Watershed Management Area 15. *(Continued on page 15)*

Coastal Plains (Cont.)

Relatively undisturbed waterway segments offer prime spawning opportunities for anadromous fish, which provide food for the growing bald eagle and osprey populations. Other threatened and endangered species like Bog Turtle, Pine Barrens Tree Frog, Southern Gray Tree Frog, Swamp Pink, Knieskern's beaked-rush, Parkers Pipewort, and Barred Owl thrive in the fragile ecology of the river and its watershed. The region is rich in culture and history as well. Evidence of the Lenape Indians before occupation by Europeans in the early 1700s can be found. Remnants of structures which converted bog iron into cannon balls during the Revolutionary War, blast furnaces, sawmills, glass factories and brick and tile works are scattered throughout the watershed.

Approximately 25% of the main river corridor is in state or county ownership, which offers the public prime recreational opportunities and open space protection. The Great Egg has been recognized as the longest canoeable river in the Pinelands National Reserve, and its rich history and scenic vistas are irreplaceable. But because 75% of the riparian lands are in private ownership, balancing preservation, recreational use, and individual rights and interests makes management of the river corridor a complex responsibility.

Today, stream flow depletion from groundwater withdrawals is becoming one of the major threats to the Great Egg and the other Pinelands rivers. One of the major goals of establishing the Pinelands National Reserve and the Pinelands Protection Act was to protect the vast Kirkwood-Cohansey aquifer containing an estimated 17 trillion gallons of pristine quality water, and its intricate surface water interconnections to the rivers and wetlands of the Pinelands. But the drought of 2002 caused the lowest stream flows in recorded history for the Mullica, Maurice, and Great Egg Harbor Rivers, even though this particular drought was not the worst drought in recorded history.

These facts have triggered serious concerns about the long term sustainability of regional water supplies, as well as serious questions about the wisdom of preserving certain areas of the Pinelands while sacrificing other areas of the Pinelands with a transfer of high development densities, in the same water region. While the Great Egg Harbor Watershed has been designated as a nationally valuable Scenic and Recreational River, it has also been partially zoned to accommodate major land use receiving areas, called Pinelands Regional Growth Areas, for high density development transfers to protect the Pinelands core area.

Since the Pinelands Comprehensive Management Plan established the Transfer of Development Rights (TDR) program and set up the Pinelands Regional Growth Areas to receive more dense development in the early 1980s, substantial amounts of this transferred development have now been accomplished. This is especially true in Atlantic County, with major commercial and residential development demands being driven by the rapidly growing Casino industry.

The rapid and dense development in the Great Egg Harbor Watershed and other Pinelands watersheds, especially in the Regional Growth Areas, is now having negative cumulative impacts on water quantity, water quality, and the conservation of the essential ecological character of the Pinelands in these areas. Substantial increases in impervious land cover are cutting off aquifer recharge and increasing stormwater discharges and nonpoint source pollution. The ever increasing drinking water withdrawals from the Kirkwood-Cohansey Aquifer are now depleting the aquifer system at a growing rate, as millions of gallons of pristine aquifer waters are pumped out, used once, treated in regional plants, and discharged into the ocean every day.

The recent focus on regional watershed management at both the state and national level is facilitating an increased understanding of how to effectively manage and mitigate some of the negative impacts of rapidly increasing land use in the Pinelands National Reserve. Having major federally supported programs and organizations already in place, like the Pinelands Commission, and two Wild and Scenic Rivers in the Pinelands, provides a very solid foundation to address changing conditions and increasing threats to the natural resources in the Pinelands and its rivers.

The Pinelands Commission is very actively engaged with Environmental-Monitoring Programs and Management Plan Reviews, and the current "Gibson Bill" water study project is a fine example of the Pinelands Comprehensive Management Plan in action to assess and protect water resources. Both the Great Egg Harbor River and the Maurice River have Comprehensive Management Plans in place as well, which are fine foundations for action and implementation to also protect those important water resources.

The Great Egg Harbor Watershed Association (GEHWA) actively seeks out protection partnerships with federal, state, county, local agencies, and the public, to accomplish its mission to protect the Great Egg Harbor River in the Pinelands. GEHWA is determined to assure the long term protection of our Pinelands river resources for the benefit and enjoyment of future generations , and believes that dedicated partners working together are the key to success. *

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Pinelands Book "2004 Book of the Year" Selection

One Book New Jersey, a program sponsored by the New Jersey Library Association, selected ***The Pine Barrens,*** by John McPhee, as their ***Book of the Year 2004***. Originally published in 1978, ***The Pine Barrens*** was featured this year in public libraries, reading groups, and other educational events throughout the state. According to the Pinelands Preservation Alliance, this book ***"brought public attention to the Pine Barrens at a critical point in time and, just as important, helped persuade one individual, then-Governor Brendan Byrne, to lead the extraordinary legislative effort to save the Pine Barrens ecosystem from development."*** The PPA attributes subsequent motivation for The Pinelands Protection Act and the Pinelands Comprehensive Management to the influence of this book .

John McPhee, portrayed as one of the premier essayists of 20th century America., presents the botanical, cultural, hydrological, and historical peculiarities of the Pinelands region, as well as efforts to preserve it from the effects of urban sprawl. The goal of the ***One Book New Jersey*** program is to facilitate a common experience of shared literature by encouraging the state's residents to read the same book and participate in discussions or events related to that book. For more information on OBNJ see ***www.obnj.org***

Features

New Jersey Flows

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